RESEARCH ARTICLE

Advancements in 3D Printed PLA-Starch Composites: Mechanical Strength and Biocompatibility for Medical Implants

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ABSTRACT

The advent of 3D printing has opened new avenues for the development of customized medical implants. Among biodegradable materials, Polylactic Acid (PLA) and starch-based composites have shown promise due to their biocompatibility and biodegradability. This study aims to investigate the mechanical performance of PLA, starch-based composites, and a PLA-starch composite in the context of medical implant applications. We focus on key mechanical properties, such as tensile strength, compressive strength, impact resistance, fatigue behavior, and biocompatibility, to assess their suitability for load-bearing and non-load-bearing applications. The results show that PLA excels in strength, while starch-based composites offer flexibility and enhanced biodegradability. The PLA-starch composite shows potential for intermediate applications where both biodegradability and strength are required.

Keywords: PLA, Starch-based composites, PLA-starch composite, 3D printing, Mechanical properties, Medical implants, Biocompatibility, Additive manufacturing, Tensile strength, Compressive strength.

INTRODUCTION

The additive manufacturing (AM) method called 3D printing, has gained significant attention in recent years due to its potential to create highly customizable and patient-specific medical implants.[1] The advantages of biodegradable materials such as Polylactic Acid (PLA) and starch-based composites are evident in applications where temporary

implants, scaffolding for tissue engineering, and environmentally friendly materials are of high importance. PLA, a thermoplastic polymer, is derived from renewable resources such as corn starch and is known for its biocompatibility and biodegradability. [2] Similarly, starch-based composites, which incorporate natural starch materials, are gaining attention for their sustainability and potential as bio-based alternatives. However, the mechanical properties of these materials, particularly for load-bearing applications in medical implants, require thorough evaluation. In this study, we compare the properties of pure PLA, starch-based composites, and PLA-starch compositesa blend aimed at improving the performance of both materials by combining PLA's strength with starch's flexibility and biodegradability. [3]

MATERIALS AND METHODS

MATERIALS

Three distinct materials were prepared for 3D printing:

- PLA (Polylactic Acid): PLA filament was used as the base material due to its well-established mechanical properties and biodegradability.
- Starch-Based Composite: A polymer-starch blend was used, where corn starch was mixed with a biodegradable polymer (in a ratio optimized for mechanical performance), providing flexibility and improving biodegradability.
- PLA-Starch Composite: This composite material was created by blending PLA with a 50% concentration of starch, seeking to combine PLA's mechanical strength with the flexibility and biodegradability of starch.

Sample Preparation

Specimens for mechanical testing (tensile, compressive, and impact tests) were prepared using Fused Deposition Modelling (FDM) technology, which is commonly employed for 3D printing of polymer-based materials.

RESULTS

Tensile Strength

In table 1, PLA exhibited the highest tensile strength at 55.2 MPa, but its elongation at break was relatively low (6.5%), indicating higher stiffness and brittleness. Starch-based composites showed a tensile strength of 28.1 MPa, but elongation at break was significantly higher (12%), reflecting better flexibility. PLA-Starch composites displayed an intermediate performance, with 40.0 MPa tensile strength and 9.1% elongation, suggesting a good compromise between strength and flexibility.

Compressive Strength

In table 2, PLA demonstrated superior compressive strength (100 MPa), making it suitable for high-load applications, such as bone implants. PLA-Starch composites exhibited moderate compressive strength (72 MPa), providing a middle ground between PLA's high strength and starch's lower strength. Starch-based composites had the lowest compressive strength (45 MPa), limiting their suitability to non-load-bearing applications.

Impact Resistance

In table 3, PLA exhibited moderate resistance to impact, absorbing 0.36 J of energy before failure, suggesting it could withstand moderate shock loads. PLA-Starch composites showed improved impact resistance (0.26 J) compared to pure starch, highlighting a combination of strength and toughness. Starch-based composites exhibited the lowest impact resistance (0.17 J), indicating poor performance under shock loading conditions.

Fatigue Resistance

In table 4, PLA demonstrated the highest fatigue limit (30 MPa), making it suitable for long-term, cyclic loading in medical implants. PLA-Starch composites exhibited a fatigue limit of 22 MPa, indicating moderate resistance to

repetitive stresses. Starch-based composites showed a lower fatigue limit (15 MPa), suggesting that they are more suited for short-term or low-stress applications.

Water absorption

Water absorption was calculated using

WA(%) = Final weight (g) – Initial weight (g)/ Intial weight X 100

PLA exhibited the lowest water absorption, ensuring stability in moist environments. Starch-based composites showed higher water absorption due to their hydrophilic nature, making them less suitable for long-term applications.In Figure 1 it showsPLA-Starch composites demonstrated controlled water absorption, balancing biodegradability and mechanical integrity.

3D Printing and Medical Applications

In figure 2- Filaments (1.75 mm) were extruded for fused deposition modeling (FDM) 3D printing.PLA implants demonstrated superior mechanical integrity for high-load applications (e.g., bone implants).PLA-starch composites provided customizable degradation profiles for temporary implants.

Sterility and Biocompatibility

Endotoxin levels of the 3D-printed PLA implant were below the ISO 10993-11 standard (0.03 EU/mL).

Biodegradation

The 3D printed PLA (polylactic acid) implant is dissolved in PBS (phosphate buffered saline), for biodegradation in the hydrolysis process where the ester bonds in the PLA chain are broken down by water molecules, and obtained lactic acid monomers can be mobilized by our body microbial biome Starch-based composites degraded rapidly in soil, making them ideal for short-term applications. PLA-Starch composites exhibited moderate degradation rates, making them suitable for temporary medical implants.PLA degraded at a slower rate, ensuring longer functionality in biomedical applications.[6]

DISCUSSION

Mechanical and Thermal Properties

PLA exhibited superior tensile strength and thermal stability, making it ideal for load-bearing medical implants. The incorporation of starch into PLA improved flexibility, providing tuneable mechanical properties. The mechanical performance of PLA-starch composites depended on the PLA-to-starch ratio, with higher PLA content enhancing strength and higher starch content improving biodegradability. [7,8]

Biodegradability and Water Solubility

Starch-based composites degraded rapidly in moist environments, making them suitable for disposable medical applications. PLA-starch composites displayed controlled degradation, providing customized degradation profiles for temporary implants. Water solubility tests showed that starch-rich composites had higher dissolution rates, making them preferable for applications requiring quick disintegration. [9,10,11]

PLA in Medical Implants

PLA remains the preferred material for load-bearing implants due to its superior mechanical properties. PLA-starch composites offer an alternative for temporary scaffolds and biodegradable implants where flexibility and controlled degradation are required. The biocompatibility evaluation confirmed and ensuring their safety for medical applications. [12,13]

CONCLUSION

This study evaluates the mechanical and biocompatibility properties of PLA, starch-based composites, and PLA-starch composites for potential medical implant applications. PLA remains the material of choice for load-bearing implants due to its strength and biocompatibility. However, PLA-starch composites offer an attractive alternative for biodegradable scaffolds and temporary implants, where both flexibility and biodegradability are key considerations.

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Conflict of Interest Statement

The authors declare no conflicts of interest related to this research.

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Table 1: Tensile Strength

Material	Tensile Strength (MPa)	Elongation at Break (%)	Young's Modulus (MPa)
PLA	55.2 ± 3.1	6.5 ± 0.3	2,020 ± 70
Starch Composite	28.1 ± 1.5	12.0 ± 0.4	1,220 ± 50
PLA + Starch	40.0 ± 2.8	9.1 ± 0.6	1,640 ± 60

Table 2: Compressive Strength

Material	Compressive Strength (MPa)
PLA	100 ± 4.2
Starch Composite	45 ± 3.6
PLA + Starch	72 ± 5.0

Table 3: Impact Resistance

Material	Impact Energy Absorbed (J)
PLA	0.36 ± 0.05
Starch Composite	0.17 ± 0.03
PLA + Starch	0.26 ± 0.04

Table 4 Fatigue Resistance

Material	Fatigue Limit (MPa)
PLA	30 ± 2.5
Starch Composite	15 ± 1.2
PLA + Starch	22 ± 1.8

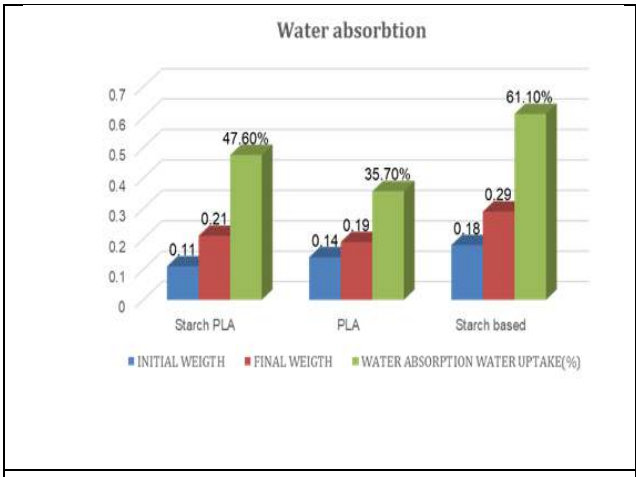


Figure 1: Water absorption

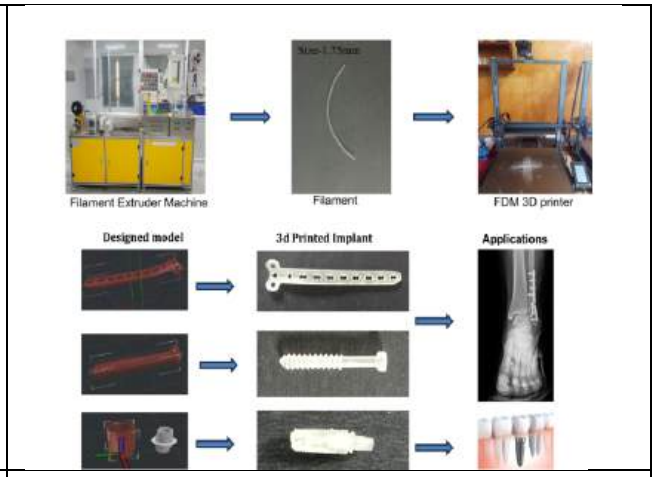
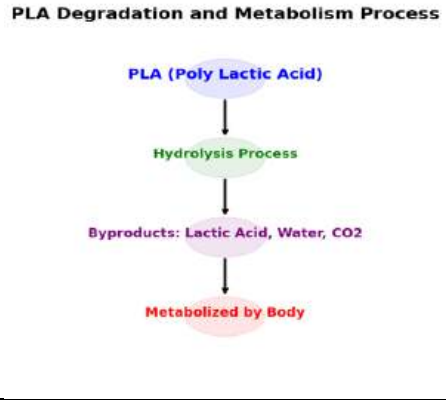


Figure 2: 3D Printing and Medical Applications



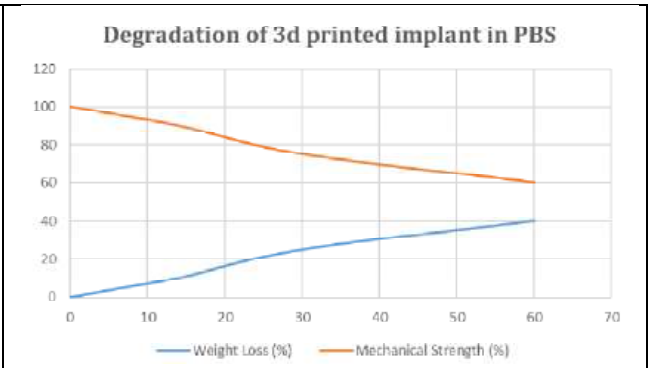


Figure 3: PLA Implant degradation

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RESEARCH ARTICLE

A Study on the Effect of Certain Components in Oil Pesticides Expresses Pesticide Activity

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ABSTRACT

Different types of botanical pesticides are used in the management of insect pests since they are bio-degradable, eco-friendly, economical, leave behind lesser number of residues and do not favour resistance building and pest resurgence. Among plant based pesticides, oils are highly effective and a mixture of selected oils is ideal for managing pests. Oil from the seeds of *Azadirachta indica* (A. Juss) and *Croton tiglium* (L.) and the rind of *Anacardium occidentale* (L.) were extracted using petroleum ether and acetonitrile as solvents in Soxhlet extraction method. The active principles of the three different oils were elucidated using GC-MS analysis. Comparison was made with GC-MS pattern for neem oil. The GC-MS analysis of neem oil, extracted in petroleum ether recorded about 13 peaks. Peak 1 indicated the presence of n-cetyl thiocyanate with a retention time of 10.32 minutes. At the retention time of 37.67 min, camphor was identified.

Keywords: *Azadirachta indica, Anacardium occidentale, Croton tiglium*, GCMS

INTRODUCTION

The large-scale use of chemical pesticides in agriculture and public health leads to adverse effects such as development of pesticide resistance, frequent pest out breaks, emergence of new pests, pollution and health hazards. In order to search for environmentally safe alternatives, scientists considered the pesticides of biological origin (bio-pesticides) in the place of synthetic insecticides. Replacement of synthetic insecticides by bio-rational insecticide is a universally acceptable and practicable approach worldwide. The use of plants, plant materials or crude plant extracts (botanical insecticides) for the protection of crops and stored products from insect pests is probably as old as crop protection itself (Thacker 2002). Throughout history, plant products have been successfully exploited as insecticides, insect repellents, and insect antifeedants (Rathi and Gopalakrishnan 2005). The pesticidal or insecticidal properties of plants depend on the chemical compounds or bioactive compounds that kill, repel, deter feeding instinct and behaviour and set obstacles in the oviposition of insects. Chemical constituents and biological properties of pesticides produced from natural products have been recently attracting the attention of many scientists to avoid the problems caused by synthetic compounds (Abou-Yousef *et al.,* 2010). Secondary chemicals produced by plants have a significant impact on insects. Insecticidal plant products are innumerable. Different parts of plants like leaves, stems, roots, fruits and seeds have insecticidal activities. Tissues from various botanical species have been used to protect commodities in the rural storage of grains. The dried fruits of *Capsicum* sp., the powdered roots of *Derris elliptica* (Wallich) Benth and the leaves and seeds of neem tree, *A.indica* have been variously used in the protection of stored agricultural products. The water extract of the root bark of *D.microcarpum* is coated over bags before grains are put in for storage while the dried leaves are placed inside the sacks before grains are introduced to act as an insect repellent (Hassan *et al*., 2010). Neem tree is one of the pesticidal plants which have the property in almost all parts of the plant. The neem trees belonging to Meliaceae family have been the subject of botanical biocontrol research (Mondali *et al*., 2009). The Meliaceae member, specifically *Azadirachta indica* A. Juss. (Indian neem tree), contains at least 35 biologically active principles, of which Nimbin and Azadirachtin (Pennington, 1981) are the most active insecticidal ingredients and are present predominantly in the seeds, leaves and other parts of the neem tree (Mulla and Su, 1999). Cahew nut shell liquid (*Anacardium occidentale* Linn.) is used for the control of insects like termites.

Croton tiglium Linn. seeds which are popularly used in the field of medicine, mainly as laxatives contain a number of insecticidal compounds also (Dictionary of Natural Products, 1982). Plant based oil pesticides are more viable than any other products. Generally, seeds are the rich source of oils than leaves, roots, flowers, barks and stems of plants. The active ingredients of neem plant are located in their maximum amounts in the seed and kernel (Vijayalakshmi *et al*., 1995). Neem oil extracted from the seed kernel of neem plant has been widely used throughout the world for medicinal and agricultural purpose with emphasis on health use and use as an effective anti-germ product and insect repellent. The cashew tree (*Anacardium occidentale* L.) represents one of the major and cheapest sources of non-isoprenoid phenolic lipids, which have a variety of biological properties, as molluscicides, insecticides, fungicides, and anti-termite compounds. The Cashew Nut Shell Liquid (CNSL) is contained between the inner and outer shell (pericarp) in a honey comb matrix. CNSL is a unique natural source of Meta allayl phenols with a variable degree of unsaturation attached to the benzene ring (De Lima *et al*., 2008). To know the quality and property of a formulated pesticide there is a need to study the chemical parameters, and its components that have insecticidal, ovicidal and repellency characteristics. This study was carried out to formulate a neem oil based pesticide, characterize its physic-chemical parameters and to analyze pesticidal components.

MATERIALS AND METHODS

Procurement of materials for oil formulation

Neem seeds (*A. indica)*, rind of cashew (*Anacardium occidentale* L.*)* and *Croton tiglium* L. seeds are the raw materials for the preparation of the oil pesticide. Neem oil was purchased from a nearby oil mill, neem seeds and cashew nuts with epicarp from the local market and the *C. tiglium* seeds from the local native Ayurvedic medical shop.

Preparation of materials for oil extraction

The cashew nuts and the *C. tiglium* seeds were sundried. The epicarp of the cashew nut was cut into small pieces after removing the nuts mechanically. The *C.tiglium* seeds were ground in an electric blender and the ground materials were stored in large plastic containers.

Extraction of oil by Soxhlet method

Exactly 50 g each of ground neem and *C. tiglium* seeds and grated cashew epicarp were weighed in a sensitive electronic balance and individually wrapped in white muslin cloth and tied with a twine. The packed materials were placed in a 1 lit Sohxlet extraction apparatus and the extraction was made at 60-80^{o}C with petroleum ether and acetonitrile solvents separately. After extraction of the oil, the solvent was recovered using a rotary vacuum evaporator (Model: PBV-7D).

Preparation of plant oils for GC-MS analysis

1.0 ml of neem oil and triple oil were measured out and both oils were individually diluted with 5 ml of both, petroleum ether and acetonitrile solvents and filled in 15 ml screw capped bottles and closed tightly. Croton oil (1 ml) and cashew oil (1 ml) were also diluted in 5 ml petroleum ether solvent individually and filled in screw capped bottles.

GCMS analysis of the oil extraction

The oil samples were individually examined using GCMS analysis using Shimadzu GC-MS-QP 5050 A GC equipment. Software Class 5000 was used. The library of structures was from the searched library: Wiley 229. The LIB Column used was DB 5 with 0.53 mm ID and standard timing of 30 m on a 1.5 μm film. The carrier gas was Helium with a flow rate 1 ml/min. The ionization mode was set at EL (70 ev). The temperature was programmed to be at 40°C (static for 2 min.) up to 250°C (static for 7.5 min.). Both the detection and injector temperatures were 250°C. Identification of chemical compounds of the oils was achieved by using library searched data base Wiley 229 LIB and by comparing their retention indices and mass fragmentation patterns with those of the available references and with published data. The percentage composition of components of the volatiles was determined by computerized peak area measurements.

RESULTS

The GC-MS analysis of neem oil *(A. indica)* extracted in petroleum ether recorded about 13 peaks. Peak 1 indicated the presence of n-cetyl thiocyanate with a retention time of 10.32 minutes. Pentadecane and Nonadecane were observed with retention timings of 10.32 and 12.98 min. respectively. Acridine, 9, 10-dihydro-9, 9-dimethyl was observed in the 7th peak with 22.06 min. retention time. At the retention time of 37.67 min., camphor was identified (Table 1.1 and Fig. 1.1). Approximately, 10 peaks were identified in the GC-MS analysis of neem oil *(A. indica)* extracted in Acetonitrile solvent. Glycerin, Methanamine and Benzenamine N-phenyl were observed in the first, second and fifth peaks with retention timings of 4.86 and 16.33 min. The retention timing of 18.62 min. in the seventh peak indicated the presence of cis-coniferryl alcohol. Acridine, 9, 10-dihydro-9, 9- dimethyl and 1, 2-Benzenedicarbarcylic acid and bis (2-ethylhexyl) ester were recorded in the ninth and tenth peaks with a retention time of 22.05 and 31.50 min. respectively (Table 1.2 and Fig. 1.2). The GC-MS analysis of cashew oil *(A. occidentale)* extracted in petroleum ether revealed the presence of Nerolidol and 8, 11, 14-Eicosatrienoic acid with retention timings of 14.79 and 20.73 min. Acetic acid, phenol, 3-pentadecyl, Niobium, dichloro, 1, 2-Ethanediol, 1, 2-diphenyl-, Benzene, 1-(1, 1-dimethyl ethoxy) -4- ethyl and 1H-Imidazole, 1-2(2-propenyl) were identified in the subsequent peaks (Table 2 and Fig. 2). The GC-MS analysis of *C. tiglium* revealed 9 possible compounds with different retention timings. The compounds observed were Benzenamine, N-phenyl, Tetradecanoic acid, Benzoic acid, 7, 10-Hexadecadienoic acid, 2, 6-Adamantanedoane, 4-iodo, Ricinoleic acid and 1, 2-Benzene dicarboxylic acid (Table 3 and Fig. 3). About 10 peaks were detected in the GC-MS pattern of triple oil prepared by Soxhlet extraction with Acetonitrile. Ethanol 2-amino- was recorded in the first peak with a retention time (RT) 4.81 min. Nerolidol isomer

and Farnesol had a retention time of 14.81 min. Other probable chemical compounds recorded were Ricinoleic acid, 9-octadecenoic acid, Silane, Phenol, 4-mehtyl, and 1, 2-Benzenedicarboxylic acid (Table 4 and Fig. 4). The compounds identified in the first and second peaks associated with the GCMS analysis of triple oil prepared by solvent extraction with petroleum ether were Benzeneamine, N-nitroso-N-phenyl and 12-Nor-Caryophyll-5-EN-2-ON with RT values of 16.34 and 22.58 min. In the third peak, Camphor was detected with a RT of 23.02 min. The chemical compounds like 12, Hydroxy-9-octadecenoic acid, 1, 2-Benzenedicarbarxylic acid and Ricinoleic acid were observed at different RT intervals (Table 5 and Fig. 5).

DISCUSSION

In the present study, the oil used as an efficient pesticide was extracted by solvent extraction method. The chemical parameters of a pesticide determine the quality and insecticidal activity of the pesticide. The stability of the botanical pesticides depends upon the physical characteristics of that particular pesticide. Certain chemical compounds present in plant seed oils accelerate the pesticidal properties. These compounds repel the insects, prevent egg laying, hinder the feeding habit of insects, propel the death of insects and kill the eggs. Every plant has its own insecticidal properties due to such chemical compounds. The GC-MS analysis reveals the chemicals compounds present in the oil samples. Sivropoulou *et al.* (1997) have identified germacrene-D (15.85 percent), β-caryophyllene (12.35 percent), α-humelene (9.31 percent) and germecrene (6.19 percent) as major constituents in the essential oils of leaves of *Lantana camara* L. in South China. Dua *et al.* (2010) identified caryophyllene (16.37 percent), eucalyptal (10.75 percent), α-humelene (8.22 percent) and germecrene as major constituents in *L. camara*. Eucalyptol is the main constituent (15.57 percent) of essential oil of eucalyptus, which exhibit pesticidal activity (Adhikari *et al.,* 1992). Some compounds observed in the present study were reported by other authors in earlier studies. Farnesol was identified in the pesticide (triple oil) which was also reported by Duke (1992) who stated that Farnesol and germacrene-D have pesticidal activity. Farnesol is a natural organic compound which is an acyclic sesquiterpene alcohol found as a colourless liquid. Farnesol is present in many essential oils such as citronella, nerali, cyclamen, lemongrass, tuberose, musk, balsam and tolu. Farnesol is a natural pesticide for mites and is a pheromone for several other insects. The GC-MS analysis of petroleum ether extract of *C. tiglium* seeds revealed the presence of Benzoic acid, Ricinoleic acid, Benzene dicarboxylic acid, 2,6-Adamantanedione, Tetradecanoic acid and hexadecadienoic acid. The same compounds were reported by Saputera *et al.* (2006) in the GC-MS analysis of *C. tiglium* seeds.

Falodun *et al.* (2009) identified fatty acid derivatives, sesquiterpenes, hydrocarbons, caryophyllene, Hexadecanoic acid and tetradecanoic acid as major components while studying chemical composition of the leaf essential of *Pyrenacantha staudtii* Hutch and Dalz. Benzoic acid, Hexadecanoic acid, Eicosanoic acid, Docosanoic acid and Glycerol were reported in the GC-MS analysis of *Paeonia peregrina* Mill., and *Paeonia tenuifolia* L. (Ivanova *et al.,* 2002). More or less similar compounds were also noticed in the present study. Vuorela *et al.* (2004) identified a number of important compounds in the root extracts of *Senna italica* Mill. subsp. *arachoides* and these naturally derived compounds play a major role as lead structures for the development of synthetic analogues. Magano *et al.* (2008) reported that chrysophanic acid (1, 8-dihydroxy-3-methylanthraquinone) and hexadecanoic acid have been previously identified in plant based material with arthropocidal activities. Members of the genus *Senna* with high levels of chrysophanic acid are known to have antifungal, anti-bacterial and anti-mite properties. Aromatic and amino acids play an important role in life of insects. Aromatic acids may serve as egg-hatching factors for mosquitoes (He and Huang, 2011) and as insecticides and repellents (Mittal and Subbarao, 2003). Benzoic acid is an aromatic acid which was obtained in the GC-MS analysis of present study. The GC-MS analysis of neem oil showed the presence of Benzenedicarboxylic acid. Hassan *et al.* (2010) identified two components as carboxylic compounds, Hexanedioic acid, mono (2-ethylhexyl) ester and 1, 2-Benzene-dicarboxylic acid, mono (2-ethylhexyl) ester with mass 147 and 279 in the root bark extract of *Detarium microcarpum* Guill and Perr. These compounds already have synthetic analogues and the Hexanedioic acid, mono (2-ethyl-hexyl) ester compound acts as an acaricide (a substance that kills mites and ticks) for use in orchards and also as an inert ingredient in pesticides among other uses. Benzenedicarboxylic acid acts as an insect repellent. The GC-MS analysis of neem oil extracted in petroleum ether showed the presence of

Pentadecane, Nonadecane, Tetracosane, Hexadecane, Octodecane, Hexacosane and Heptacosane. The same compounds were also reported by Siddiqui *et al.* (2002) in the GC-EIMS analysis of ethanolic extracts of fresh fruit coatings of *A. indica.* Imidazole was observed in the GC-MS analysis of *A. occidentale* oil. An imidazole derivative, KK-42 was considered as potent inhibitor of ecdysteroid biosynthesis of females of the meal worm, *Tenebrio molitor* (L.) (Amrani *et al.*, 2004). Pence (1965) reported that imidazole formulations were effective against a number of insects and related arthropods, including silver fish, cockroaches, termites, carabid beetles, bed bugs, fleas, flies, mosquitoes, ticks, spiders, phytophagous mites, fabric-feeding and stored-products insects. Camphor was identified as a compound in the petroleum ether extract of neem seed and the combined oil extract. E-Abd-El-Aziz *et al.* (2007) observed camphor in the GLC pattern of *Ocimum americanum* L. Eugenol caused 40 percent larval morality with 36.84 percent reduction in pupation. Camphor and gereniol were observed by Pande *et al.* (2010) in the gas chromatographic investigation of *Coriandrum sativum* L. Geranyl acetae, linalool, nerol and neral were the main components reported. Liu *et al.* (2010) reported the presence of camphor in the GC-MS analysis of *Artemisia mongolica* Fisch. ex Besser and stated that the plant has fumigant toxicity against *S. zeamais.* Nerolidol was observed in the GC-MS analysis of cashew oil and the pesticide (triple oil). Nerolidol, also known as peruviol, is a naturally occurring sesquiterpene found in the essential oils of many types of plants and flowers. The presence of nerolidol was reported by Tiwary *et al.* (2007) in the GC-MS analysis of *Zanthoxylum aramatum* (DC). Phenol, 3-pentadecyl was found in the GC-MS analysis of cashew oil extracted in petroleum ether. The same compound was also reported by Risfaheri *et al.* (2009) in HPLC analysis of cashew nut shell liquid. In earlier studies it was observed that phytochemicals have a major role in mosquito control programme (Palsson and Janeson, 1999). Gopieshkhanna and Kannabiran (2007) have reported that the carbohydrates, saponins, phytosterols, phenols, flavanoids and tannins in the plant extract show mosquito larvicidal activity.

CONCLUSIONS

Prolonged periods of chemical pesticide usage lead to pest resistance, health hazards and environmental pollution. Natural oil pesticide contains some pest control components. Neem oil had certain components which control pest activities. It prevents environmental hazards. The use of plants, plant materials or crude plant extracts (botanical insecticides) for the protection of crops and stored products from insect pests is probably as old as crop protection itself.

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Table 1.GC-MS characterization of neem oil (petroleum ether solvent)

SI. No.	Retention Time (RT)	Relative Strength Index (RSI)	Compound Name	MF	MW
1.	10.32	991	n-cetyl thiocyanate	$C_{17}H_3NS$	283
2.	10.32	990	Pentadecane	$C_{15}H_{32}$	212
3.	12.98	992	Nonadecane	$C_{19}H_{40}$	268
4.	12.98	977	2,6,10-trimethyl, tridecane	$C_{17}H_{34}$	226
5.	16.33	915	Benzenamine, N-phenyl	$C_{12}H_{11}N$	169
6.	21.31	968	2,4,5-Trimethoxy-3 ethylaniline	$C_{11}H_{17}NO_3$	211
7.	22.06	882	Acridine, 9,10-dihydro-9,9-dimethyl	$C_{15}H_{15}N$	209
8.	25.98	953	Hexadecanoic acid, butyl ester	$C_{12}H_{40}O_2$	312
9.	30.51	986	Tetracosane	$C_{24}H_{50}$	338
10.	31.51	980	Di-(2-ethylhexyl)phthalate	$C_{24}H_{38}O_4$	390
11.	31.51	995	1,2-Benzenedicarboxylic acid	$C_{24}H_{38}O_4$	390
12.	37.53	932	9-Octadecanoic acid	$C_{18}H_{34}O_2$	282
13.	37.67	952	Camphor (CAS)	$C_{10}H_{16}O$	152

Table 2.GC-MS characterization of neem oil (Acetonitrile)

I. No.	(RT)	RSI	Compound Name	MF	MW
1.	4.86	914	Glycerin	$C_3H_8O_3$	92
2.	4.86	893	Methananine, N-methoxy	C_2H_7NO	61
3.	10.10	861	Trans-pent-2-enoic acid	$C_5H_8O_2$	100
4.	11.52	850	4-methyl-5-methylthio-1,3,4 thiadiazolium-2-thiolate	$C_4H_6N_2S_2$	178
5.	16.33	982	Benzenamine, N-phenyl	$C_{12}H_{11}N$	169
6.	18.62	952	4-[(IE)-3-Hydroxy-1-propenyl]-2-methoxy phenol	$C_{10}H_{12}O_3$	180
7.	18.62	948	cis-coniferryl alcohol	$C_{10}H_{12}O_3$	180
8.	22.05	919	9-Acridinamine	$C_{13}H_{10}N_2$	194
9.	22.05	865	Acridine, 9,10-dihydro-9,9-dimethyl	$C1_5H_{15}N$	209
10.	31.50	997	1,2-Benzenedicarboxylic acid, bis (2-ethylhexyl)	$C_{24}H_{38}O_4$	390

Table 3. GC-MS characterisation of cashew oil (petroleum ether)

SI. No.	(RT)	RSI	Compound Name	MF	MW
1.	14.79	932	Nerolidol	$C_{15}H_{26}O$	222
2.	20.73	928	8,11,14-Eicosatrienoic	$C_{20}H_{34}O_2$	306
3.	21.45	962	Hexadecanoic acid	$C_{17}H_{34}O_2$	270
4.	24.54	947	9-Ocatdecenoic acid	$C_{19}H_{36}O_2$	296
5.	27.83	955	Acetic acid, 3-methyl phenyl ester	$C_9H_{10}O_2$	150
6.	27.83	912	Phenol, 3-pentadecyl	$C_{21}H_{36}O$	304
7.	28.91	982	1-Butanol, 4-butoxy	$C_8H_{18}O_2$	146
8.	31.48	947	1,2-Ethanediol	$C_{14}H_{14}O_2$	214
9.	31.48	924	Niobium,dichloro	$C_{15}H_{23}Cl_2N_6$	108

10.	35.25	909	1H-Imidazole, 1-(2-propenyl)	$C_6H_8N_2$	366
11.	35.59	851	Benzene, 1-(1,1-dimethylethoxy) -4-methyl	$C_{11}H_{16}O$	164

Table 4. GC-MS characterisation of *Croton tiglium* oil (petroleum ether)

SI.No	(RT)	RSI	Compound Name	MF	MW
1.	16.34	936	3-(1,3-buta-dienel)-indole	$C_{12}H_{11}N$	169
2.	16.34	930	Benzenamine, N-phenyl	$C_{12}H_{11}N$	169
3.	16.34	974	Benzenamine, N-nitroso, N-phenyl	$C_{12}H_{10}N_2O$	198
4.	19.57	918	Tetradecanoic acid	$C_{14}H_{28}O_2$	228
5.	22.56	965	2, 4-Dihydroxy-6-[8′(z)-pentadecenyl]benzoic acid	$C_{22}H_{34}O_2$	362
6.	24.50	928	7,10-Hexadecadienoic acid	$C_{17}H_{30}O_2$	266
7.	24.78	910	2,6-Adamantanedione, 4-iodo	$C_{10}H_{11}IO_2$	290
8.	26.80	977	Ricinoleic acid	$C_{18}H_{34}O_3$	298
9.	31.63	996	1,2-Benzenedicarboxylic acid	$C_{24}H_{38}O_4$	390

Table 5. GC-MS characterization of triple oil (Acetonitrile)

SI. No	(RT)	RSI	Compound Name	MF	MW
1.	4.81	916	Ethanol,2-amino-(CAS)	C_2H_7NO	61
2.	14.81	988	NEROLIDOL ISOMER	$C_{15}H_{26}O$	222
3.	14.81	939	Farnesol	$C_{15}H_{26}O$	222
4.	16.34	926	Benzenamine, N-phenyl	$C_{12}H_{11}N$	169
5.	21.46	985	Ricinoleic acid	$C_{18}H_{34}O_3$	298
6.	27.84	987	(R,Z)-12-Hydroxy-9-Octadecenoic acid	$C_{18}H_{34}O_3$	298
7.	30.91	831	Silane, phenyl (CAS)	C_6H_8Si	108
8.	30.91	809	Phenol, 4-,methyl –(CAS)	C_7H_8O	108
9.	31.53	988	1,2-Benzenedicarboxylic acid, bis(2-ethylexyl) ester	$C_{24}H_{38}O_4$	390
10.	35.48	982	(R,Z)-12-Hydroxy-9-Octadecenoic acid	$C_{18}H_{34}O_3$	298

Table 6.GC-MS characterization of triple oil (petroleum ether)

SI. No	(RT)	RSI	Compound Name	MF	MW
1.	16.34	968	Benzenamine, N-nitroso, N-phenyl (CAS)	$C_{12}H_{10}N_2O$	198
2.	22.58	931	12-NOR-CARYOPHYLL-5-EN-2-ON	$C_{14}H_{22}O$	206
3.	23.02	949	Camphor (CAS)	$C_{10}H_{16}O$	152
4.	24.53	984	(RZ)-12, Hydroxy-9-Octa-decenoic acid	$C_{18}H_{34}O_3$	298
5.	30.79	939	(E,E)-6-(Dimethyl-amino)-3-methyl-3,5-hecadien-2-one	$C_9H_{15}NO$	153
6.	31.50	996	1,2-Benzenedicarboxylic acid	$C_{24}H_{38}O_4$	390
7.	34.85	989	Ricinoleic acid	$C_{18}H_{34}O_3$	298
8.	34.85	966	2,5-dipropylcyclo-heptanol	$C_{13}H_{26}O$	198

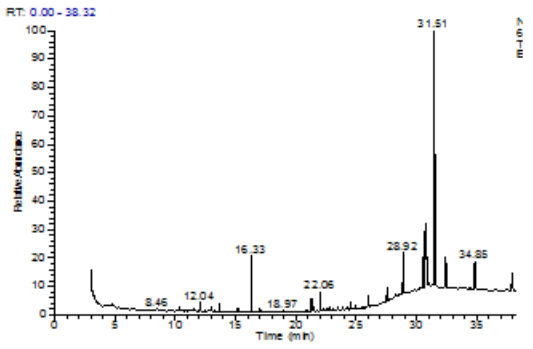


Figure 1. Gas chromatogram of *A. indica* oil extracted in petroleum ether

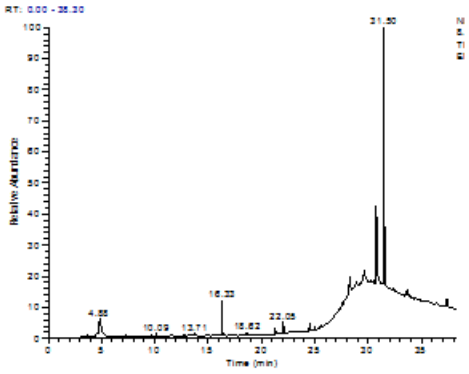


Figure 2. Gas chromatogram of *A. indica* oil extracted in acetonitrile

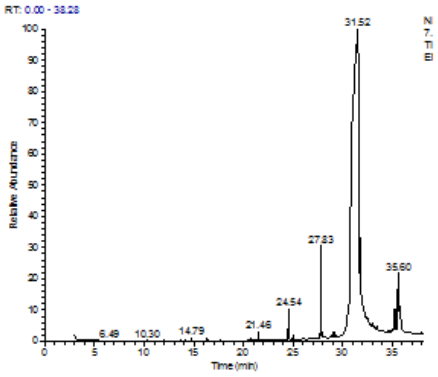


Figure 3. Gas chromatogram of *A. occidentale* oil extracted in petroleum ether

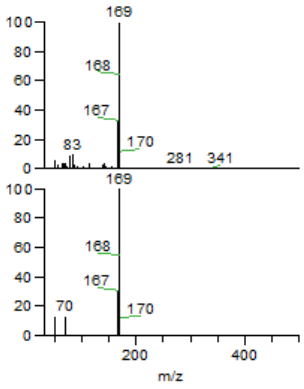


Figure 4. Mass spectrum of Benzeneamine, N-nitoso-N-phenyl of *C. tiglium* oil extracted in petroleum ether

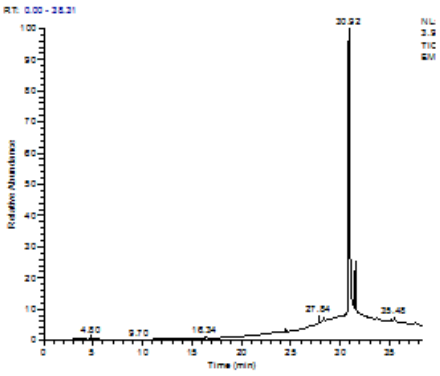


Figure 5. Gas chromatogram of triple oil extracted in acetonitrile

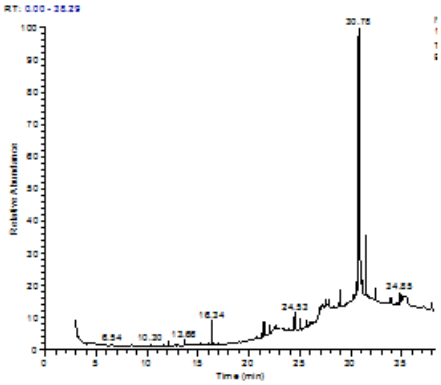


Figure 6.Gas chromatogram of triple oil extracted in petroleum ether

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RESEARCH ARTICLE

Bioactive Peptide α-Lactalbumin as a Breast Milk Supplement

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ABSTRACT

α-lactalbumin is a 14.2 kDa whey protein found in milk and is used as an important ingredient in infant formulas. It is involved in lactose synthesis and thus creates an osmotic "pressure" that helps in milk production. It has a high content of all essential and branched chain amino acids, especially tryptophan and leucine. Adding bovine α-lactalbumin to infant formula is recommended because it alters the infant's plasma amino acid pattern, similar to that of breastfed infants. α-lactalbumin has been shown to alleviate feeding-related gastrointestinal problems like regurgitation, abdominal discomfort and constipation in breastfed new-borns. Being rich in tryptophan, it serves as an ideal protein for infant formulas and confers several benefits to the neonate including enhanced immunity, prebiotic activity and higher absorption of trace elements. Recently, it was found that multimeric α-lactalbumin possesses a unique folding form known as the "molten globule state" that exhibits anti-inflammatory activity and increases apoptosis, possibly affecting mucosal cell renewal and proliferation.

Keywords: α-lactalbumin, bioactive peptide, infant formula, milk supplement, infant health

INTRODUCTION

In human milk, α-lacalbumin (α-LA) accounts for 28% of its overall protein content, but in cow's milk, it makes up only 3%. Human and bovine α-LA proteins are quite similar, with 73.9% of their amino acid sequences being identical. The length of both α-LA variants is 123 amino acids. There is a deep split between the two domains. Concurrently, the cysteine bridge connecting residues 73 and 91 holds the two domains together and forms the Ca^{2+} binding loop. Additionally, 61-77 forms a significant disulfide bridge that joins the two domains. Overall, four disulfide bridges stabilise the α-LA structure. Since α-LA contains a high concentration of essential amino acids, it can be used in low-protein new-born formulae. Lowering formulas' protein content has been recommended as a preventive measure to minimize children's possibility of overweight and obesity, while further study is required on the long-term impact on body composition. α-LA can be added to baby formula to lower its total protein level and make it more similar to human milk with regard to of protein composition and concentration. α-LA can be added to new born formula to lower its total protein level and resemble it to breast milk in terms of protein concentration and consumption. It has also been demonstrated that the α-LA enriched low-protein formula increases the energy efficiency. Rosie, the first transgenic cow, was created in 1997. It comprises the gene for human α-LA. One litre of milk contained 2.4 grams of human α-LA.

Properties of α-lactalbumin

Native α-LA is structured with two main domains: a large α-helical domain and a smaller β-sheet domain, linked together by a calcium-binding loop (Fig.1). The α-helical domain includes three prominent α-helices (spanning residues 5-11, 23-24, and 86-98) and two brief 310 helices (residues 18-20 and 115-118). The β-sheet domain features a series of loops, a small three-stranded anti-parallel β-pleated sheet (comprising residues 41-44, 47-50, and 55-56), and a short 310 helix (with three residues per turn and an intra-chain hydrogen bond loop of 10 atoms; residues 77-80).

Physical properties

The well-known structure of α-LA is made up of four disulfide bridges and 123 amino acids. The isoelectric point lies between 4.2 and 4.5, and the molecular weight is 14178 Da. The two main types of α-LA are apo-state and holo-state. The first form is called the holo-state, and it is bound and folded by calcium. The apo-state, which occurs in acidic locations is associated with the unfolding of the β-sheet and the release of calcium ions.

Physiological properties

Upon α-LA's attachment to galactosyltransferase, galactose can be converted to N-acetyl glucosamine, and lactose can then be synthesized from glucose and uridyldiphosphate-galactose. (Fig.1) Galactosyltransferase can also facilitate synthesis of other disaccharides, but with α-LA as a regulatory unit, only lactose is being produced.[4]

Anticancer properties

Human α-LA that has been rendered lethal to tumour cells (HAMLET) is a very powerful apoptosis inducer. HAMLET has also been shown to have anticancer cytolytic action against a variety of human malignancies. Similar properties are seen to be exhibited by bovine α- LA (BAMLET).

Antimicrobial properties

α-LA interacts with lysozyme at the physiological pH found in human and bovine milk. This interaction enhances the antimicrobial effectiveness of the complex, making it more effective against both Gram-positive and Gram-negative bacteria.

Antiviral properties

Antiviral peptides have been discovered from α-Lactalbumin (α-La). By using proteolytic enzymes like trypsin (EC 3.4.21.4), chymotrypsin (EC 3.4.21.1), and pepsin, several peptide fragments with antiherpetic properties were isolated from α-LA. The development of the infant gut is influenced by various factors, including the nutrients and

biologically active compounds present in milk. α-LA is thought to have a beneficial effect on gut development and immune health by releasing bioactive peptides in the small intestine. The small intestine breaks down α-LA and absorbs amino acids as individual molecules and tiny peptides. Breastfed infants' stools have no intact α-LA. Breastfeed infant's microbiomes are mediated by lactobacillus and, in particular, a variety of bifidobacterium species, whereas formula fed infant's microbiomes are more akin to adult makeup. It has been demonstrated that supplementing infant formulas with extra α-Lac has enhancing probiotic effects on the microbiota by encouraging the growth of specific bacterial species, namely *Bifidobacteriuminfantis* and *Bifidobacteriumbreve*, in a way that is comparable to breast milk. α-LA is readily available to infants, where it is broken down and absorbed. The resulting oligopeptides and amino acids have been demonstrated to enhance essential immune processes, including macrophage phagocytosis and the proliferation of Bifidobacteria. Prebiotic benefits of peptides from the digestion of the amino acid lactic acid. For example, three bioactive peptides from the peptide lactic acid are anti-microbial. Some peptides released from the digestion of α-LA have been shown to have anti-cancer, anti-bacterial, anti-hypertensive, anti-immunomodulatory, anti-opioid, mineral-binding and anti-oxidant effects. (Fig. 2) Additionally, it has been demonstrated that a few of the peptides produced by the hydrolysis of herpes simplex and HIV-1 virus by trypsin, chymotrypsin and pepsin may have particular antiviral properties. The gut microbiome plays a significant role in the long-term survival, growth, and development of premature newborns, according to recent studies. Similar to the benefits of breast-milk, suitable milk proteins may diversify the gut flora. By carrying out this, patients with NEC and/or sepsis would be less lightly to experience dysbiosis. Therefore, it has been proposed by researchers that creating infant formula with higher β-lactalbumin and lower β-lactoglobulin levels would produce an amino acid composition more akin to human milk and a plasma amino acid profile more like to breastfed infants. But by itself, cow's milk protein isn't a good source of nutrition for newborns. It can't be used as the only source of whey protein since, while having high concentrations of tryptophan and cysteine, it has incredibly low quantities of arginine. It is possible to more accurately match infant's amino acid requirements with carefully balanced combinations of regular bovine casein fractions and α-LA rich whey fractions, that are now economically accessible. As for comfort formulas, formula's enriched with α-LA has shown to be better adopted and endured by infants than regular formula.

α-lactalbumin and absorption of trace elements

Nearly all of the minerals and trace elements that are known to be necessary for human health are found in milk. These are frequently found in forms that the body can readily absorb and use, such as calcium and zinc, due to their high bioavailability. Trace amounts of metals, including Zn, Fe and Mg, can be bound by α-LA and then released throughout the gastrointestinal tract's absorbing mechanism. This is particularly crucial for the provision of micronutrients during an infant's feeding. Research on the production and characterization of this sort of interaction and such as the protein micronutrient Zn, is therefore essential from a scientific and industrial aspect. Zn is among the elements that are recognized as trans-metals. The molecular weight of Zn which is 65.38 units is the result of the combination of five isotopes: 64,66,67,68 and 70 amu. Given its chemical properties, it exhibits a dual valence state and acts as a reducing agent in biological fluids. In solution, the zinc ion becomes hydrated, leading to the formation of coordination complexes. One of the most significant micronutrient is Zinc ion, which is usually coordinated by six water molecules. It is necessary for preserving homeostasis, the immune system's efficient activity and growth, but taking too many supplements might have detrimental effects that are comparable to the body's inability to absorb certain elements. It is a catalytic component of many biological events and a cofactor of numerous enzymes. Therefore, consuming protein-Zn complexes can encourage an individual's healthy growth. Zn interacts with histidine, glutamic and aspartic acid, and other amino acid moieties to form complexes with α-LA. The protein surface has two types of binding sites. The first set is associated with a bond of approximately 104 to 105, while the second set corresponds to a bond around 103. In proportion to the molar ratio of zinc to protein, metal binds to protein progressively. In contrast to the standard protein form, the Zn-protein complex exhibits lower temperature stability, which increases it's susceptibility to proteolytic enzyme digestion and causes aggregation. The bovine α-LA composition and its constituent with Zn have been studied using circular dichroism and NMR. Only minor local structural alteration rather than significant structural alterations were caused by Zn's binding to the holo form. Using the Fourier Transform Infrared Spectroscopy (FT-IR) technique, single and relatively small structural modifications of the protein in the form of apo and holo resulting from binding with Zn were observed. During an infant's rapid

growth, an adequate amount of trace minerals, such as iron and zinc, is crucial. To make up for their decreased bioavailability, infant formulae frequently include trace mineral amounts that are higher than those in human milk. α-LA contains two calcium binding sites, one of which could be taken up by Fe or Zn. Research on young rhesus monkeys and humans suggest that α-LA could boost the absorption of Zn but not Fe. The presence of metal ions at α-LA's metal binding sites mostly affects its physical properties. α-LA is molten and globule-like when associated metal ions are absent. Zn^{2+} binding to the Ca^{2+} loaded protein reduces its stability and leads to aggregation, however metal ion binding, particularly Ca^{2+} binding, increases the stability of α-LA against heat,different denaturing agents and proteases. Additionally, α-La supports the growth of beneficial microorganisms like bifidobacteria, which lowers the gut pH and potentially improves mineral absorption. Most clinical studies on α-LA-enriched infant formulas have focused on evaluating the infants' growth, formula acceptance, and plasma amino acid levels following consumption.

α- lactalbumin and infant's immune response

Human milk contains α-LA in significant amounts (20–28% of total protein), suggesting its potential use in baby formulae. Giving formula enhanced with α-LA to babies has been shown to have positive impacts on the immune system and gut microbiota. By promoting the activity of cells involved in the immune response, α – LA aids in proper functioning of immune system. Additionally, they have antioxidant properties that protect cells from any damage.S everal studies carried out in 1980s showed that α-LA enhanced mice's immune system. It is unexpected to find no evidence of the immune-modulatory effects of α-LA in spite of these researches. The presence of an unknown peptide in hydrolysed α-LA has been shown to have impacts on both T- and B- lymphocyte activity from α-LA, an immune-modulatory tri-peptide, appears to work by attaching to the particular GLF receptors on human monocytes and macrophages to promote their adhesion and phagocytosis. Additionally a study using a different peptide (Try-Gly-Gly) from α-LA showed that this peptide stimulated human peripheral blood cells. α-domain - blue and β-domain - green. Tryptophan residues - blue and disulfide bridges - yellow. Residues involved in coordinating Zn^{2+} ions - red.(Eugene A. Permyakov , Lawrence J. Berliner, 2000).

α-lactalbumin and infant's brain development

Cysteine, an amino acid required to synthesis glutathione, is abundant in α- LA.[23] Strong antioxidant glutathione contributes to increased immunity. α- LA creates a strong complex that is harmless to normal cells but exhibits specific anti-tumour activity against malignant neoplastic cells, such as Caco-2, HepG-2, PC-3, and MCF-7 tumour cells. For an infant's growth and development, primarily the development of its brain, sleep is fundamental. Both melatonin and serotonin are recognized as important sleep regulators during life; however, since serotonin cannot pass the blood-brain barrier, it needs to be produced inside the brain. Tryptophan is a crucial amino acid in the synthesis of serotonin since it is a precursor to serotonin and can penetrate the blood-brain barrier. Tryptophan is usually seen as one of the most important limiting amino acids in proteins taken in our diet, and its plasma concentrations are used to assess protein quality in formulas given to babies. It is a key precursor for serotonin which performs diverse C.N.S functions including hunger control, sleep regulation, memory formation, learning process among others temperature regulation and moods and behaviour as well as the development of neural and synaptic connections. By lowering the total amount of proteins found in infant formula and increasing the proportion of α-LA, brain serotonin activity increases, cortisol level decrease and mood is enhanced among people who are susceptible to changes. Additionally this alteration enhances tryptophan plasma levels relative to those of other major neutral amino acids. Apart from its impact on the sleep-walk cycle and CNS, serotonin has also been found to be crucial forb gut motility and immunological function. Meanwhile, tryptophan plays regulatory roles in the gut.

Side effects of α-lactalbumin

A diet that is high in α-LA raises the ratio of tryptophan compared to other neutral amino acids, which could subsequently boost serotonin levels in the brain and cause complications. It can cause nausea, vomiting and abdominal pain. It can interact with certain medications, such as blood thinners and cause allergic reaction in some people. Additionally, it can increase the risk of the kidney stones and causes an imbalance in electrolytes. Therefore, the concentration of α-LA in infant milk formulas should be optimal so as to avoid any of these complications.

Bovine α-LA is a significant food allergen present in milk, notable for its stability due to its four disulfide bonds and calcium-binding properties. Incorporating bovine α-LA into infant formula has been suggested as a way to alter the plasma amino acid profile in infants. This modification might enable a reduction in the formula's overall protein content, potentially impacting growth.

CONCLUSION

Specific proteins included in infant formula, such as α-LA, which contains necessary amino acids, may enhance growth, immunological responses, and intestinal health in addition to improving the absorption of vital trace elements like Fe and Zn. α- LA has been linked to improved mineral binding, immune system modulation, apoptosis and suppression of tumours and altered gut microbiota in infants by fostering bifidobacteria and stifling the growth of possible pathogens, according via *in vitro* research and clinical trials. These benefits would be similar to those breast milk provides for formula-fed infants. An increasing body of research indicates that health, cognition, and the development of the brain and other organs depend on the bilateral interaction that occurs within the microbiota-gut-brain axis. Subsequent investigations must evaluate the precise impacts of α-LA on immune response, gut microbiota, and trace element levels and the accurate amounts of α-LA that has to be included in an infant formula. It is said that breastfeeding is the best option for a infant's growth and development. If this isn't feasible, complex mixtures - like ones that contain: α-LA offers a useful alternative.

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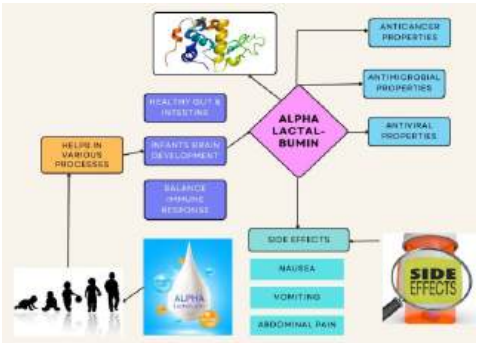


Fig 1

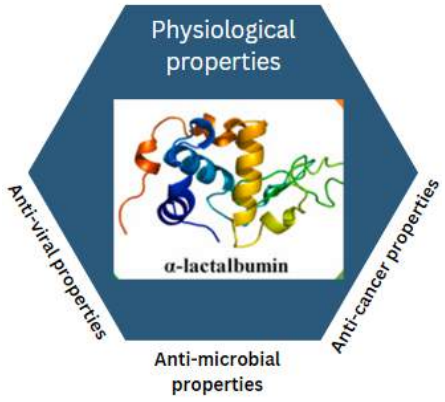


Fig 2: Physiological properties of α-LA

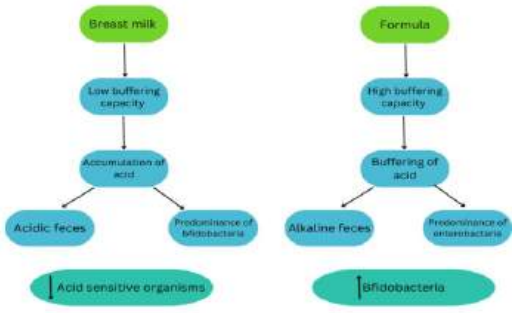


Fig 3: Physiochemical patterns of fecal floras
(Wolfram M. Brück, 2017)

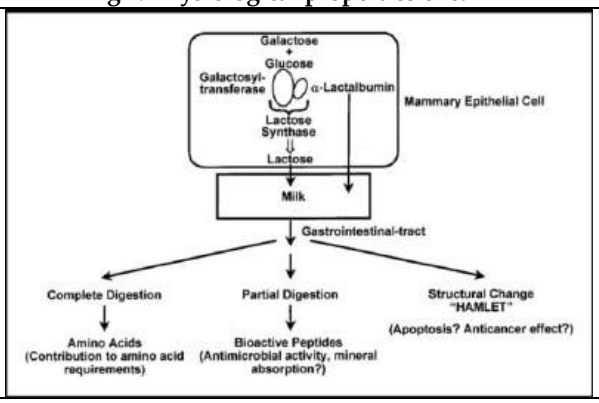


Fig.4: Digestion of α- LA and it's affects (Bo Lönnerdal and Eric L. Lien, 2008).

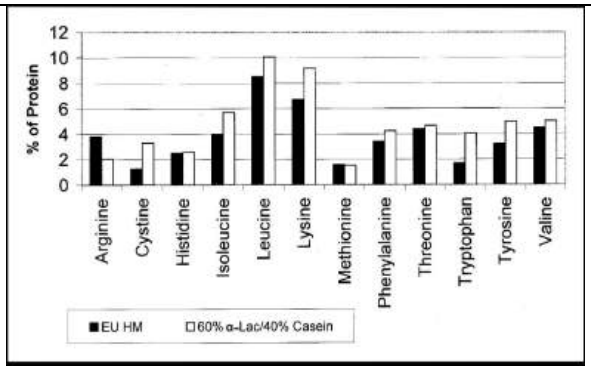


Fig.5: Amino acid composition of whey-predominant formula with bovine α-LA(Bo Lönnerdal and Eric L. Lien, 2008).

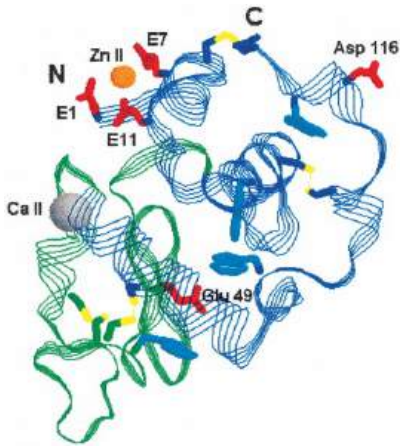


Fig 6: The X-ray structure of α-LA from native buffalo is depicted:α-domain - blue and β-domain - green. Tryptophan residues - blue and disulfide bridges - yellow. Residues involved in coordinating Zn^{2+} ions - red.(Eugene A. Permyakov , Lawrence J. Berliner, 2000).

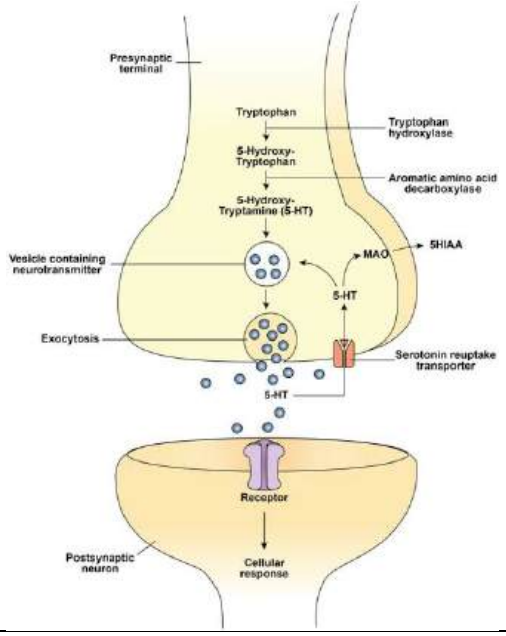


Fig 7: Synthesis of serotonin and its function in the neuron(Donald Layman, Bo Lönnerdal and John D Fernstrom, 2018).

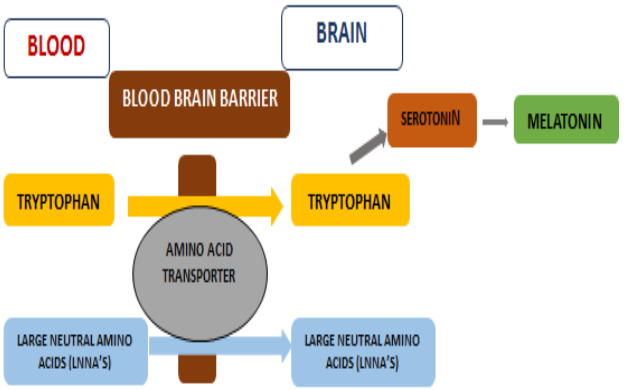


Fig.8.Transport of TRP across blood-barrier and subsequent serotonin synthesis. (Posted by Research and development)

RESEARCH ARTICLE

Antimicrobial Activity of *Actinomycetes* Isolated from Mangrove Rhizosphere Soil in Vellar Estuary

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ABSTRACT

Marine actinomycetes are commonly used to manufacture new medicinal compounds due to their enormous diversity, however, this is currently under investigation. In this study, we identified five marine actinomycetes from the mangrove rhizosphere soil of the Vellar estuary in Cuddalore, Tamil Nadu, India(VM 01, VM 02, VM 03, VM 04,). The isolates' morphological and physiochemical characteristics were identified. Streptococcus sp., Staphylococcussp., Escherichia coli, Klebsiella sp., were used as test organisms for primary screening for antimicrobial activity. All the isolates VM04, VM02, VM 03, and VM01were found to have antimicrobial activity with maximal zones of inhibition of 7mm, 6mm, and 8mm, 9mm for E.coli, and the four isolates were not shown less zone of inhibition against targeted pathogens. Among the four isolates, VM04 showed the highest zone of inhibition against pathogens. The outcome of these findings may be crucial for future investigations towards the invention of wide-ranging antibiotics for therapeutic applications.

Keywords: *Actinomycetes*, Biochemical characteristics, antimicrobial activity

INTRODUCTION

Mangroves, which grow in intertidal zones along tropical and subtropical coasts, are one of the world's most abundant ecosystems. The mangrove environment provides a rich supply of unique plants, bacteria, algae, and animals for the creation of biologically active compounds [[1]]. According to [[2]], the environments are defined by sandy or muddy soil with high salinity, a rather wide range, a high average temperature, and strong winds, mangrove soils create significant environments for the development of various microorganisms. The most prevalent microorganisms in mangroves are bacteria and fungi, which support the productivity of ecosystems by engaging them in important nutrient cycles [[3]]. Additionally, such bacteria can create bioactive metabolites that may be used for both industrial and therapeutic applications. Mangrove soil isolated fungi have been shown to generate medicinal substances including antimicrobials antiviral, antioxidants, and anticancer as well as industrial enzymes like lipase, cellulase, protease, and pectinase [[4]]. Actinomycetes are one of the major bacterial species that produce bioactive chemicals in mangrove soils. According to [[5]], actinomycetes are filamentous Gram-positive bacteria with morphology resembling fungi, a large genome of more than 8 Mbp, high G+C content, and biosynthetic gene clusters relevant to the production of secondary compounds. Actinomycetes that have been identified from mangrove sediments and soils have the potential to produce antibiotics, anticancer drugs, and antioxidants. Actinomycetes are known to be the primary manufacturers of antibiotics. Actinomycetes manufacture more than 80% of the antibiotics that are now in use, including tetracycline, macrolide, chloramphenicol, nucleosides, and polyenes [[6], [7], [8]]. Streptomyces species in particular are known to be the largest producers of antibiotics among them [[9]].In the current investigation, soil samples from the mangrove rhizosphere, which were obtained from several areas of the cellar estuary, were isolated and screened for actinomycetes that produce antimicrobials. Toanalyze and report the distribution of the antimicrobial activity of microorganisms gathered from sample locations, the present investigation is important.

MATERIALS AND METHODS

Sample collection

Using the purposive sampling technique, soil samples were taken from the Vellar estuary Mangrove, Parangipettai, and Cuddalore district at two separate places. Location I consisted of 10 sample points, while Location II consisted of 8 sample points. We collected 100 g of dirt from each sampling location. Using a soil boring, samples were obtained from 0 to 15 cm deep [[10]], and they were then placed in sterile plastic bags. The obtained sample was examined for physicochemical characteristics, such as soil pH (4–6.4), salinity (0–15%), temperature (27–28°C), humidity (70–82%), and temperature (27–28°C) [[11]].

soil sample preparation

For a week, soil samples were heated and dried to get rid of any undesired Gram-negative bacteria. samples that have been baked in an oven for 30 minutes at 65°C after being air-dried at ambient temperature, placed in an aluminum cup, then heated for another 30 minutes [[12], [13]].

Isolation of Actinomycetes

The soil samples were inoculated into Starch Casein Agar (SCA) medium supplemented with 0.1% chloramphenicol and 0.1% griseofulvin using the pour plate technique [[14]]. The soil samples were suspended in sterile distilled water (1:9 w/v). After that, the samples were kept at 27°C for 1-4 weeks [[12]].

Characterization and identification

The actinomycetes were identified using macroscopic and microscopic examinations, as well as physiological tests, as recommended by Bergey's Manual of Systematic Bacteriology, 2nd Edition, Vol 5, Actinomycetes, Part A.Macroscopic Characterization. Aerial mycelium, submerged mycelium, color, and diffusible pigments were all

detected in isolated actinomycetes. Microscopic inspection was carried out using a cover slip and the Gram-staining technique. The solidified starch casein agar medium plate had a sterile cover slip put into it at a 45° angle to the agar surface. Along the medium's surface where it meets the surface of the submerged cover slip, an actinomycete isolate was injected. For four days, it was incubated at 28 °C. Using sterile forceps, the cover slip was removed and put on a unique, clean glass slide, where it was then viewed using an oil immersion objective. [[15]].For each isolate, a loopful of a pure culture colony that had been incubating for about 7 days was placed in starch-casein broth and incubated at 28°C for 4 days. The culture suspension was employed for various protein consumption tests, catalase, and oxidase tests, and sugar utilization tests after the emergence of turbidity.

Antimicrobial activity test

Four actinomycetes isolates were chosen for antibacterial activity testing. The isolates were cultured for one week at 32°C in Nutrient Broth (NB medium). Crude antimicrobial compounds (CACs) were extracted from supernatants by centrifugation at 6000 rpm for 10 minutes. The disc diffusion technique was used to conduct an antibacterial test against *Staphylococcus aureus, Escherichia coli, Klebsiella sp.,* and*streptococcus sp.,*

RESULTS

Sampling sites

The Mangrove Centre Vellar estuary have *Rhizophora* and *Avicennia* species dominate the vegetation. Soil samples were taken from locations I (105 m from the sea) and II (40 m from the sea) for this investigation. (Table 1) shows the soil qualities that were sampled. Locations I and II were split into I-A and II-A, which have pH ranges of 5 to 6, and I-B and II-B, which have pH ranges of 4 to 8, which are relatively acidic.

Isolation of actinomycetes from mangrove Rhizosphere soil

There were four isolates of actinomycetes found at the sample site of location I, whereas none were found at location II (Table 2). It was discovered specifically by the VM02 isolate that actinomycetes could flourish in acidic soil. The four isolates differ in a variety of macroscopic and microscopic ways (Table 3). Figure 2 depicts the isolates' colony morphology, and Figure 3 displays the Gram-staining results. Different colony morphological characteristics may be seen in four isolates of actinomycetes (Table 3). Actinomycetes colonies often have microscopic features such as being tiny, dry, wrinkled, fibroma-like, or velvety on the surface. The VM04 isolate in this investigation was dry, the VM 03 isolate had a fibrotic surface, the VM02 isolate had a minor wrinkle, the VM 01 isolate had a smooth surface, and the VM 01 isolate also had a silky texture. Furthermore, VM 02 had grey aerial mycelium, VM 04 had white aerial mycelium, VM 01 had white aerial mycelium with filaments, and VM 03 had yellow aerial mycelium with scraper edges.

Screening of antimicrobial activity

Actinomycetes isolated from Vellar estuary mangrove soil may inhibit the development of *E. coli*, *streptococcus sp.,staphylococcus sp.,* and *klebseilla sp.*(Table 4). It might be related to the isolates' capacity to limit the development of Gram-negative and gram-positive bacteria. The VM04 isolate has the highest inhibition zone against *E. coli* (9 mm), whereas the VM 02 isolate has the smallest (6mm). The size of the clear zone in the initial screening test findings suggested that VM 04 had the greatest inhibitory zone. Inhibitory zone was compared positive control P1 – Streptomycin, P2- Ampicillin (Figure 3). The VM01 produce highest zone of inhibition 7mm, 4mm, 2mm,2mm against *E.coli, streptococcus sp., staphylococcus sp., and klebsiella sp.,* VM02 produces lowest zone of inhibition 3mm against *klebsiellasp.,and* VM04 Produce highest zone of inhibition 5mm against klebseilla .

Identification of the isolate with the greatest antibacterial activity

The VM 04 isolate had the largest inhibitory zone against all the pathogens and it shows it was studied further to discover its genus. Table 5 shows the results of the biochemical analysis of the VM 04 isolate. VM04 is a Gram-

positive with a grey aerial mycelium and a spiral-shaped spore chain that produces catalase. The VM04 isolate shared 92.8% of its physiological features with the Streptomyces genus [[16]].

DISCUSSION

The diversity of actinomycetes is significantly influenced by the physical and chemical properties of soil [[17]]. Actinomycetes are a source of bioactive compounds with antibacterial, antifungal, antiviral, and antiparasitic action, according to empirical evidence [[17]].According to [[18]], several actinomycetes that generate antimicrobial chemicals are aerobic chemoorganotrophic, contain oxidative metabolites, and draw energy from a variety of carbon sources. Actinomycetes may grow at their best at temperatures between 28 and 32 °C. Actinomycetes grow best at temperatures between 28 and 32 °C, according to [[19]].According to [[20]], actinomycetes may grow in the pH range of 4-5 and thrive in 6.5-8.0. The actinomycetes used in this investigation were found in soil that had a pH of 4. Location I, which had a pH of 4-6 and a salinity of 2%–15%, was able to effectively isolate four actinomycetes. At site II, which had 0% salinity and the same pH, there were no actinomycetes. It shows that actinomycetes' development is not solely influenced by pH. Environmental variables such as temperature, pH, salinity, dissolved oxygen, dissolved nitrate, dissolved nitrite, dissolved phosphate, and dissolved ammonia all had an impact on the density of actinomycetes. Environmental factors can potentially reduce the variety of actinomycetes in a given area. The existence and distribution of actinomycetes' habitat are influenced by the physical and chemical characteristics of the soil [[21]]. The majority of actinomycetes are found in wet and coastal soil. It is because actinomycetes may grow and reproduce under certain environmental circumstances. In biological applications including antibacterial, anticancer, antifungal, and enzyme makers, marine actinomyces play a significant part [[21]]. Actinomycetes cannot develop in several environmental circumstances, including excessive salinity, acidic environments, and extremely high temperatures. However, certain actinomycetes have been discovered in coastal soils, which may provide the proper environment and nutrients for their development. Under ideal climatic conditions, actinomycetes generate the best antibiotics [[8], [17]]. However, the salinities from both locations were not too high in this investigation, although just a few isolates were collected. Site I yielded four isolates (VM 01, VM 02, VM03, and VM04), but site II yielded none of the actinomycetes isolates. The soil at position II had an unpleasant odor and a light brown color that may make actinomycetes undesirable.In a prior investigation, [[22]] discovered 10 isolates of actinomycetes strains in mangrove sediments in Egypt's Red Sea. In addition, thirty actinomycetes have been isolated from Antarctica [[23]].

In comparison, [[24]] identified actinomycetes from Nipah worm pelleted feces and the digestive tract. It demonstrates that actinomycetes may be isolated from a variety of habitats as long as the environment fits the nutritional demands of actinomycetes [[24]].Actinomycetes isolated from the vellar estuary's mangrove rhizosphere soil, Parangipettai, belonging to the *Streptomyces and Saccharopolyspora spp.* genera (Table 3) inhibited the development of *E. coli , S. aureus or K. pneumoniae, staphylococcus sp.,.* Previous research has shown that actinomycetes can limit the development of *Bacillus, Staphylococcus, E. coli, Klebsiella, and Pseudomonas* [[25]]. Streptomyces is one of the Actinomycetes genera that generates the most antibiotics. Streptomyces antibiotics are often streptomycin generated by *S.griceus,* which can inhibit most Gram-negative bacteria. *Streptomyces spp.* generates spectinomycin, which inhibits Mycobacterium TB growth. *S. fradiae* generates broad-spectrum antibiotics such as neomycin. *S. aurefaciens* produces tetracycline, which inhibits Gram-positive and Gram-negative bacteria with a broad range, including Rickettsia's. Gram-negative bacteria are inhibited by erythromycin, which is generated by S. erythroid. S. Venezuela chloramphenicol has a limited antibiotic range, whereas Streptomyces generates many more antibiotics. The genus Streptomyces produces around 60 different antibiotics.VM -04 was the isolate that generated crude antimicrobial compounds (CACs) with the greatest inhibition against *E. coli*. Overall, the actinomycetes isolated from the mangrove rhizosphere soil in Vellar Estuary Parangipettai show antibacterial activity against *E. coli*, according to this study. As a result, Streptomyces spp strain VM-04 might be developed as an antibacterial agent.

CONCLUSION

An effort was made to identify several strains of actinomycetes with antibacterial activity from the mangrove rhizosphere soil in the Vellar estuary, Parangipettai. There is currently a need to discover novel antimicrobial-producing strains since existing medications have failed owing to the development of resistance among microbes. The current study is also a little contribution to this requirement. Isolates that demonstrated broad-spectrum effectiveness against the test pathogens might be investigated as possible antibacterial chemical compounds.

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Table 1. Soil physiochemical parameters

Location	pH	Temp. (°C)	Salinity(%)	Moisture
LI -a	6.3 ± 0.2	27.6 ± 0.4	9.1 ± 5.2	7.5 ± 0.5
LI -b	4.1 ± 0.1	28.0 ± 0.1	15.0 ± 0.2	8.2 ±0.5
LII -a	5.8 ±0.4	28.7 ± 0.4	0.2 ± 0.0	8.1 ± 0.2
LII -b	4.7 ± 0.0	29.1 ± 0.2	8.2 ± 0.2	8.3 ± 0.1

Table 2. Actinomycetes isolated from mangrove rhizosphere soil in Vellar estuary

Location	Code of the sample	Amount of the sample
LI -a	VM 01	2
LI -b	VM 02	2
LII -a	VM03	2
LII -b	VM 04	2

Table 3. Characteristics of Actinomycetes isolates from mangrove rhizosphere soil in Vellar estuary

		Macroscopic			Microscopic	
Code	Color of aerialmycelium	The color of the substratemycelium	Change the color of the medium	Gram	Spore	The shape of the spore chain
VM 01	White	Gray	No	+(purple)	Yes	*Streptomyces*/Spiral
VM 02	Gray	Pink	Pink	+(purple)	Yes	*Streptomyces*/Straight
VM03	White	Blackish Green	No	+(purple)	Yes	*Saccharopolyspora*spp/flexous
VM 04	Yellow	Yellow	Yellow	+(purple)	Yes	*Streptomyces*/Straight

Table 4. The inhibitory zone of Actinomycetes against *Escherichiacoli, streptococcus sp.,Staphylococcusaureus,* and *Klebsiella sp.,*P1 – Streptomycin, P2- Ampicillin

Organism	*VM01*	*VM02*	*VM03*	*VM04*	P1	P2
E.coli	7mm	6mm	8mm	9mm	10mm	9mm
Streptococcus sp	4mm	5mm	3mm	7mm	8mm	8mm
Staphylococcus sp	2mm	4mm	3mm	6mm	8mm	8mm
Klebsiella sp	2mm	3mm	3mm	5mm	7mm	7mm

Table 5. Biochemical features of the isolate of VM 04

Tests	Results
Gram	+
Color of aerialmycelium	Gray
The shape of the spore chain	Spiral
Catalase	+
Motility	-
Glucose	-
Xylose	-
Arabinose	-
Rhamnose	-
Raffinose	-
Mannitol	-
Inositol	-
Sucrose	-

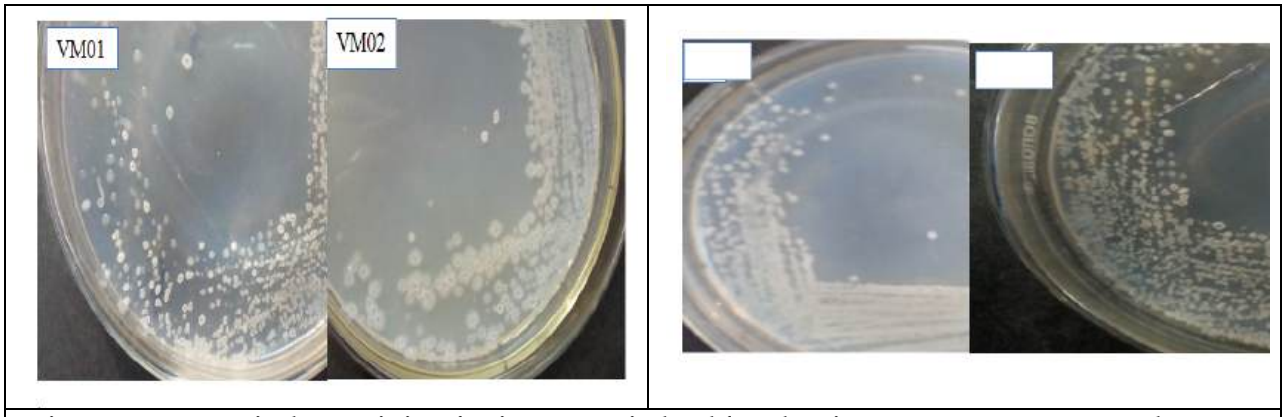


Figure 1. Macroscopic characteristics of actinomycetes isolated from location I. VM 04, VM03VM 01and VM 02.

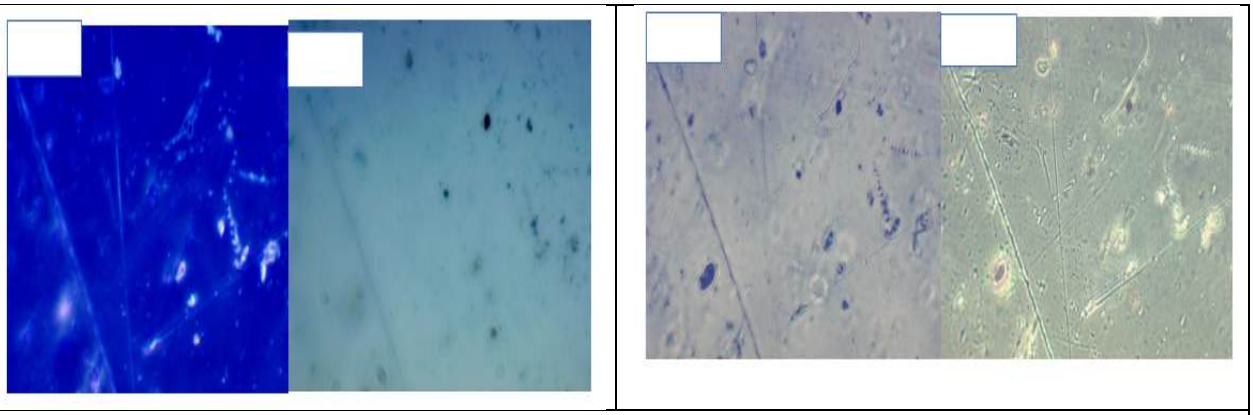


Figure 2. Microscopic characteristics of actinomycetes isolated from mangrove soil obtained inVellar estuary by Gram staining.VM 04, VM03, VM 01,and VM 02



Figure 3. The inhibitory zone of actinomycetes against *E.coli ,streptococcus sp., , staphylococcus sp.,klebseilla sp.,by* disk diffusion method. The code S1, S2,S3,S4 indicates VM01,VM02,VM03,VM04. P1 – Streptomycin, P2-Ampicillin.

RESEARCH ARTICLE

The Liverwort *Frullania monocera*– New to the Western Ghats from Palani Hills

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ABSTRACT

The liverwort *Frullania monocera* has been collected in the Palani Hills of the Western Ghats for the first time. In India, it was earlier known only from Assam. The present discovery raises the number of *Frullania* species to 21 in the Western Ghats. A description, a photographic plate and a key to distinguish the typical species *F. monocera* from its variety *acutiloba* are provided.

Keywords: *Frullania acutiloba*, *F. monocera* var. *Acutiloba*, Misamari, Assam.

INTRODUCTION

Frullania Raddi has approximately 673 species world-wide (von Konrat *et al*. 2016; Sukkharak 2018). In India, so far 58 species and 14 infraspecific taxa have been reported (Singh *et al*. 2016). In the Western Ghats, so far 20 species have been reported (Daniels 2010; Daniels & Kariyappa 2019). While documenting the bryoflora of the Palani Hills in the Western Ghats, a material of *Frullania* was collected which after a detailed study was identified as *F. monocera* (Hook.f. & Taylor) Taylor. In India it was earlier known only from Misamari in Assam. Hence, the present record is an addition to the *Frullania* species of the Western

Ghats thereby raising the number of species to 21. A description, a photographic plate and a key to distinguish the typical species *F. monocera* var. *monocera* from its variety *F. monocera* var. *acutiloba* are provided.

MATERIALS AND METHODS

Samples were collected after monsoon rains. Specimens were dissected and observed under an Olympus SZ51 binocular stereomicroscope and photographs of relevant parts were taken using an Olympus BX43 compound research microscope. Identification was made following monographs and recent publications and also by consultation. Collected specimens are housed at the Herbarium of Scott Christian College, Nagercoil (SCCN).

TAXONOMY

Frullania monocera (Hook.f. & Taylor) Taylor in Gottsche, Lindenb. & Nees, Syn. Hepat. 3: 418. 1845; S. Hatt., J. Hattori Bot. Lab. 45: 347, f. 18. 1979 & 47: 103. 1980; S. Hatt. & P.-j. Lin, J. Hattori Bot. Lab. 59: 139. 1985; Bapna & Kachroo, Hepatic. India 2: 173. 2000; D.K. Singh & al., Liverw. & Hornw. India: 90. 2016; Söderström *et al*., Phytokeys 59: 281. 2016. *Jungermannia monocera* Hook.f. & Taylor, London J. Bot. 4: 89. 1845. - Type: Australia, Van Diemen's Land (= Tasmania), *Taylor s.n*. in hb. FH [00290606] (lectotype by Hentschel *et al*. 2015); in hb S, Herb. Lehman., sent 1847, Taylor [B143254]; in hb W, Lindenberg Hepat. 714a [W0259690]. *Frullania hampeana* Nees in Gottsche & al., Syn. Hepat.: 426. 1845; Verd., Ann. Bryol. Suppl. 1: 44. 1930; S. Hatt., J. Jap. Bot. 20: 264. 1944; Inoue, J. Jap. Bot. 36: 187. 1961; S. Rob., J. Jap. Bot. 27: 129. 1964; Kachroo, Bull. Bot. Surv. India 12: 230. 1970; Parihar & al., Hepat. Anthocerot. India: 22. 1994. *F. lanciloba* Steph., Sp. Hepat. 4: 404. 1910. *F. tortusa* Verd., Ann. Bryol. 2: 136. 1929. (Fig. 1) Plants dioicous, 8–13 mm long, dark green to brown. Stems irregularly pinnately branched, ca 0.18 × 0.16 mm in cross section, 8- or 9-celled across; cells homogenous, 14–20 × 15–25 μm, irregularly quadrate-hexagonal, thick-walled. Leaves imbricate, obliquely to wide–spreading, dorsally arching half to full stem-width beyond the farther edge of the stem, 0.08–0.13 × 0.07–0.12 mm, oblong-elliptic, rounded-appendiculate at base dorsally, slightly undulate, obtuse to broadly acute at apex; cells irregularly rounded–hexagonal, with distinct trigones and intermediate nodular thickenings; apical cells 10–16 × 12–20 μm; median cells 14–30 × 16–24 μm; basal cells 20–40 × 16–24 μm; oil bodies disintegrated; lobules 0.22–0.48 × 0.23–0.4 mm, explanate to galeate, with a piliferous beak which extends across and beyond the ventral margin of leaf; vertex widely–rounded; mouth wide. Styli 4–6-celled, setaceous, hyaline. Underleaves transversely to subtransversely inserted, 0.3–0.4 × 0.28–0.38 mm, obcuneate-obovate to obovate-rotundate, 2-lobed for 1/4 to 1/3 at apex, with a narrow to rounded sinus; lobes triangular to ovate, 2- or more-toothed at margin, attenuate-acute to piliferous at apex. Male inflorescence not seen. Female inflorescences terminal on stems or branches or lateral; bracts faintly concave, 0.8–1 × 0.74–0.8 mm, plano–convex, arched dorsally and rounded-appendiculate at base, undulate to slightly incurved at margin, apiculate at apex; lobules ovate-lanceolate, lobed and incurved at basal margin, long-acuminate at apex; bracteoles 0.7–1.1 × 0.4–0.8 mm, oblong-ovate, 2-lobed for more than half at apex; lobes lanceolate, one-toothed at margin, acuminate at apex. Perianth not seen.

Habitat

Corticolous on *Rhododendron* × *pulchrum* var. *phoeniceum* (Sweet) Rehder (Ericaceae), in a home-garden, ca 1000 m.

Distribution

Australia, Bonin Islands, China, Indonesia, Japan, Malaysia, New Caledonia, Norfolk Island, New Zealand, Papua New Guinea, Sri Lanka, Tahiti, Taiwan, Thailand and India: Northeast India (Misamari in Assam) and Western Ghats of Tamil Nadu (Dindigul).

Specimens examined

Western Ghats: Tamil Nadu, Dindigul District, Palani Hills, Kodaikanal, ca 1000 m, 10º14'7.55" N, 77º29'32.4" E, 21.11.2022, *D.T.T. Daniels* 228 p.p. (SCCN).

Ecological notes

Frullania monocera was found as an epiphyte on *Rhododendron* × *pulchrum* var. *phoeniceum* (Sweet) Rehder (Ericaceae), in a home-garden, at an elevation of ca 1000 m.

DISCUSSION

Frullania monocera was originally described as *Jungermannia monocera* by Hooker and Taylor (1845) the type of which came from Australia. Taylor in Gottsche *et al*. (1845) transferred *Jungermannia monocera* under *Frullania* Raddi and made a new combination *F. monocera* (Hook.f. & Taylor) Taylor. Mitten (1861) described *Frullania acutiloba* from a collection made by Perrottet in Nilgiri Hills on the Western Ghats of Tamil Nadu. Hentschel *et al*. (2015) reduced *F. acutiloba* to a variety under *F. monocera* thereby making a new combination *F. monocera* (Hook.f. & Taylor) Taylor var. *acutiloba* (Mitt.) Hentschel & Konrat which was followed by Sukkharak (2018). Unfortunately, Hentschel *et al*. (2015) did not provide a reason for the renaming or any character that could be used to distinguish the different varieties. It was a purely formal classification without any justification. Hence, a key is provided here to distinguish between the two taxa.

Key to the varieties of *F. monocera*

1a. Leaf lobes widely incurved at apex; underleaf margin mostly entire or one-toothed on one side ---------- var. *acutiloba*

1b. Leaf lobes never incurved at apex; underleaf margin one- or more-toothed on both sides – ---------- var. *monocera*

Thus, *F. monocera* which is currently added to the *Frullania* species of the Western Ghats is *F. monocera* (Hook.f. & Taylor) Taylor var. *monocera*.

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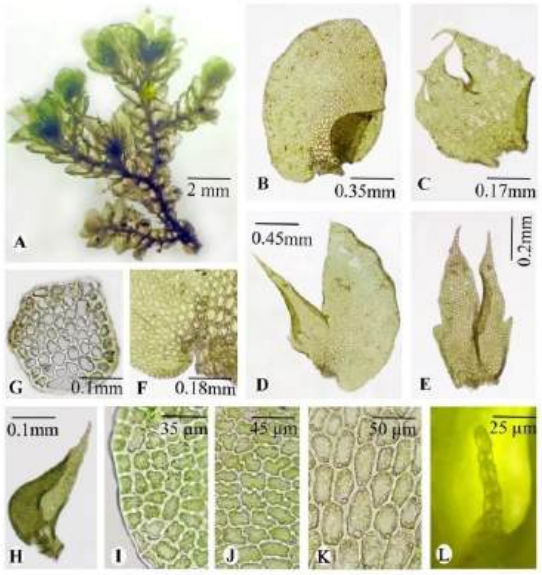


Fig. 1(A–L). Frullania monocera (Hook.f. & Taylor) Gottsche, Lindenb. & Nees A. Plant B. Leaf C. Underleaf D. Female bract E. Female bracteole F. Leaf base G. Cross section of stem H. Leaf lobule I. Leaf apical cells J. Leaf median cells K. Leaf basal cells L. Stylus (*D.T.T. Daniels* 228)

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RESEARCH ARTICLE

Evaluation of Bio-Fortified Composite for Improving Seed Quality Parameters on some Selected Crop Species

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ABSTRACT

The present study investigates the effect of plant-based composite seed coatings on seed quality, germination, and plant growth. The prepared herbal composite made of using the plants such *Allium sativum,Zingiber officinale, Terminalia chebula,Cinnamomum albiflorum,Syzygium aromaticum* were found to significantly enhance various physical parameters, including shoot and root length on *Sorghum bicolor and Cicer arietinum*. The nontoxic herbal coatings enhanced the seed germination biochemical parameters such as carbohydrate, protein, Total fatty acids considerably. The prepared herbal composite which produced disease free seedling due to its phytochemical composition. The important phytochemicals such as alkaloids, flavonoids, are also reported to be present Additionally, the GC-MS analysis of one of the composite coatings revealed the presence of several bioactive compounds, such as copaene, caryophyllene, and alpha-caryophyllene. These compounds have been reported to possess insecticidal and antimicrobial properties, as well as potential benefits for plant growth and development. The findings of this research suggest that plant-based composite seed coatings can be a promising approach to improve seed quality, germination rates, and overall plant performance.

Keywords: Biofortified Composite, GC- MS Analysis, Physiological Parameters, Physical Parameters, Plant Growth, Antimicrobial Properties

INTRODUCTION

Agriculture is an important sector of Indian subcontinent. Farmers are more important for any nation. For any crop, the time from harvesting to sowing and seedling establishment is very crucial as seeds are exposed to a wide range of environmental stresses viz., biotic and abiotic stresses that can alter the quality aspects of seeds (Zinsmeister *et al.,* 2020, Zaheer et al., 2021). The judicious use of crop specific physical, physiological, chemical and biological agents could offer an attractive option for the development of sustainable good crop establishment, growth and productivity Seed enhancements are post-harvest treatments that improve the performance of seeds such as germination, seedling growth and facilitate the delivery of seeds and other planting materials required at the sowing. Seed priming is one of the most important physiological seed enhancement method. It is a hydration treatment of seeds which involves controlled imbibitions and induction of the pregermi native metabolism (activation), but radicle emergence is prevented (Kalaivani *et al.,* 2010). The hydration treatment is withdrawn before esiccation tolerance of the seed is lost (Bose *et al*.,2018). Seeds can be primed by soaking seeds in solutions up elemental with plant hormones or beneficial micro organisms for a specific period of time (Araújo *et al.,* 2016). The hydrated primed seeds can be reverted back to safe moisture content by drying for storage, distribution and planting. Seed priming is an easy and effective technique to get speedy and uniform emergence, high seedling vigour and higher yields of crops.

This controlled hydration technique stimulates metabolic processes during early phase of germination before protrusion of radicle (Araújo *et al.,* 2016). Higher rate of germination of primed seeds primarily happens because of reduction in the lag time of imbibition (Araújo *et al.,*2016), enzymatic activation, accumulation of germination enhancing metabolites (Hussain et al., 2015), metabolicre pair during imbibition and osmotic adjustment (Hussain *et al.* 2016). Seed quality plays an important role in crop production and lack of quality seed is one of the major hindrances in bridging the yield gap. Seed enhancement process involves pre-sowing hydration treatments or priming, hardening, coating technologies, seed conditioning and pregermination but excludes treatments for control of seed borne pathogens. In magneto priming, magnetic field is used as a non-invasive physical stimulant to improve seedling vigour and stress tolerance of the crop in the field. Nano priming can augment performance of seeds in many ways such as enhancing amylase activity, increasing soluble sugar content to support early seedlings growth, up-regulating the expression of aquaporin gene in germinating seeds, increased stress stolerance through lower ROS production, creation of nanopores for enhanced water uptake etc. This paper reviews the scope and relevance seed enhancement for sustainable agriculture with a special emphasis on recent advances in seed priming technologies. The factors that have an important contribution in the success of seed coating includes particle size distribution, porosity, water absorbing and holding capacity and extent of toxicity. So, it is desirable that precise distinguished coating agents and procedures can turn out to be relatively clear for improving seed quality and to obtain higher productivity (Ben-Jabeur *et al.,* 2021). In this connection the present study was carried out to prepare a seed coating with herbal powders as coatings using various methods. At present there are many chemicals are found in to perform the seed coating.

MATERIALS AND METHODS

The effect of composite the plants such *Allium sativum*, *Zingiber officinale*, *Terminalia chebula*, *Cinnamomum albiflorum*,*Syzygium aromaticum* were selected and coated on the seeds of study species *Cicer arietinum L.* and *Sorghum bicolor* Moench. The healthy plant parts were crushed and grounded using pestle and mortar the extracts were prepared using distilled water. The filterate was made through "whatman no.1" filter paper and the pure extract obtained taken as extract. the seeds were washed in sterile water. The seeds were soaked in extract in specific five treatments. The seeds were soaked and moistened with requisite amount of extract solution. Then the seeds were kept at one side and rolled in seed germination sheet. The seeds were moistened with distilled water and kept separately rolled germination sheet.the seeds with sheets kept in beaker containing water. Radicle emergence was considered as the criteria for seed germination. Germination count in each treatment was recorded. The shoot length, root length and plant length were calculated and interpreted accordingly (Asha Sinha and shrvan kumar,,2019).

Germination percentage(%)
Number of germinated seeds were recorded every 48 hours after initiation of germination until 10 days. (Deepak *et al.*,2020) Germination percentage = (no. of seed germinated /Total no. of seed sown)×100

Plant height at 20 days
Height of the selected plants was measured from the base of the plant upto the growing tip of the main stem with meter scale and expressed in centimeters..(Deepak *et al.*,2020)

Plant fresh weight
Twenty plants from each replication were uprooted at 22 DAS and their weight was measured with the help of balance machine and expressed in grams..(Deepak et al.,2020)

Total dry matter
Twenty plants from each replication were uprooted at 22 DAS and shade dried and their weight was measured with the help of balance machine and expressed in grams..(Deepak *et al.*,2020)

Preliminary phytochemical analysis:
The extracts were screened for presence of important phytochemical such as alkaloids, steroids, Terpenoids, Flavonoid, Coumarin, Saponins, Glycosides, Phenol and tannins by using standard methods.(Edeoga *et al.*, 2005,Harbone *et al.*, 1973,Yadav *et al.*, 2014Kokate *et al.*, 2000 Shreya *et al.*, 2013

Estimation of Chlorophyll Content
The contents of chlorophyll a, b and total chlorophyll were estimated on the foliar treated and non-treated leaves by Arnon, 1949.

Estimation of carbohydrate.
The estimation of carbohydrates from treated leaves using modified anthrone method. (Shekappa devindra,2015)

ESTIMATION OF PROTEIN BY BRADFORD METHOD
The protein content was estimated for treated and non - treated parts of the plants were made using Bradford method (Nicholas, 2002).

RESULTS AND DISCUSSION

Seed coating and layering is an innovative process to coat the seeds with a composite made of many substance including chemicals and other substances. For the present study an eco-friendly plant based biocomposite was prepared to coat the seeds aiming to control against the seed infection by pathogens. The seed composite is completely made of 5 different plant materials. The extracts including *Alliumsativum, Terminalia chebula, Syzygium aromaticum*, *Zingiber officinale* and *Cinnamomum sp.* were taken. All the extracts were mixed in a definite ratio and made into a composite. These composite were mixed with a little neem oil to facilitate the coating on seeds. This will increase the spread ability and coating ability of the composite. Table :-1 and 2 The composites made of five different plant extracts were tabulated. The composite ingredients were mixed at a definite ratio according to nature of the plant material. There are two methods were tried to coat the composite and evaluated the seed parameters in *Cicer arietinum L.* and *Sorghum bicolor Moench* on physical and biochemical behaviour of the seeds. The extracts were coated on the seeds in a wet condition and resulted to have 53 % germination in control. Subsequently the treated seeds were showed the fluctuations from 52% to 62% from W_1 and W_2 respectively in *Cicer arietinium*. On the other hand the Sorghum bicolor responded to have the maximum germination percentage of 88% in the W_4 composite. The study clearly exhibits that composites are very less influence over the germination physiology of the study crops. The result is in conformity with Ahmed *et al*.,(2014).He observed increased germination percentage in rice seeds, when

treated in neem extract(1:).Khatun *et al.,* (2010) also observed increased germination percentage in lentil seeds treated with neem leaf powder. Hasan *et al.,* (2015) found that extract of onion bulb and leaf extract of neem increased seed germination by decreasing the viral infection. The physical parameters like shoot length, root length, seedling fresh weight and dry weight were calculated using the method on the *Cicer arietinum* and *Sorghum bicolor*. The W_3 composite is highly influenced on 37.89 cm of shoot length and 34.94 cm of Root length and seedling weight is 26.14 and about 2.95 gm was reported for the biomass content of the plant on the dry weight basis of the seedling. The physical parameters of *Sorghum bicolor* as influenced by the various treatments on shoot length, root length, seedling weight and dry weight were tabulated in the table:- 6 the W_3 treatment influences the shoot length to 12.11cm and root length with 10.66cm in the W_5 treatment. These two treatments which supports the shoot and root length clearly opines with that W_3 and W_4 treatment supports shoot and root system biochemical pathways .Table:-5 and 6. The crop *Cicer arietinum* exhibit it's the 4.353 mg/g of total chlorophyll content in the composite treatment of W_4 on wet method. Table :-7 . The crop *Sorghum bicolor* at W_5 composite treatment was 5.132 mg/g when compared with other composite concentrations. The carbohydrate content was on various treatment were recorded in the table :-10. The W_1 composite wet coating supported the carbohydrate production in the crop of *Cicer arietinium* on the study period. Subsequently the protein content was also enhanced by the composite treatment as 0.321 mg/gm at W_3 composite treatment. When compared with control and other treatments. Seed coating is a finite process to preserve the seeds from infestation from pests and pathogens. Similarly the results were found to be more relevant with Deepak *et al.,* 2020 that seed priming with garlic reduce the infection rate and also enhances growth and yield of lentil. This may be due to the presence of Allicin. Similar results were reported by Vigneshwari (2002) reported that seeds hardened with brasssinolide 0.1 ppm had positive effect on drought resistance which was evident from its increased physiological and biochemical aspects of finger millet seeds that resulted in increased yield of seed. Many studies on the improvement of growth and yield due to pre sowing seed hardening are documented (Solaimalai and Subbarmanu, 2004 ; Meek and Oosterhugs , 2005).

The study was undertaken to evaluate the phytochemical constituents of the water extract to confirm the presence of bioactive compounds. The phytochemical test was conducted using third (T_3) extract of wet treatment method. In third treatment the root length, shoot length, fresh weight, dry weight and the protein content of the plant were increased. The water extract of T_3 showed the presence of glycosides , tannin , saponins , resin , steroids and phenols. The study ultimately evaluates the effect of herbal biocomposite on the seeds. The seedlings germination rate, root and shoot length, the biochemical parameters are considerably increased. Additionally the biocompositehas the presence of important phytochemicals which may protects the seeds from pathogenic organisms. The GCMS analysis also confirms the presence of important phytochemicals which may improve the seedling growth in many ways.With the above results it is confirmed that the prepared herbal biocompositewas one of the cost effective and ecofriendly approach in growth and development of crops. The GC-MS analysis of the herbal biocomposite extract revealed the presence of a diverse range of bioactive compounds, including phenolics, fatty acids, terpenes, and sterols. The major component identified was Phenol, 2-methoxy-3-(2-propenyl) (commonly known as eugenol), accounting for 40.76% of the total composition, known for its strong antimicrobial and antioxidant properties. Significant fatty acids such as 9-Octadecenoic acid (oleic acid) and n-Hexadecanoic acid (palmitic acid) were also detected in substantial amounts, contributing to seedling vigor and disease resistance. Terpenoids like Caryophyllene, Copaene, and Caryophyllene oxide were present, supporting plant defense mechanisms. The presence of gingerol, squalene, vitamin E, and stigmasterol indicates the antioxidant and growth-promoting potential of the composite. Minor components such as benzoic acid derivatives, hydrazides, and benzofurans further enhance the therapeutic and protective qualities of the extract. Overall, the phytochemical profile confirms the biocomposite's richness in compounds that promote seed health, growth, and protection against pathogens.

CONCLUSION

The present study highlights the potential of a plant-based herbal biocomposite as an effective seed coating material. The use of natural extracts from five medicinal plants combined with neem oil proved to be a sustainable approach to

enhance seed health and early seedling vigor. This eco-friendly method aims at preventing seed-borne infections and supporting initial plant development. Seed coating with herbal composites demonstrated positive effects on physical and biochemical parameters of the tested crops. Enhanced germination, shoot and root growth, as well as increased chlorophyll, carbohydrate, and protein levels, were observed. The treatment also indicated improved resistance to environmental stress and potential protection from pathogens. The phytochemical analysis confirmed the presence of several bioactive compounds in the extracts. These compounds likely contributed to improved plant growth and defense responses. This herbal coating method aligns with sustainable agriculture goals by reducing dependency on synthetic chemicals. It promotes environmentally conscious farming practices and offers a cost-effective alternative for seed treatment. Overall, the biocomposite serves as a valuable tool for improving crop performance.

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Table:- 1 showing the formulations of composite for wet method.

Composite	W 1	W 2	W 3	W 4	W 5
Allium sativum	10	20	10	10	10
Terminalia chebula	10	5	5	10	10
Syzygium aromaticum	10	5	10	5	20
Zingiber officinale	10	10	5	20	5
Cinnamomum tamala	10	10	20	5	5

Table:-2 showing the germination percentage of study crop species after treating plant extract *Cicer arietinum* L.

Sl.no	Treatment	No. of plants	No. of plants germinated	Germination percentage
1	Control	100	79	79
2	1	100	82	82
3	2	100	85	85
4	3	100	84	84
5	4	100	88	88
6	5	100	83	83

Table :-3 showing the germination percentage of study crop species after treating plant extract *Sorghum bicolor.*

Sl.no	Treatment	No. of plants	No. of plants germinated	Germination percentage
1	Control	100	79	79
2	1	100	82	82
3	2	100	85	85
4	3	100	84	84
5	4	100	88	88
6	5	100	83	83

Table:-4 showing the composite effect on physical parameters caused by plant extract on *Cicer arietinum* L.

Sl:no	Treatment	Shoot length (cm)	Root length (cm)	Seedling weight (gm)	Dry weight (gm)
1	Control	32.34 ± 1.85	31.00 ± 1.02	19.03 ± 0.96	01.28 ± 0.07
2	1	31.67 ± 1.36	34.78 ± 1.56	21.12 ± 1.28	01.32 ± 0.17
3	2	28.22 ± 1.26	34.00 ± 1.73	20.51 ± 1.36	02.27 ± 0.19
4	3	37.89 ± 0.55	34.94 ± 0.86	26.14 ± 1.88	02.95 ± 0.25
5	4	25.86 ± 1.23	23.17 ± 1.37	22.62 ± 0.99	01.92 ± 0.39
6	5	25.05 ± 1.12	25.94 ± 1.35	24.00 ± 1.03	0.1.73 ± 0.52

Table :-5 showing the composite effect on physical parameters caused by plant extract on *Sorghum bicolor.*

Sl:no	Treatment	Shoot length (cm)	Root length (cm)	Seedling weight (gm)	Dry weight (gm)
1	Control	10.21 ± 0.65	09.19 ± 0.79	03.01 ± 0.09	0.22 ± 0.01
2	1	09.50 ± 0.64	08.44 ± 0.66	02.82 ± 0.15	0.31 ± 0.06

3	2	09.89 ± 0.51	08.66 ± 0.53	02.91 ± 0.06	0.28 ± 0.12
4	3	12.11 ± 0.65	09.27 ± 0.58	03.47 ± 0.08	0.49 ± 0.69
5	4	10.11 ± 0.64	08.66 ± 0.64	03.65 ± 0.17	0.43 ± 0.13
6	5	09.94 ± 0.76	10.66 ± 0.82	03.42 ± 0.11	0.29 ± 0.05

Table:- 6 showing composite effect on carbohydrate and protein caused by plant extract on *Cicer arietinum* L.

Sl:no	Treatment	Total chlorophyll(mg g-1)	Carbohydrate(mg/gm)	Protein(mg/gm)
1	Control	1.872	0.78	0.116
2	1	3.023	0.99	0.122
3	2	1.292	0.58	0.282
4	3	1.858	0.18	0.321
5	4	4.353	0.39	0.116
6	5	1.488	0.25	0.168

Table:-7 showing composite effect on carbohydrate and protein caused by plant extract on *Sorghum bicolor.*

Sl:no	Treatment	Total chlorophyll(mg g-1)	Carbohydrate(mg/gm)	Protein(mg/gm)
1	Control	3.414	0.54	0.101
2	1	3.371	0.96	0.128
3	2	2.313	0.85	0.196
4	3	2.684	0.57	0.124
5	4	3.049	0.63	0.138
6	5	5.132	0.37	0.102

Table : 8 showing the results of qualitative phytochemical parameter for biocomposite.

SL NO	Phytochemicals	Presence /absence
1	Alkaloids	-
2	Glycosides	+
3	Tannin	+
4	Saponins	+
5	Terpenoids	-
6	Resin	+
7	Flavonoids	-
8	Steroids	+
9	Phenol	+
10	Quinones	-

+ present -Absent

Table-9 Showing the list of compounds detected through GCMS analysis for the prepared better performed Biocomposite

Pk#	RT	Area%	Compound name	Molecular formula	Molecular weight	CAS#
1	8.409	40.76	Phenol, 2-methoxy-3-(2-propenyl)	$C_{10}H_{12}O_2$	164.20	32712 001941-12-4 98
2	8.620	0.16	Copaene 62246	$C_{15}H_{24}$	204.3511	003856-25-5 97
3	9.042	1.48	Caryophyllene	$C_{15}H_{24}$	204.3511	62264 000087-44-5 99
4	9.353	0.18	alpha-Caryophyllene	$C_{15}H_{26}O$	204.35	62311 006753-98-6 97

5	9.486	0.26	Benzene, 1-(1,5-dimethyl-4-hexenyl)-4-methyl	$C_{15}H_{22}$	202.33	60872 000644-30-4 98
6	9.597	0.49	1,3-Cyclohexadiene, 5-(1,5-dimethy l-4-hexenyl)-2-methyl-	$C_{15}H_{24}$	204.35	62419 000495-60-3 93
7	9.708	0.21	Cyclohexene, 1-methyl-4-(5-methyl 1-methylene-4-hexenyl)-, (S)-	$C_{15}H_{24}$	204.3512	- 62392 000495-61-4 98
8	9.853	0.37	Cyclohexene, 3-(1,5-dimethyl-4-hex	$C_{15}H$	20.3511	62401 020307-83-9 96
9	10.431	0.28	Caryophyllene oxide	$C_{15}H_{260}$	22.3505	74752 001139-30-6 76
10	10.842	0.22	2-Butanone, 4-(4-hydroxy-3-methoxy phenyl)-	$C_{11}H_{14}O_3$	194.2271	54427 000122-48-5 95
11	10.997	0.11	2-Naphthalenemethanol, decahydro	$C_{15}H_{260}$	222.3663	76571 000473-15-4 96
12	11.164	0.09	2',3',4' Trimethoxyacetophenone	$C_{11}H_{14}O_4$	210.23	66696 013909-73-4 81
13	13.041	9.84	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	256.4	102726 000057-10-3 99
14	14.230	37.87	9-Octadecenoic acid, (E)-	$C_{18}H_{34}O_2$	282.4614	122794 000112-79-8 99
15	14.397	1.65	Octadecanoic acid	$C_{18}H_{36}O_2$	284.48	124560 000057-11-4 95
16	14.708	0.15	Octadecanoic acid	$C_{18}H_{36}O_2$	284.48	124560 000057-11-4 92
17	14.763	0.21	Benzoic acid, 3-(acetylamino)-	$C_9H_9NO_3$	179.17	43984 000587-48-4 43
18	15.119	0.80	3,6-Dimethyl-2,3,3a,4,5,7a-hexahyd robenzofuran	$C_{10}H_{16}O$	152.23	24842 070786-44-6 47
19	16.063	0.20	9,12-Octadecadienoic acid (Z,Z)-	$C_{18}H_{32}O$	280.4455	121227 000060-33-3 89
20	16.152	0.10	9,19-Cyclolanost-24-en-3-ol, (3.be ta.)-	$C_{32}H_{52}O_3$	484.8	202807 000469-38-5 59
21	16.274	0.40	15-Hydroxypentadecanoic acid	$C_{15}H_{18}O_7$	144.05	104174 004617-33-8 38
22	16.963	0.17	3-Hydroxy-2-p-tolyl-2-butenenitril	$C_5H_{10}O_2$	102.1317	39665 1000243-87-8 22
23	17.219	1.55	9,17-Octadecadienal, (Z)-	$C_{18}H_{32}O$	264.4461	108922 056554-35-9 96

24	17.363	0.31	Gingerol	$C_{17}H_{26}O_4$	294.38	132026 023513-14-6 47
25	17.830	0.13	Squalene	$C_{30}H_{50}$	422.8	198698 007683-64-9 81
26	18.318	0.08	Octadecane	$C_{18}H_{38}$	254.494	101148 000593-45-3 87
27	19.285	0.18	3-Oxatricyclo [4.2.0.0(2,4)] octan-7 -one	$C_7H_8O_2$	110.1537	10339 1000211-18-1 22
28	19.485	0.11	Cyclohexanecarboxamide, N-furfuryl	$C_7H_{13}NO$	127.184	64671 006341-32-8 35
29	19.796	0.14	Octadecane	$C_{18}H_{38}$	254.494	101148 000593-45-3 90
30	19.996	0.39	Stigmastan-3,5-diene	$C_{29}H_{48}$	396.7	194367 1000214-16-4 91
31	20.163	0.32	Vitamin E	$C_{29}H_{50}O_2$	430.7061	203745 000059-02-9 98
32	21.307	0.09	Cholestan-3-ol, 5-chloro-6-nitroacetate (ester), (3.beta.,5.alpha .,6.beta.)-			-, 214010 001431-22-7 53
33	21.585	0.10	Stigmasterol	$C_{29}H_{48}O$	412.7	199251 000083-48-7 84
34	29.718	0.16	16-Hexadecanoyl hydrazide	$C_{16}H_{34}N_{20}$	270.45	113532 002619-88-7 50
35	22.329	0.46	Ergost-5-en-3-ol, (3.beta.)-	$C_{28}H_{480}$	400.7	195904 004651-51-8 58

RESEARCH ARTICLE

Virtual Screening of Natural Compounds as Isocitrate Lyase Inhibitors in *Escherichia coli* and *Aspergillus nidulans*: Insights from Molecular Docking

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ABSTRACT

Respiration is a vital process for energy production and can be targeted by inhibiting key enzymes involved in metabolism. Enzyme Isocitrate lyase (ICL) converts isocitrate into glyoxylate and succinate and, is crucial for fungal virulence, cellular penetration, and infection in humans. In this study, we aimed to identify a molecule that inhibits Isocitrate lyase using *in silico* methods. Multiple sequence alignment of Isocitrate lyase protein sequences from eleven selected organisms listed in Table2, whose ICL structure were available in PDB database, was performed using the T-Coffee web server. 3-D model of ICL for all eleven organisms was determined using Swiss-Modeler and secondary structure prediction was carried out with Biovia Discovery Visualizer tool. Based on literature survey, 17 different phytochemicals from nine medicinal plants were selected for molecular docking. Molecular docking of all selected phytochemicals was performed with Auto Dock 4.2.6 tool to obtain binding energies of ligand-receptor interactions. Phytochemical named Ishwarol showed improved binding energy than normal and control drug molecule taken for evaluation, and therefore can be considered as a lead molecule.

Keywords: Isocitrate lyase, Enzyme, glyoxylate cycle, Molecular docking, Phytochemicals, ADMET

INTRODUCTION

Isocitrate lyase (ICL) belongs to the family of Lyases enzyme, specifically the oxo-acid-lyases, which cleaves carbon-carbon bonds. Isocitrate lyase is an important enzyme in Glyoxylate cycle, which catalyzes the reversible cleavage of isocitrate into succinate and glyoxylate. The Glyoxylate cycle is found in archaea, bacteria, protists, plants, fungi and nematodes. The glyoxylate cycle bypass the CO_2-generating steps of the TCA cycle and allow the net assimilation of carbon from C_2 compounds, allowing micro-organisms to replenish the pool of TCA cycle intermediates necessary for gluconeogenesis and other biosynthetic processes [1]. In *Saccharomyces cerevisiae*, pyruvate carboxylase and the glyoxylate cycle have been experimentally identified to be the main anaplerotic routes during growth on glucose and ethanol [2]. The products, succinate and glyoxylate, in glyoxylate cycle are replenished to Tricarboxylic acid (TCA) cycle as intermediates, reviving TCA cycle [3]. An estimation of tuberculosis (TB) incidence reported by WHO states that a total of 10.6 million people get infected with TB in 2021 [4]. Icl1 and Icl2 are required for fatty acid catabolism and virulence in *Mycobacterium tuberculosis*. Deletion of both genes result in complete damage of intracellular replication and rapid elimination from the lungs, suggesting ICL role during infection [5]. *Rhodococcus equi,* a gram positive bacteria that mostly causes cavitary pneumonia and lung abscess, especially in immmuno-compromised hosts requires ICL for virulence and long term survival [6][7]. *Salmonella enterica* has shown that ICL is required for persistence during chronic infection, but not for acute lethal infection [8]. *Pseudomonas aeruginosa* which persists in the lungs of cystic fibrosis patients has shown constitutive upregulation of ICL gene leading to increase in hydrogen cyanide production, a potent inhibitor of cellular respiration [9].

Additionally upregulation of genes is shown in *P.aeruginosa* that are needed for replication: fatty acid and lipid metabolism, choline metabolism, nitrogen metabolism, amino acid degradation and the glyoxylate cycle [10]. Transcriptome analysis and molecular techniques done on *Paracoccidioides brasilinesis,* an agent of paracoccidioidomycosis, has reported upregulation of glyoxylate cycle genes during morphological transition [11][12][13]. *Penicillium marneffei*, a dimorphic fungus that cause disseminated disease in human immunodeficiency virus infected patients, showed higher expression levels of isocitrate lyase after macrophage internalization [14]. Glyoxylate cycle and their enzymes has also given an alternative carbon adaptation strategy that has been developed by many fungal species such as *Candida spp.* for survival and pathogenesis in hosts phagocytes such as macrophages that restricts pathogen's preferred carbon source, glucose [15]. Role of ICL in fungal pathogens causing various diseases in plants have also been reported [16][17][18]. A WHO report estimates that 450 000 incident cases of MDR/RR-TB (Multi-Drug Resistant/ Rifampicin-resistant) have occurred in 2021, an increase in 3.1% since 2020 [21]. Many pathogens have developed a mechanism to counter drugs and have become multi drug resistant or antibiotic resistant. Plant based phytochemicals shows an effective drug action against pathogens with least side effects. The potential drug candidates designed against ICLs with specific active site interact with hydrogen bond and thereby inhibit the activity of pathogenic ICLs, with no side effect on the host. Hence, we are interested in screening potential phytochemicals as drug molecules against ICLs and look into their effectiveness against pathogenic microbes. Hence present study focuses on in silico docking work on selected phytochemicals as lead molecules to check their binding affinities to modelled ICL protein in comparison to known antimicrobial drugs. This may help to come out with leads of next-generation drugs against virulent ICLs involved in infection and proliferation of many pathogens

METHODS

Selection and drug-likeness identification of phytochemicals for drug design

Selection of phytochemicals from medicinal plants for inhibitor design

Based on the review of research papers, 61 Indian medicinal plants belonging to 33 different families used in various disorders were screened and selected having antimicrobial properties [22]. List of phytochemicals selected is given in Table 1. All of the phytochemicals 3D structure were retrieved from PubChem database in Structure Data Format (SDF). The SDF files were converted to PDB files by the help of Open babel for further analysis. The chemical structures of synthetic inhibitors itaconate, nitropropionate and bromopyruvate were similarly processed as controls.

Drug-likeness test of phytochemicals using ADMET Lab2.0

Absorption, distribution, metabolism, excretion and toxicity must be evaluated before drug design otherwise can lead to failure of drug development. Therefore drug likeness test of 17 phytochemicals and three controls were evaluated by input to ADMET Evaluation service given by ADMET Lab2.0 in SDF format files and various descriptors (LogP, Mol. Wt, nHA, nHD, nRot and Vol) values were obtained as mentioned in table 1[32]. The descriptors refer to Lipinski rule of five which states that an active oral drug should qualify the following criteria: molecular weight should be less than 500 Da, log P should be < 5, H-bond acceptor should be < 10, H-bond donor should be < 5, number of rotatable bonds should be > 5 and additionally molecular volume for the compounds should be between 500 and 2000 [33].

Consensus generation,
phylogenetic tree construction and In-silico homology modelling of protein
Consensus sequence generation through MSA and phylogenetic tree construction

11 organisms belonging to kingdom fungi and bacteria having known structure for ICL were chosen for MSA (Multiple Sequence Alignment). Table 2 shows organisms name with the PDB ID. Protein sequences of ICL were retrieved directly by the T-Coffee server of EBI (European Bioinformatics Institute), when PDB format files of all ICL structures were given for MSA [34]. The following parameters were set. The output format was set to ClustalW and matrix as BLOSUM. Protein sequences were submitted to T-coffee web server for automatic generation of phylogenetic tree The consensus sequence generation was done in the Jalview software by inserting the link given on result viewers tab of T-Coffee website. [35].

***In-silico* homology model construction**

Though 3D structure of ICLs were available at PDB database, we were in search for a common and representative ICL structure for all eleven organisms. As we have earlier generated a consensus sequence representing common sequence of ICL for all eleven organisms therefore consensus sequence was submitted to the Swiss modeller website [36] as the target sequence. A homology model of ICL was generated by modeller by searching identity of templates available in integrated database matching the target sequence.

Superimposition and Active site identification
Superimposition of similar proteins

The 3D structures of ICL and the model ICL protein must relate and show identical sequences conserving the physiochemical properties of the amino acid residues. Therefore to check whether the properties and structure is conserved or not, ICL was superimposed with the ICL of *Candida albicans* which showed highest similarity, with the help of Biovia Discovery Client software [37].

Active site identification

TIM-Barrel like motif of isocitrate lyase is the active site of the enzyme. Therefore, targeting the active site in docking requires coordinates of residues involved in the formation of active site. The coordinates of 24 amino acids were retrieved from the PDB file format of model ICL monomer. Coordinates for X, Y, and Z axis were opted for all the 24 amino acids participating in the formation of TIM-Barrel. The coordinates were: X = -17.86, Y = 18.82, Z = 39.315.

Docking studies using Autodock 4.2.6
Preparation of receptor protein and ligands

The homology model of ICL is the receptor protein and the phytochemicals along with the three control drugs are the ligands binding to receptor. Previous to docking, polar hydrogens were added to the receptor and then assigned the partial atomic kollman charges using Autodock 4.2.6 [38]. 17 phytochemicals and three drugs taken for comparison, Gasteiger charges were added and rotatable bonds were determined. Autogrid 4.2.6 calculates various forces like electrostatic, Vander Waal, hydrogen bonding, and desolvation effects. Grids map was generated by creating a grid box having spacing adjusted to 0.636 Å to enable ligand binding. The grid dimension was adjusted to

40X40X40 points. Autodock 4.2.6 uses GPF (Grid Parameter File) file to calculate grid points and perform docking. For each ligand binding to receptor, it was fitted into grid box and targeted docking was performed.

Docking modeled ICL with ligands

Autodock 4.2.6 was used to evaluate binding affinity of ligands and three synthetic drugs (nitropropionate, bromopyruvate and itaconate) to homology model of ICL enzyme. Docking energy of all phytochemical molecules and drugs, model ICL enzyme were evaluated by using empirical-free functions and Lamarckian genetic algorithm. While running autodock it calculates binding free energy based on different electrostatic, Vander Waal, hydrogen bonding, and desolvation effects. "flexible" ligand-docking mode and targeted docking was employed for each docking run. The docking files were further analyzed for results.

RESULTS

Phytochemical studies

Selection of phytochemical models for inhibitor design

There are many advantages and benefits associated with the use of medicinal plants, the main ones being their cost-effectiveness and global availability. Various medicinal plants have crucial phytochemicals possessing anti-microbial, anti-bacterial, anti- fungal, anti-nematocidal and anti-viral activity on pathogenic biomolecule. The phytochemicals selected from various medicinal plants have to qualify the drug- likeness test that is they have to follow the Lipinski rule of five for various parameters. The independent parameters for the 17 phytochemicals were determined using ADMET Lab 2.0 and represented in table 1. In general, an orally active drug should not have more than one violation of following descriptors: H-bond donors, H-bond acceptors, molecular weight and LogP. It has been observed that almost all 6 violators (Beta caryophyllene, Beta sitosterol, Cinnabarone, Friedelin, Lupeol, Ursolic acid) have logP > 5. The control drugs do not violate any parameter of Lipinski rule of five.

Consensus generation and phylogenetic tree construction,

***In-silico* homology modelling of protein and Superimposition**

Consensus sequence generation and phylogenetic tree construction

Consensus sequences were generated from the result of multiple sequence alignment of eleven organisms by using Jalview. Jalview automatically calculates the number of conserved physio-chemical properties. Its calculation is based on the one used in the AMAS method of MSA [39]. A clear differentiation can be made between eukaryotic species (7EBC, 7EBE, 5E9F, 5E9H, 1DQU) and prokaryotic species (3I4E, 3LG3, 1IGW, 7CMX, 3P0X, 1F61). A cladogram, figure1, is generated by using distance based method, which performs Neighbor Joining algorithm. The tree shows that the ICL genes are conserved among the species.

Homology modeling studies

C.albicans structure was having 60.51% similarity with the consensus sequence and having a GMQE score of 0.81, indicating high quality of similarity among the two monomer. Thus a model was created. The structures of *C. albicans* monomer and model protein is shown in figure 2.1 and figure 2.2, respectively. Secondary structure of the model protein shown in Biovia Discovery visualiser processed by Kabsch and Lander method consist of 21 α-helices and 11 β-sheets.

Structure of Model monomer

The monomer of model protein (figure 2.1) consists of 559 residues long chains. The N-terminal region of the polypeptide chain starts with the residue Methionine. This leads into three consecutive helices (α1, α2, α3) that lie on the periphery of the molecule, where they pack against the main elements of domain I. The structure then starts to fold into a central parallel β sheet of nine strands, alternating generally with one or more helices (β1, β2, β3, β4, β6, β8, β9, β10 and β11). Thus overall fold is that of an (β/α)9 β2 barrel which closely relates to TIM barrel. Beyond the last strand in the TIM barrel (β11) the chain folds into a series of α helices (α18- α21) forming an extension that leads

towards the C terminus. This fold is interrupted in only one place, immediately after β6 and gives rise to a second domain, domain II, which consists of approximately 100 consecutive amino acids (265-369) that form a peripheral head to the subunit. Domain II is a largely helical domain (α10- α14) that includes one short β-sheet motif. The TIM Barrel motif consists of β1, α3, α4, β2, α5, α6, α7, β3, α8, β4, α9, β6, α15, β9, α16, β10, α17 and β11

Superimposition of model ICL with *C.albicans*

Comparative studies are important in finding remote protein structure homologs. Comparative analyses between two proteins (Model protein and *C.albicans*, 7EBE) was performed by Biovia Discovery visualizer revealed RMSD value as 0.843. Superimposition results states a clear conservation of two structures. Figure 3 depicts the superimposition structures evaluated through sequence alignment of main chain atoms. The green shaded is model monomer and the orange shaded monomer is 7EBE.

Docking studies using Autodock 4.2.6:

Docking ICL with Phytochemicals

Targeted docking mode was applied to find the binding free energy as specific coordinates of the active site were available. 17 phytochemicals and three drug inhibiting ICL were docked with the model ICL for finding the best binding affinity energy. We have determined the binding-free energy as shown in table 3 which reflects the binding affinity of 17 phytochemicals and 3 control drugs to model ICL. The docking studies showed that out of seventeen phytochemicals, Ishwarol shows the highest binding affinity of 7.9 kcal/mol and vitexin with least among seventeen phytochemicals was -2. The docking results are classified into three categories based on the binding energy: **High, Normal, and Low**. The three controls taken during docking analysis showed binding energy between -4 to -4.34. Thus, it is ideal to consider binding energy in the range of -4 as normal range. Below -4 and above -4 is considered high and low binding energy results, respectively.

Docking Interactions of inhibitors with ICL

MSA and secondary structure prediction has helped us to know and confirm the conservation of active site. Three control drugs taken during research shows the H- bond interaction with Asn149 (α6), Gln152 (α6), Ile185 (near β3), Gly210 (β4), Ala212 (β4), Arg183 (β3), which are all part of the TIM-barrel like active site. The interactions with residues Gln152 and Ile185 are found common in all three control drugs. Out of the 17 phytochemicals autodock was able to find H-bond interactions with only nine phytochemicals. Although when interactions were searched by Biovia discovery visualizer, 11 phytochemicals were found to have H-bond interactions (table 3). The conclusion that can be drawn by comparing affinity energies and binding poses, that the ligands bind active site cleft better than prescribed drugs. The first five highest binding interactions of ICL with phytochemicals are shown in Figures 4-8.

DISCUSSION

The enzyme isocitrate lyase is an important protein playing role in the development and virulence of bacterial, fungal and protists infections in humans and plants mentioned earlier. The inhibition of glyoxylate cycle by inhibiting ICL offer an excellent platform for drug designing as ICL is totally absent in mammals. Hence, ICL is a valid target molecule for not only control and eradication of pathogenic microorganisms but also it may nullify the occurrence of multiple resistant strains. Here we considered the ICL structures of *Escherichia coli* and *Aspergillus nidulans* as our model structure for prokaryotic and eukaryotic organisms. The molecular weight of ICL varies between prokaryotic, 48 kDa and eukaryotic, 67 kDa. Comparison of sequences reveals that this difference is largely associated with an insertion of approximately 100 amino acid residues towards C-terminus of the enzyme in eukaryotic ICL. The homotetramer of *E.coli* and *A.nidulans* consist of four subunits : A, B, C, D. The eukaryotic ICL subunit is folded into two domains whereas the prokaryotic is folded into single domain. Both the organisms consist of TIM barrel like motif consisting of β-sheets alternating in between with one or more α-helices. This TIM-barrel like motif is considered as the active site of ICL.ICL is a homo tetramer requiring Mg^{2+} or Mn^{2+} and a thiol for its activity. During catalysis, isocitrate is deprotonated, forming succinate and glyoxylate. The subunit interfaces in the E. coli enzyme

are entirely analogous to those found in the *A.nidulans* ICL [19][20]. Glyoxylate binds ICL at the C-terminal end of TIM-barrel motif, consistent with the general location of active site in other enzymes with this fold [20]. *E. coli* ICL revealed a similar feature associated with the same piece of protein structure and occupying the same position as the glyoxylate in the *A. nidulans* ICL [19, 20]. MSA and superimposition works confirm the conservation of TIM barrel motif as active site in the ICL model monomer, which is the representative structure for all the organisms chosen for research as is derived from the consensus sequence generated after MSA. The bound state and unbound state between the receptor and ligand molecules are determined by the concept of free energy in docking studies using drug discovery tool AutoDock 4.2.6. The negative and low value of binding energy indicates strong binding affinity between receptor-ligand and that the ligand is in the most favourable conformation otherwise it shows unbound state. Targeted docking with specific coordinates was performed at the active site of model ICL protein. Ishwarol showed the highest binding affinity and better than the three control drugs. Thus, ICL inhibition opens the door to the development of next-generation drugs like ishwarol which would help to eradicate and control the pathogenic microorganisms causing diseases. Phytochemicals chosen from important medicinal plants from various literature sources for inhibition of ICL allows alternative lead to that resistant drugs besides having lower side effects. Selection of phytochemicals was made easier by the ADMET screening tool. The most advantage of this in-silico work is that it leads to screening more efficient anti-ICL leads.

CONCLUSION

The enzyme Isocitrate lyase has become a potential candidate to study functional mechanisms and design drug. It is mostly because the enzyme is not found in mammals, giving a chance to defeat various disease across world. Structural studies revealed that the active site is present in the TIM-barrel like domain of the ICL, and thus can become potential target for molecular docking. Also, our secondary structure comparisons has made deep insight to the helices and sheets conservation, proving the above statement, but still a lot work is to be done. Molecular docking studies of phytochemicals binding to Isocitrate lyase, a key enzyme of glyoxylate cycle can become lead molecules for future drug development. Our docking studies have confirmed a tight binding of phytochemicals to model protein active site. Phytochemicals have shown effective and better binding affinity with ICL during our research as that of the controls or synthetic drug does. Also, the binding energy of the most phytochemicals are strongly matching with that of the controls taken, indicating a positive result towards the development of novel drugs. Such phytochemicals can become leads to develop more drugs to treat diseases like tuberculosis. Still, we consider that the general structure has not been revealed completely and further research requires to target the active site of the enzyme effectively and accurately. Finally, we have given the overall view of the potential of phytochemicals in targeting receptor ICL. In the future it may be possible to have phytochemicals as oral drugs that we have cited in this research paper.

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Table 1. List of Phytochemicals with Descriptors

S.no	COMPOUND NAME	PubChemID	LogP	Mol.Wt.	nHA	nHD	nRot	Vol
1	Alpha copaene	442355	4.884	204.35	0	0	1	239.69
2	Aristolactone	13821316	4.367	232.32	2	1	1	257.92
3	Beta caryophyllene	20831623	5.261	204.35	0	0	0	245.61
4	Beta elemene	6918391	4.79	204.35	0	0	3	251.53
5	Beta sitosterol	222284	7.663	414.7	1	1	6	482.07
6	Chelerythrine	2703	4.916	348.4	5	0	2	352.74
7	Chrysophanol	10208	4.158	254.24	4	2	0	256.4
8	Cinnabarone	15230226	5.212	528.6	7	4	11	555.06
9	Citlalitrione	6449926	2.669	330.4	4	0	0	344.87
10	Friedelin	91472	7.545	426.7	1	0	0	490.81
11	Gadain	100949515	3.87	352.3	6	0	3	343.34
12	Ishwarol	42608203	3.375	220.3	1	1	0	242.56
13	Jatamanin A	46211034	0.832	198.22	4	2	0	194.29
14	Lupeol	259846	7.291	426.7	1	1	1	490.81
15	Rhein	10168	3.524	284.22	6	3	1	271.34
16	Ursolic acid	64945	6.083	456.7	3	2	1	505.75
17	Vitexin	5280441	0.33	432.4	10	7	3	404.36
18	Itaconate	811	0.565	130.1	4	2	2	122.288
19	Nitropropionate	97978	0.643	147.13	5	0	4	135.921
20	Bromopyruvate	70684	0.035	166.96	3	1	2	100.826

Note: Log P Liphophilicity, Mol. Wt Molecular weight, nHA no. of H-acceptor, nHD no. of H-donor, nRot no. of rotatable bonds, Vol Volume

Table 2. List of Organisms with their PDB ID

Sr. No.	Organism Name	PDB ID
1	*Saccharomyces cerevisiae*	7EBC
2	*Candida albicans*	7EBE
3	*Magnaporthaeoryzae*	5E9F
4	*Aspergillus nidulans*	1DQU
5	*Fusarium graminearum*	5E9H
6	*Burkholderia pseudomallei*	3I4E
7	*Yersinia pestis*	3LG3
8	*Brucella Melitensis*	3P0X
9	*Bscillus cereus*	7CMX
10	*Escherichia coli*	1IGW
11	*Mycobacterium tuberculosis*	1F61

Table 3. Predicted Binding Energy using Autodock 4.2.6

CATEGORY	PHYTOCHEMICAL	BINDING ENERGY
HIGH	Ishwarol	-7.96

	Friedelin	-6.57
	Beta Sitosterol	-6.37
	Lupeol	-5.73
	Gadain	-5.45
	Jatamanin A	-5.44
	Citlalitrione	-5.38
	Alpha copaene	-5.36
	Beta caryophyllene	-5.02
NORMAL	Aristolactone	-4.89
	Chelerythrine	-4.6
	Ursolic acid	-4.55
	Beta elemene	-4.5
	Chrysophanol	-4.3
	Rhein	-4.24
LOW	Cinnabarone	-2.4
	Vitexin	-2
CONTROL	Itaconate	-4.34
	Bromopyruvate	-4
	Nitropropionate	-4.31

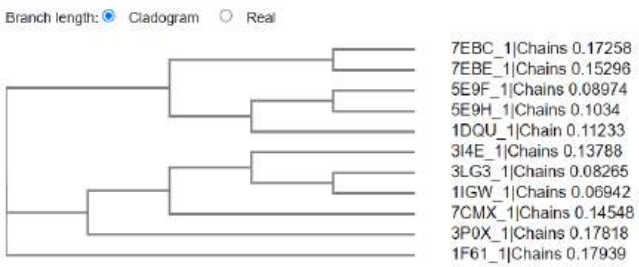


Figure 1. Phylogenetic tree

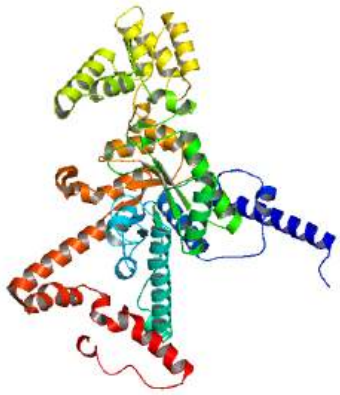


Figure 2. ICL monomer of *C. albicans*

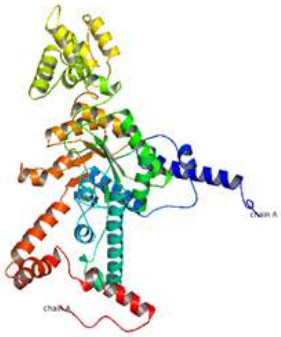


Figure 3. ICL monomer of model protein



Figure 4. Superimposition of model ICL and *C. albicans* ICL

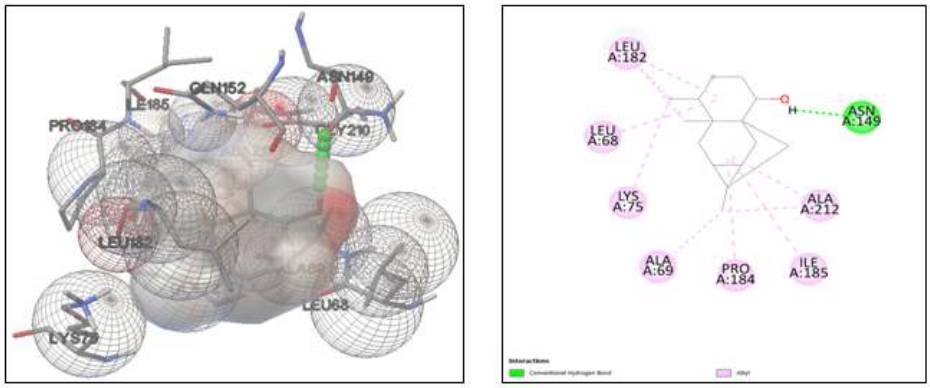


Figure 5. Ishwarol docked with ICL and its interactions

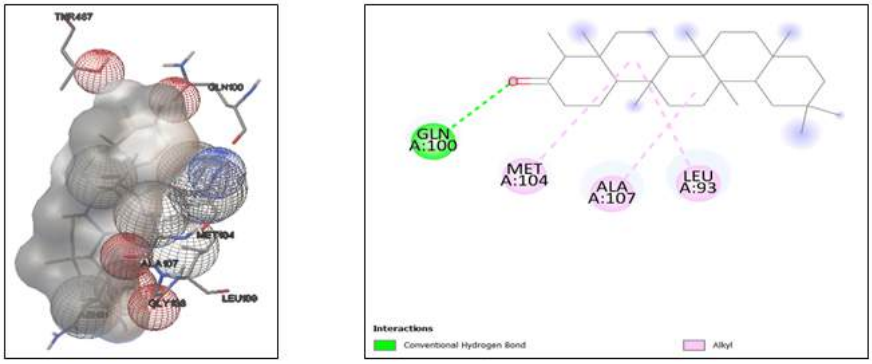


Figure 6. Friedelin docked with ICL and its interactions

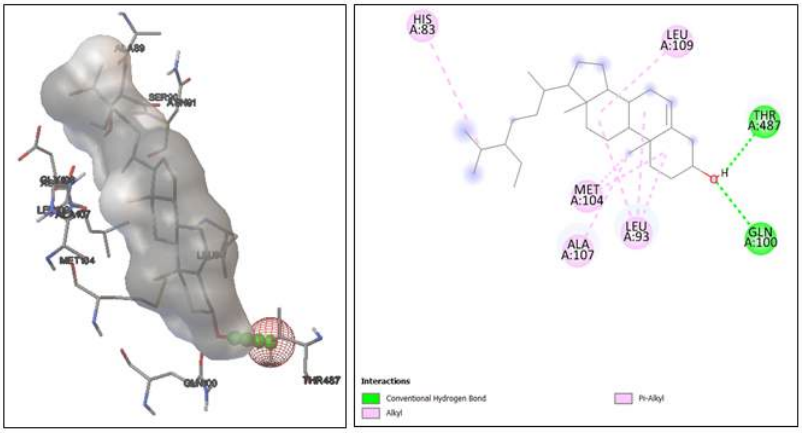


Figure 7. Betasitosterol docked with ICL and its interactions

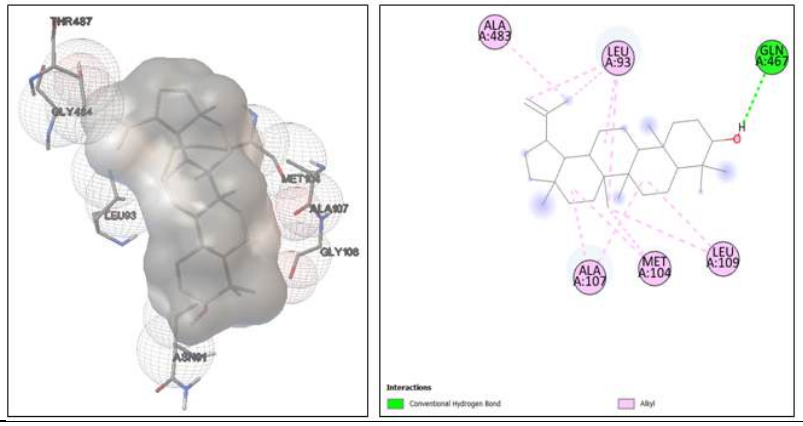


Figure 8. Lupeol docked with ICL and its interactions

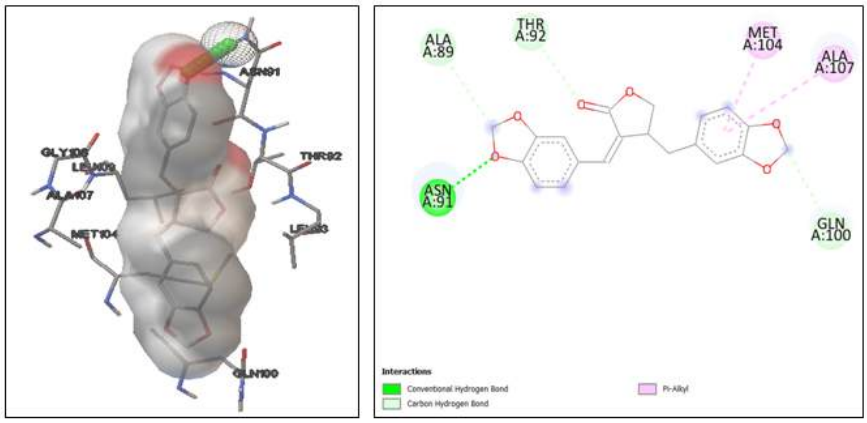


Figure 8. Gadain docked with ICL and its interactions

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RESEARCH ARTICLE

Age and Growth of *Bubblefin wrasse, Halichoeres nigrescens* (Bloch & Schneider, 1801 ; Labridae) from Gulf of Mannar, Southeast Coast of India

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ABSTRACT

Growth parameters of Bubblefin wrasse, *Halichoeres nigrescens* were estimated for the first time by using length frequency data using FiSAT software (several tools such as Powell-Wether all method, ELEFAN and von Bertalanffy growth estimates). Based on the progression of modes in the length-frequency data, these tools calculate the growth parameters such as asymptotic length ($L\infty$), growth coefficient (K) and t_0 (age at which fish would have had zero length). The maximum $L\infty$ values obtained in the present study are 157.50 mm for males and 154.88 mm for females. The t_0 values estimated for males and females were -0.1348 yr and -0.15631 yr, respectively. The estimated growth performance index (Ø′) values for males and females of *H. nigrescens* were 4.041 and 3.938 respectively. The life span of both the sexes was found to be 8 years. These growth parameters can be used effectively in studying the population dynamics, stock assessment and ecological pathway (ECOPATH) for ecosystem-based management of these fishes.

Keywords: Wrasse, Growth parameters, Life span, Length-frequency data, Gulf of Mannar

INTRODUCTION

Fisheries research aims to predict how well stock performs at the fishery level and its relation to the various degrees of fishing effort undertaken (King, 2007). Fishes are the largest and most diverse group of vertebrates considered as an important protein source for the growing human population and play an essential role in ecosystem services (Vieira, 2023). Age estimation studies provide information on fish life history characteristics that is essential for effective fishery management of resources (Cailliet et al., 2001). Fish growth involves complex physiological process (catabolism and anabolism), which are related to gains through the feeding (food and energy consumption) and losses (faeces, excretion and heat production) at individual level (Wootton, 1998). Changes over time in somatic growth rates have been documented for many fish taxa (Thorson and Minte-Vera, 2016) under biological and environmental conditions for greater understanding. Age and growth studies can in no way be neglected while dealing with population dynamics, fishery scouting, fishery forecasts and fishery surveys (Chugnova, 1963). Inaccurate age determination will have impact on the accuracy of population dynamics and future management of the fishery and species (Campana, 2001), serious over exploitation or under exploitation of the stock of a species, often through underestimating true age and producing optimistic estimates of the rates of growth and mortality (Laiding and Pearson, 2003) is important for a fishery. As the fields of genomics and bioinformatics continue to evolve, researchers are actively exploring innovative avenues for the age and growth assessment of fish (Vieira, 2023), in order to select the mathematical model, the understanding of the study species on its size range, fishery, habitat, ecology is a must for one who is applying equilibrium yield models to the management of a fishery (Mohanraj, 2000). Studies on age and growth rate of marine teleosts from Indian waters are largely based on length frequency distribution and the length frequency method which is a useful tool for providing the much-needed information for improving the fishery and management decision process. Even though studies with otolith have been undertaken for the establishment of age in Indian marine fishes, management measure like harvest control rule and the establishment of Minimum Legal Size for a fishery is mostly undertaken through the mathematical based modelling involving the length frequency data (Teena et al., 2021; Sivadas et al., 2017). In age and growth studies mathematical functions have been used to describe growth curves (Beverton and Holt, 1957; Ricker, 1975; Weatherley and Gill, 1987). The von Bertalanffys growth equation is widely used for determining growth from length distributions. Several graphical and computer-based routines such as LFSA (Sparre, 1987), COMPLEAT ELEFAN (Gayanilo *et al*., 1989), MULTIFAN (Fournier *et al*., 1990), LFDA (Kirkwood *et al*., 2001) and FiSAT (Gayanilo and Pauly, 1997) are also available to analyze single and multiple length-frequency distributions.

The family Labridae (wrasses) is highly diverse, with approximately 600 species in 82 genera distributed worldwide in both coastal and offshore waters, in tropical, subtropical and temperate regions (West neat and Alfaro, 2005). Labrid fish is mostly associated with the reef ecosystem (Wainwright et al., 2002) in undertaking its ecological services which are important for the healthiness of the reef. The study species, *H.nigrescens* commonly called as bubblefin wrasses and in the domestic aquarium trade it is known as "common wrasse" mainly due to its high availability and the common species among the labroid fish diversity in the coral reef ecosystems of Gulf of Mannar. These species are incidentally caught from the coral reef trap fishery where the fishermen target on food fishes (Snappers, emperors, groupers, goatfish, parrot fish and grunts) associated with reef system. Target fishing like skin diving coupled with small mesh size gill net covering the reef area and disturbing the fish resulting in snagging, wedging and entangling is collected for marine aquarium trade (Murugan and Durgekar, 2012). The occurrence of *H. nigrescens* from the by catch bottom trawlers has been observed in the Gulf of Mannar waters. Since labrid fishes exhibiting the scrapping behavior in the reef system assessing its population status is very much important which is linked to the health of the reef ecosystem in maintaining the coral reef – macro algal complex interactions. Through literature survey it revealed that growth studies on wrasses are limited (Currey and Simpfendorfer, 2009). Labrid fishes exhibit the protogyny (sex reversal pattern) as the usual pathway in the reproductive strategy (Cowen, 1990; Fairclough, 2005; Gillanders, 1995; Nakazono and Kusen, 1991; Sadovy et al., 2003; Westneat, 2001). The population structure of protogynous hermaphrodites has typically more females at smaller and younger age classes and more males at larger and older age classes (Currey and Simpfendorfer, 2009). Studies on age growth for fishes belonging to

the family Labridae has attracted researchers to undertake considerable research, which includes the examined the growth and reproduction of the wrasse, *Pseudolabrus celidotus* in New Zealand waters (Jones, 1980). Treasurer (1994) provided insight information on the distribution pattern, age and growth of wrasses *Ctenolabrus rupestris, Centrolabrus exoletus*, *Crenilabrus melops, Labrus bergyita,* and *L. mixtus* in the west coast of Scotland waters. Likewise, Gordoa *et al.,* (2000) analyzed the age and growth of four species of wrasses, *Labrus merula, Coris julis, Symphodus roissali* and *Symphodus tinca* from the north-western Mediterranean Sea. Welsford and Lyle (2005) estimated the growth rates for purple wrasse, *Notolabrus fucicola* inhabiting the east coast of Tasmanian waters. Vijayanand, (2006) evaluated the age and growth of *Thalassoma lunare* from Gulf of Mannar, Indian coastal waters. In view of relevance of growth parameters for fisheries management, the interest and inquisitiveness in studies on growth in tropical fishes have amplified, since tropical fisheries is very much complex and productive. Information available on the age and growth of wrasses from Indian waters is very much limited. Therefore, the present study was undertaken to garner the biological information like the maximum size, age and growth parameters of *H.nigrescens* from Gulf of Mannar, Southeast coast of India based on length frequency data to calculate vital demographic dynamic factors and to estimate the stock of these fishes which are having a great demand in the marine aquarium trade in the domestic market.

MATERIALS AND METHODS

Study area and sample collection

Fish individuals were collected monthly coral reef fish trap from landing centers of Killakarai, Gulf of Mannar (11.9416° N to 79.8424° E) during January 2022 to December 2022; however, no sampling was done in May due to fishing holiday declared by the government. The fishes were identified following (Murugan and Namboothri, 2012) and the measurements were taken following the method suggested by Hubbs and Lagler (1964). The samples were brought to the laboratory and cleaned in tap water. Male and female individuals were identified by examining the gonads by cutting the body cavity. A total of 1285 specimens of *H. nigrescens* (males and females) total length (TL) ranging from 7.0cm to 14.9cm were analyzed. The length frequency data for males and females of each sampling were grouped in 5mm class intervals. The total length (TL) of each fish was measured from the anterior-most edge of the snout to the posterior-most edge of caudal fin to the nearest mm with a measuring board. Weight (W) was measured to the nearest 0.1 g by an electronic balance (Roy Electronic balance) after draining the water from the buckle cavity and wiping the moisture content on the body of fish. Fish with damaged caudal fin were discarded.

Age and growth estimation

Size frequency data were collected on a monthly basis and the obtained data has been classified into size classes and those data were subjected to the non-parametric method which passes through the greatest number of modes, giving estimates of L_∞ and *K* (Wetherall 1986). Powell-Wetherall method (Beverton and Holt 1956) was used to calculate the ratio of total mortality and growth coefficient (Z/K) as an initial estimate of asymptotic length (L_∞). Gulland and Holt plot (1959) was used to study the growth increment data to estimate Lα and K. Length frequency data were then analyzed by Electronic Length Frequency Analysis (ELEFAN I) (Pauly 1980; Pauly 1983) using the appropriate routines in FiSAT II package for growth estimation. In this method the growth parameters, asymptotic length (L_∞) and growth coefficient (K) were estimated following the von Bertalanffy growth equation (Wetherall 1986):

$L_t = L_\infty [1 - e^{-K(t-t_0)}]$

Where L_t is the length at age t, L_∞ is the asymptotic length in cm, K is the growth coefficient and t_0 is the age at which fish would have had zero length if they had always grown according to the above equation. Parameters of L_∞ and K were computed from the ELEFAN I. The t_0 value from the length-frequency data cannot be estimated by ELEFAN, t_0 is estimated by substituting the L and K in the following equation:

$\log(t_0) = -0.176 + 0.260 \log L - 1.0 \log K$

Growth performance index was calculated by the equation (Pauly & Munro 1984):

$\Phi = \log_{10}K + 2\log_{10}L_\infty$

Longevity was estimated from the following equation (Pauly 1983):

$t_{max} = 3/K + t_0$

RESULTS

The sub adults (7.6cm) were dominant during the month of June whereas the largest one was represented during the month of April (14.9cm). For males, the smallest sized group was represented during July (7.0 cm) and the largest during April (13.2 cm). Powell-Wetherall plots for the estimation of L_∞ and Z/K showed that the L_∞ values obtained for males and females were of *H. nigrescens* were 157.50mm and 153.54mm respectively. The alignment of points on the straight line was quite satisfactory with a good coefficient of correlation (0.999) (Fig. 2). The optimized growth parameters (L_∞ and K) and the goodness of fit index (Rn) obtained for males and females of *H. nigrescens* by ELEFAN I method in the FiSAT II package are given in Table 1. The non- seasonalized length frequency histograms of growth curves for males and females of *H. nigrescens* are shown in (Fig. 3). The automatic search routine in FiSAT II Package derived the L_∞ and 'K' values of 157.50 mm and 1.0 yr^{-1} for males and 154.88 mm and 1.0 $yr^{-1}$for females respectively, whereas the K-scan routines gave the values of 157.50 mm and 0.31 yr^{-1} for males and 154.88 mm and 0.45 yr^{-1} for females respectively. The growth parameters obtained for males and females of *H. nigrescens* by Appledoorn's method using the growth increment data proved that the asymptotic length obtained for males and females of *H. nigrescens* were 156.80 mm and 154.90 mm and the values of K were 0.31 and 0.46 yr^{-1} respectively (Fig. 4). The growth data obtained in the present study showed that the *H. nigrescens* have a life span of 8 years for males and 7+ years for females. The age at growth data showed that the males grow about 66mm (I year), 98mm (II year), 119mm (III year), 132mm (IV year), 140mm, 146mm (V year), 149mm (VI year), and 151mm (VII year) and 156mm (VIII year) for males. Similarly females grow 54 mm, 81 mm, 102 mm, 116mm, 127 mm, 138 mm, 151 mm and 158 mm during first, second, third, fourth, fifth, sixth, seventh and eighth years respectively (Table 3 and Fig.14 a and b) represents the growth curve of *H. nigrescens.* The t_0 values estimated for males and females were -0.1348 yr and -0.15631 yr, respectively. The estimated growth performance index (Ø') values for males and females of *H. nigrescens* were 4.041 and 3.938 respectively. Ø' value is index for comparing the growth performance of organisms in terms of their growth length.

DISCUSSION

Fisheries science and management rely heavily on accurate assessments of age and growth in fish populations (Vieira, 2023), for undertaking future management tools like harvest control rule, Minimum Legal Size for exploitation and defining conservation strategy for reef associated fishery. Stock evaluation has become a critical management technique for determining fish development and mortality in the wild (Jennings et al., 2001). Coral reefs are distinguished by their tremendous diversity and the ecosystem services they provide to the artisanal sector, food security, to combat climate change in the tropical nations are very high (Hughes et al., 2003; Spalding and Brown, 2015). Although all fisheries are multispecies and spatially heterogeneous, coral reef fisheries are an extreme in both respects (Medley et al., 1993). However, more than 80% of the shallow reefs worldwide are severely exploited because of the increasing demand for quality protein (Manikandan et al., 2014), since these shallow water resources are easily approachable to the traditional communities which the traditional gear (Murugan and Durgekar, 2012). Labrid fishes are not considered as food fishes in India, except Napolean wrasse (*Chelinus undulatus*), whereas huge demand for wrasses (bubble fin, checker board, queen, rainbow, bicolor, moon, peacock, cleaner, six bar etc.,) in the domestic market exits in India, because of such huge pressure is mainly due to Gulf of Mannar water is the only region which is facilitating reef fishes for the marine aquarium trade. Since traditional fishing like coral reef fish trap and gill net operated for ornamental reef fish collection, trammel net and bottom set gill nets are deployed in the reef and near to the reef ecosystem by the traditional fishing communities. Since the traditional fishing sectors are involved in fishing with different gears based on the seasonality, the information pertaining to the biology of these reef fishes is important for the establishment of conservation efforts and management plan for conserving the reef fishes in Gulf of Mannar waters. The results documented the age and the growth of *H. nigrescens* which has considerable proportion of the population along Gulf of Mannar region and which is consider as the dominant

species under the labroid fishes. In the present study, growth parameters L∞ and k values estimated by Powell-Wether all methods, Apple doorn's method and ELEFANI are comparable. The maximum L∞ values obtained in the present study are 157.50 mm for males and 154.88 mm for females. Ebisawa *et al*., (2010) estimated the growth parameters of blackspot tuskfish *Choerodon shoenleinii* and he reported the L∞ = 68.1 (cm), k = 0.263, and t0 = -0.023 (year). Artüz (2005) estimated the age and growth parameters of the wrasse *Labrus bergylta* as L∞= 727.94 mm. k = 0.141 and t_0 = 1.35 mm. Pallaoro and Jardas (2003) estimated the maximum life span of *Symphodus tinca* as 13 years for males and 12 years for females. The present work also confirmed that *H. nigrescens* grows up to a size of 149mm and it has maximum life span of 8 years. Sayer, *et al.,* (1996a,b) estimated the maximum age and total length for goldsinny, *Ctenolabrus rupestris* as 20+ years and 159mm, for rock cook *Centrolabrus exoletus* it was estimated as 8+ years and 165mm and similarly for corkwing, *Crenilabrus melops* it was 6+years and 212mm. From the present study it is clear that *H. nigrescens* generally grow up to a size of 140 mm approximately and the maximum size group recorded during our study was 149 mm. The catabolic growth rate (K) was 0.310 for males and 0.450 for females. The present study also revealed that the growth rate was high during the first year and decreased during the second, third, fourth, fifth, sixth, seventh and eighth year. Studies on age and growth of wrasse fishes were limited and hence the present work was useful to highlight the age and growth parameters of *H. nigrescens*.

Vijayanand, (2006) estimated the length at age of *Thalosomma lunare* in Gulf of Mannar region by von Bertalanffy's growth equation and he reported that the length of this fish varies from up to 130.06mm (1 year) to 213.52mm (4 year). The maximum size recorded was 223mm. The length at age estimation of *H. nigrescens* by von Bertantalanffys growth estimation of females was found to vary from 54mm (I year) to 146 mm (VIII year) and similarly for males, the size ranged from 66mm (I year) to 151mm (VIII year). The growth parameters of *H. nigrescens* showed significant from the wrasse species of other regions, whereas variation in growth may be due to the ecological condition and food availability (Elizarov, 1965, Weatherley and Gill, 1987). Treasurer (1994) reported that the maximum life span of wrasse *Ctenolabrus rupestris* was 16 year, 9 year for *C. exoletus*, 5 year for *C. melops*, 15 year for *Labrus bergylta* and 11 year for *L. mixtus*. Growth was more rapid prior to maturation in all species. The von Bertalanffy growth model fitted data for *C. rupestris* and *C. excletus, C. rupestris* and *C. exoletus* showed that the males were significantly larger than females in most age groups. Even though *H. nigrescens* and *T. lunare* belongs to the same family and collected from same area and habitat, *H. nigrescens* showed slow growth performance with more life span (8 years) while *T. lunare* showed high growth performance with low life span (4+ years). *T. lunare* attained maturity at earlier stage and have accelerated growth because of its shortest life span (Vijayanand, 2006). According to Munday *et al.,* (2009), in protogynous sex-changing fishes, females are expected to compete for the opportunity to change sex following the loss of a dominant male and may exhibit growth and behavioural traits that help them to maintain their dominant status after sex. Age and growth information provided here for *H. nigrescens* for population existing in Gulf of Manar water will provide the insight information for policy makers and enforcement department in formulating conservation measures for reef fishes in a larger perspective.

India is a highly biodiverse nation with coral distributed on both sides of the coast, with huge diversity of marine ornamental reef fishes (Ajithkumar et al., 2011; Murugan and Namboothri, 2012). Although, nearly 400 species of marine ornamental fishes belonging to 175 genera and 50 families are known to occur in India's marine ecosystems (Ajithkumar et al., 2011; Murugan and Namboothri, 2012; Venkatramani et al., 2004). Despite these huge resources the marine aquarium fish trade did not prosper mainly due to required technology (sustainable catching techniques, transportation, disease control, water quality requirements), whereas the industry gained importance in the domestic level and as of now gaining popularity and becoming an important facet of the fisheries sector (Prakash et al., 2017). The main hindrance related to marine ornamental fish export is due to the limited assess to harvest reef fishes sustainability from reef patches of Laccadives and Andam and Nicobar waters which would have diversified the species diversity. The Gulf of Mannar Marine Biosphere Reserve (henceforth GOMMBR), on the south-east coast of India is the only coral reef region within the country that is meeting the demand for marine ornamental taxa for whatever trade is existing in India (Murugan and Durgekar, 2012; Prakash et al., 2017). India did not appear on the list of countries that export marine aquarium fish to the US (Rhyne et al., 2012), mainly due to lack of initiative from Marine Product Export Development Authority to trap the valuable resources which would have had a livelihood

upliftment to the traditional fishing communities. Collection of marine ornamental fishes always had the conflict with the state forest department of the Gulf of Mannar National Park, despite that collection of marine ornamental fishes happens from the Gulf of Mannar National Park region. In this situation enforcing of licensing policy (certification system) should be initiated with the help of local fishers who solely depend on collection of marine ornamental taxa for their livelihood (Murugan and Durgekar, 2012; Prakash et al., 2017; Nair and Kuriakose, 2014;). Banning the fishing of a fishery resource (renewable) in a particular area is not going to end in the fisheries sector and policy makers needs to think about sustainable utilization of the resource for conservation and livelihood support, because resource need to be utilized rather than protecting them under the umbrella of coral reef, since these resources are not available in the other areas. Hence, size -based limit could be extended to prevent the catch of large size fishes to ensure that adequate numbers of brooders are left on the reef (Wood, 2001), sustainable measures need to be developed and incorporated as part of the Gulf of Mannar Biosphere Reserve Management Plan, thus focusing on the improvement of the livelihood of fishermen, without addressing the livelihood issues conservation measures will not be achieved. Providing resolving fund at the village level can't be considered as an initiative for marine biodiversity conservation, if any livelihood developed through those initiative will be only considered as additional income to the community. The present study provides information about the age and growth of a common wrasse species which is found to occur in the Gulf of Mannar region. To improve the management of resources of exploited for the marine ornamental fish resources for aquarium trade, complete understanding on the individual species' life history (breeding, growth, recruitment etc.), and ecology is necessary (Prakash et al., 2017). Hence the present study is important to address the issues related to streamlining the marine ornamental fisheries for labroid group fishes.

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AUTHOR CONTRIBUTIONS

Conceptualization, Methodology, Data Collection: PR, AM; Data Analysis: PR, AM; Writing Original Draft: PR, AM, GM; Writing Review and Editing: AM, GM, SR. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

DATA AVAILABILITY

All relevant datasets supporting the conclusions of this article are included within the article.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of financial or non-financial interests that could have influenced the outcome or interpretation of the results.

ETHICAL STATEMENT

No ethical approval is required as the study does not include activities that require ethical approval or involve protected organisms/ human subjects/ collection of samples/ protected environments.

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Table 1: Growth parameters of males and females of *H. nigrescens* obtained from different methods through length frequency data

Methods	Sex	L_∞(mm)	Z/K	K(yr^{-1})	Rn Score
Powell-Wetherall	Males	157.50	2.250		
	Females	153.54	1.789		
ELEFAN I Automatic scan	Males	157.50		1.0	0.145
	Females	154.88		1.0	0.198
K-scan	Males	157.50		0.310	0.238
	Females	154.88		0.450	0.254

Table 2. The growth data obtained age at length of males and females of *H. nigrescens* by using von Bertalanffys equation

Age	Males (mm)	Females (mm)
1	66	54
2	98	81
3	119	102
4	132	116
5	140	127

6	146	135
7	149	141
8	151	146



Fig. 1. Bubblefin wrasse, *Halichoeres nigrescens* (Bloch & Schneider, 1801) collected from Gulf of Mannar, Southeast Coast of India.

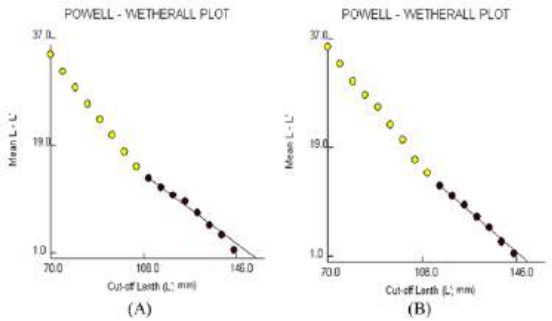


Fig. 2. Powell-Wetherall plot for males (a) and females (b) of *H. nigrescens* from Killakarai, Gulf of Mannar Southeast Coast of India.

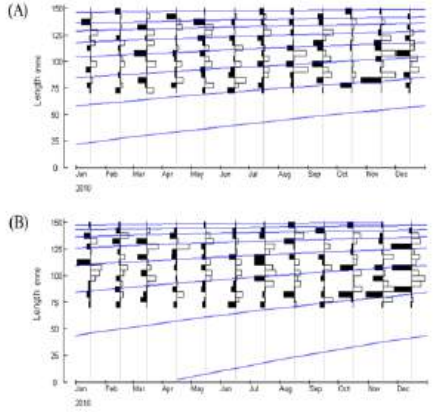


Fig. 3. Growth curve for males (a) and females (b) of *H. nigrescens* during January 2022 to December, 2022 obtained through ELEFAN I of FiSAT II package.

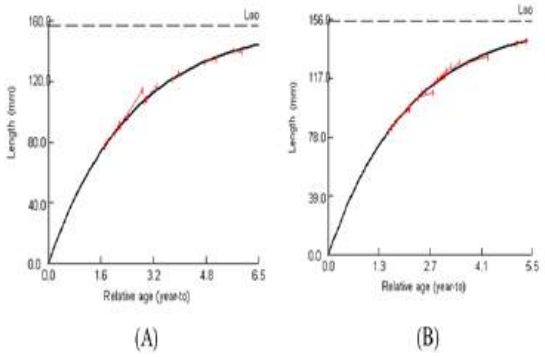


Fig. 4. Appledoorn's plot of *H. nigrescens* males (a) and females (b) of *H. nigrescens* during January 2022 to December 2022

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RESEARCH ARTICLE

Antioxidant Effect of Chlorogenic Acid Loaded Chitosan Nanoparticles: An *in vitro* Approach

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ABSTRACT

Chlorogenic acid possesses diverse pharmacological and biochemical effects. Recent studies have explored its antidiabetic, anti-inflammatory and antioxidant effects in experimental animal models. However, the poor solubility nature of this compound has been associated with its low bioavailability and therapeutic efficacies. Thus, the present study synthesized chlorogenic acid loaded chitosan nanoparticles (CACNP) to improve its bioavailability and therapeutic effects. The present study investigated has the *in vitro* free radical scavenging efficacies of CACNP using a spectrum of *in vitro* free radical scavenging assays. Ion gelation method was employed to synthesize chlorogenic acid loaded chitosan nanoparticle. The size of the synthesized nanoparticles was analyzed using a zeta sizer, and their shape was investigated with scanning electron microscopy (SEM).The present study observed a significant ability of CACNP in scavenging DPPH, ABTS, hydroxyl, superoxide, hydrogen peroxide and nitric oxide radicals under *in vitro* conditions. The antioxidant potential of CACNP would help to study its antitumor efficacy in experimental animal models.

Keywords: Antioxidants, Chlorogenic acid, Chitosan, Free radicals.

INTRODUCTION

Reactive oxygen species (ROS), at physiological concentrations, have been involved in the stimulation of immune system, regulation of cell differentiation and proliferation as well in several cell signaling pathways. A second messenger role for ROS in certain signaling pathways have also been documented[1].Reactive oxygen species especially hydroxyl and superoxide radicals would try to become stable radicals through electron pairing with DNA, proteins and lipids[2].Most human diseases develop as a result of oxidative stress, a condition arises when imbalance occurs between oxidant and antioxidant status in the human body. Accumulation of ROS in the body can lead to several diseases including malignant neoplasm[3].Human antioxidant defense mechanism are, however, stimulated to alleviate the harmful effects of excessively generated ROS by donating electrons to ROS [4]. Antioxidants are substances that have vast ability to protect the cells from oxidative damage by donating electrons to the reactive oxygen species, thereby terminating free radical mediated cellular damage as well as damage to proteins and nucleic acids [3,4]. Natural antioxidants present in medicinal plants, herbs, fruits and vegetables would combat the deleterious effects of ROS by inhibiting the continuous abstraction of hydrogen as well as by preventing the chain initiation of lipid peroxidation [5]. Thus, high intake of natural antioxidants could protect the human body from oxidative stress mediated pathological diseases. Several studies warranted a search for substances with potent antioxidant effect from naturally occurring medicinal plants or herbs. Medicinal plants are focused to have a spectrum of bioactive principles such as flavonoids and polyphenols with multiple pharmacological effects including antioxidant property[6,7]. Chlorogenic acid, a bioactive phytoconstituents, is present in several plants, fruits and vegetables. Chlorogenic acid is present at higher concentrations in plants such as *Hibiscus sabdariffa* and *Calluna vulgaris*. It is also rich in spinach, sweet potatoes, berries, lettuce and apples[8]. A large number of studies reported its multiple pharmacological efficacies including hepatoprotective, antioxidant, anti-inflammatory and antitumor properties [9-11]. Neelakandan et al.[12]investigated the antitumor effectiveness of chlorogenic acid-loaded chitosan nanoparticles in an experimental model of skin carcinogenesis.Rui et al.[13] reported the *in vitro* superoxide and ABTS scavenging activities of chlorogenic acid-chitosan conjugates. Kavi Rajan *et al*. [14] revealed the DPPH radical scavenging efficacy of chlorogenic acid-chitosan nanoparticulate. This study evaluates the radical scavenging effect, DPPH, ABTS, hydroxyl, nitric oxide,superoxide and hydrogen peroxidepotential of CACNP under in vitro conditions.

MATERIALS AND METHODS

Chemicals

The biochemicals, and chemicals required for the present study were purchased from Hi Media Laboratories, India; Sigma-Aldrich Private Limited, India; and SD Fine Chemicals, India.

Synthesis and characterization of chlorogenic acid loaded chitosan nanoparticles

Ionic gelation approach proposed by Calvo et al. [15] was used to synthesize CACNP. The chitosan polymer was first dissolved in acetic acid and chlorogenic acid was then added to the chitosan solution in the ratio of 1:3. This mixture was stirred continuously for 60 minutes. To achieve the formation of nanoparticles, sodium tripolyphosphate (TPP) was added in a drop wise manner to the chitosan chlorogenic acid mixture in the ratio of 4:1 and stirred continuously for 60 minutes. The free chlorogenic acid and chlorogenic acid nanoparticles were separated using ultracentrifugation at 15,000 rpm for 45 to 60 minutes.The lyophilized nanoparticles were subsequently used to evaluate their in vitro free radical scavenging activity and effects.

Free radical scavenging assays

DPPH radicals

Blois [16]procedure was employed to examine the DPPH radical scavenging ability of CACNP. This method helps to assess the hydrogen atom donating ability of the test compound, which is assessed by its ability to decolorize methanolic DPPH (purple colour) to yellow colour. The ability of CACNP (10-50 μg/ml) in decolorizing the

methanolic solution of DPPH was spectrophotometrically read at 517 nm. Ascorbic acid served as a comparative reference drug. The formula was utilized to calculate the percentage of DPPH radical scavenging effect. The procedure was repeated thrice for each concentration of the control and test samples.

$$\frac{\text{Control absorbance} - \text{Test absorbance}}{\text{Control absorbance}} \times 100$$

ABTS radicals

Miller et al. [17]method is used to assess the ABTS radical scavenging efficacy of CACNP. This method relies on the principle of generating the ABTS radical cation through the reaction between ABTS and potassium persulfate. This reaction generates a bluish green chromogen which was decolorized to ABTS by the antioxidant and was read at 734nm.

Superoxide radicals

The method of Nishikimi *et al.* [18] was employed to measure the superoxide radical scavenging potential of CACNP. In this method, the superoxide radical generated during NADH oxidation, which is present in the PMS/NADH (phenazine methosulfate - nicotinamide adenine dinucleotide) system, reduces nitroblue tetrazolium to form a purple color. The absorbance of this purple color is measured at 560 nm.

Hydroxyl radicals

This assay was conducted following the procedure of Halliwell et al. [19]. This method is based on the inhibition of 2-deoxyribose oxidation by hydroxyl radicals generated from the ferric chloride - ascorbic acid – ethylene diaminetetra acetic acid (EDTA) and hydrogen peroxide system.

Nitric oxide radicals

Ebrahimzadeh *et al*. [20] procedure was used to examine the nitric oxide scavenging efficacy of the CACNP. This method relies on the ability of the test compound to reduce the quantity of nitrite formed between oxygen and nitric oxide, which are generated from sodium nitropruside. The nitrite reacts with the Griess reagent and forms a red pink colour, which was read at 546nm.

Hydrogen peroxide decomposition

The hydrogen peroxide decomposition potential of CACNP was measured according to the procedure of Jayaprakasha *et al.*[21].This method evaluates the hydrogen peroxide scavenging efficacy of the test compound by examining the disappearance of hydrogen peroxide at 230 nm.

Statistical analysis

Graphical calculation was done to find out the IC_{50} concentration of the test compounds. Student's t-test were utilized to find the statistical significance between the groups. The two groups are considered statistically significant at $p<0.05$.

RESULTS AND DISCUSSIONS

Particle size of nanoparticles

The present investigation observed a mean size of CACNP as 138.9 nm with polydispersity index (PDI) of 0.229. The particle size of the nanoparticles measured with the Zetasizer closely resembled the particle size observed in scanning electron microscopy measurements (137.14 nm).

***In vitro* free radical scavenging effect of CACNP**

Free radical scavenging efficacy of CACNP was compared with the standard reference drug ascorbic acid by carrying out the spectrum of *in vitro* free radical scavenging assays. The DPPH scavenging activity of CACNP and ascorbic acid is presented in figure1. CACNP scavenges DPPH radicals effectively at an increasing concentration similar to that of ascorbic acidat each concentrations. The IC_{50} for the DPPH scavenging potential was found to be 36.2 µg/ml (CACNP) and 39.7 µg/ml (Ascorbic acid) respectively. Several in vitro antioxidant tests are accessible for evaluating the ROS scavenging capacity of test compounds. The DPPH radical scavenging assay is commonly used to assess the antioxidant properties of a test compound [22]. Ascorbic acid, butylated hydroxytoluene, and gallic acid are the most common reference antioxidants utilized in *in vitro* free radical scavenging assays to compare the antioxidant efficacy of the test compound. The antioxidant natures of these compounds are validated through their reducing capacity, preventing chain initiation of lipid peroxidation, eliminating hydrogen peroxide and scavenging ROS [22,23]. The present study noticed a potent DPPH radical scavenging ability of CACNP and the antioxidant efficacy was very much nearer to that of standard drug. The results thus show that chlorogenic acid has the vast potential to donate hydrogen to the DPPH radicals. The ABTS scavenging activity of CACNP and ascorbic acid is presented in figure 2. CACNP scavenges ABTS radicals effectively at an increasing concentration similar to that of ascorbic acid at each concentrations. The IC_{50} for the ABTS scavenging potential was found to be 26.2 µg/ml (CACNP) and 27.8 µg/ml (Ascorbic acid) respectively. ABTS assay measures the total antioxidant capacity of the test compound [23]. This method assesses the antioxidant efficacy of the test compounds by their ability to inhibit the generation of ABTS radicalcation. It has been reported that phenolic compounds showed a potent ABTS radical scavenging property[22,23]. CACNP has been found to have potent ABTS radical cation generation inhibitory effect due to their phenolic hydroxyl groups. The results of this study observed that CACNP has revealed a similar ABTS scavenging efficacy to that of standard drug. Therefore, the current study focused on evaluating the free radical scavenging capability of CACNP under in vitro conditions.

The superoxide scavenging activity of CACNP and ascorbic acid is presented in figure 3. CACNP scavenges superoxide radicals effectively at anincreasing concentration similar to that of ascorbic acid at each concentrations. The IC_{50} for the superoxide scavenging potential was found to be 21.4 µg/ml (CACNP) and 23.5 µg/ml (Ascorbic acid) respectively. Superoxide radical, a reduced form of oxygen, has been pointed out as a harmful radical that can able to cause severe oxidative damage to the biomolecules through the formation of hydroxyl radicals or hydrogen peroxide [22,24]. Oxidative damage to biomolecules has been recognized as the major pathological phenomenon in the development of several diseases [2]. The present observation revealed the dose dependent, in an increasing concentration, superoxide radical scavenging potential of CACNP, which mimics the scavenging efficacy of ascorbic acid. The study thus noticed an effective superoxide scavenging potential of CACNP under *in vitro* conditions. The hydroxyl scavenging activity of CACNP and ascorbic acid is presented in figure 4. CACNP scavenges hydroxyl radicals effectively at an increasing concentration similar to that of ascorbic acid at each concentrations. The IC_{50} for the hydroxyl scavenging potential was found to be 30.5 µg/ml (CACNP) and 32.2 µg/ml (Ascorbic acid) respectively. Hydroxyl radical accumulation has been regarded as a major threat to induce several damages to biomolecules especially to DNA, thereby resulting in several diseases including carcinogenesis [25]. In this study, hydroxyl radicals are effectively eliminated by CACNP under *in vitro* conditions and the scavenging efficacy was closer to that of ascorbic acid. The nitric oxide scavenging activity of CACNP and ascorbic acid is presented in figure 5. CACNP scavenges nitric oxide radicals effectively at an increasing concentration similar to that of ascorbic acid at each concentrations. The IC_{50} for the nitric oxide scavenging potential was found to be 17.3 µg/ml (CACNP) and 18.3µg/ml (Ascorbic acid) respectively. Nitric oxide has been reported to play a vital role in the cell signaling pathways of both normal physiological and in pathological conditions. Deregulation of nitric oxide production has been implicated in the oxidative stress mediated cell death, and DNA damage [25]. This study noticed that CACNP have the ability to effectively scavenge the nitric oxide radicals under *in vitro* conditions. The scavenging effect was increased as the dose of CACNP was enhanced and the nitric acid radical scavenging effect of CACNP was much comparable to that of ascorbic acid. The hydrogen peroxide scavenging activity of CACNP and ascorbic acid is presented in figure 6. CACNP scavenges hydrogen peroxide radicals effectively at an increasing concentration similar to that of ascorbic acid at each concentrations. The IC_{50} for the hydrogen peroxide scavenging potential was found to be 18.2 µg/ml

(CACNP) and 15.4 µg/ml (Ascorbic acid) respectively.Hydrogen peroxide is converted into hydroxyl radical in the presence of Fe^{2+} inside the cell and its accumulation has been documented as a potential threat to the cell and may prone to pathogenesis of carcinogenesis [23,25]. Its overproduction may cause protein damage by mediating oxidation of thiol groups. The present results showed a potent hydrogen peroxide elimination activity of CACNP under *in vitro* conditions and the effect was much similar to that of ascorbic acid. In the present study the antioxidant efficacy of the CACNP and ascorbic acid was examined with the help of DPPH, ABTS, hydroxyl, nitric oxide, and superoxide radical scavenging assays as well as with hydrogen peroxide decomposition potential under *in vitro* conditions. The present study observed that CACNP has a potent antioxidant property and its effect was much comparable or closer to that of ascorbic acid.

CONCLUSION

The present study thus reveals the antioxidant property of CACNP under *in vitro* conditions. Further studies will be conducted to explore the anticancer efficacy of CACNP using experimental animal model by analyzing spectrum of biomarkers related to carcinogenesis.

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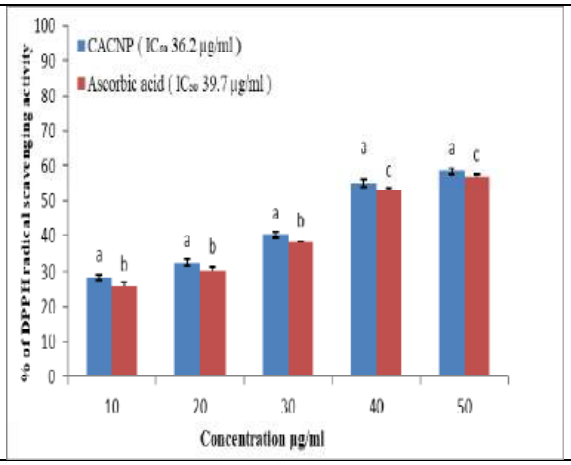


Figure 1: Effect of CACNP and ascorbic acid on scavenging DPPH radicals. Two different superscripts are statistically significant at $p < 0.05$

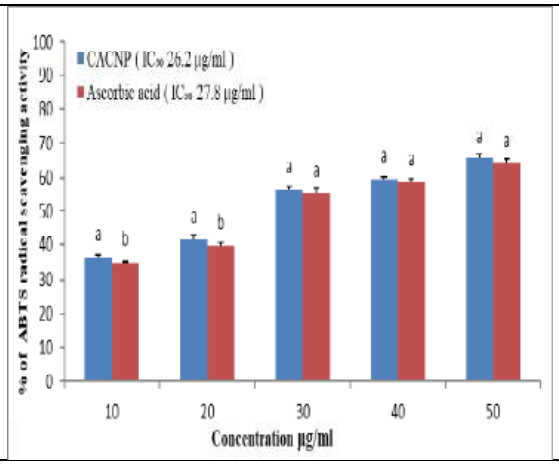


Figure 2: Effect of CACNP and ascorbic acid on scavenging ABTS radicals. Two different superscripts are statistically significant at $p < 0.05$

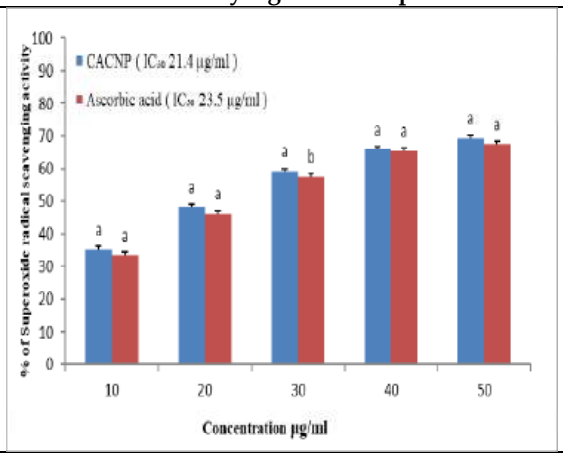


Figure 3:Effect of CACNP and ascorbic acid on scavenging superoxide radicals. Two different superscripts are statistically significant at $p < 0.05$

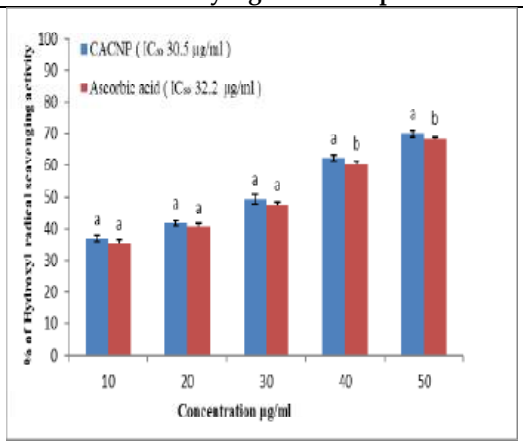


Figure 4:Effect of CACNP and ascorbic acid on scavenging hydroxyl radicals. Two different superscripts are statistically significant at $p < 0.05$

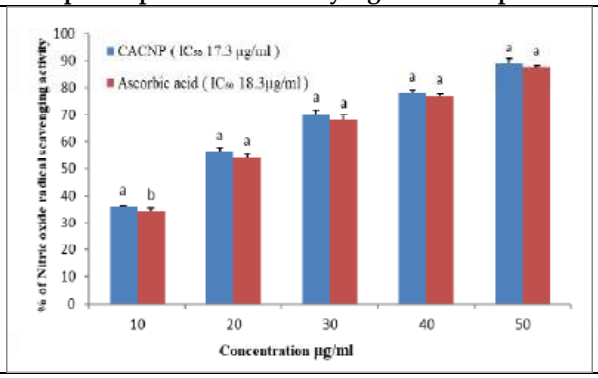


Figure 5:Effect of CACNP and ascorbic acid on scavenging nitric oxide radicals. Two different superscripts are statistically significant at $p < 0.05$

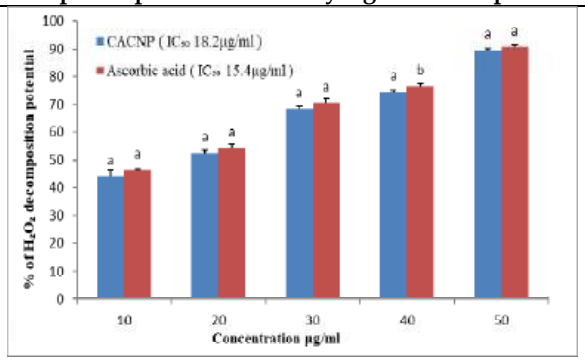


Fig. 6:Effect of CACNP and ascorbic acid on hydrogen peroxide decomposition potential. Two different superscripts are statistically significant at $p < 0.05$

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RESEARCH ARTICLE

Isolation and Characterization of Isoprenoids from Bark Extracts of *Casuarina equisetifolia*

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ABSTRACT

Casuarina equisetifolia belonging to the family *Casuarinaceae*, a tropical plant commonly called as horse tail in English, savukku marram in Tamil is used traditionally for the treatment of nervous disorders, acne, throat infections, stomach ulcer, constipation, cough, diabetes, diarrhea, dysentery, gonorrhea in Ayurveda. The plant is widely used in construction sites. This research focuses on isolating isoprenoids from the Bark Extracts. The 24 Noroleana 3,12 diene, Beta amyrone, 1,2 – Benzenedicarboxlyic acid, butyl-2-ethylhexy, Bis (2-ethylhexyl)phthalate and Lupeol were the bioactive components obtained in the preliminary analysis. 24 Noroleana 3,12 diene, Beta amyrone belonged to the isoprenoid group. The isoprenoids exhibit anti-inflammatory effect. The isoprenoids exhibit anti-inflammatory effect. The bark extracts contained phytochemicals like Flavonoids, Phenols, proteins, amino acids, resins, alkaloids, tannins, phytosterols and terpenoids. The extract exhibited anti-bacterial activity anti-oxidant activity of 0.0028%. The preliminary components were docked against TNF protein (PDB:4RSU) the binding energies were obtained. Beta amyrone exhibited binding energy of -7.1 and 24 Norolena 3,12 diene exhibited binding energy of -6.4. Both the components had exhibited binding energy higher than the binding energies of the anti-inflammatory drugs found in market like Diclofenac (-6.4) and Aspirin (-5.4). The refined extracts exhibited anti-inflammatory effect with IC_{50} being 84.72 for ethyl acetate extract and 108.41 for hexane extract. The components obtained were Palmitic acid TMS, Dihydrophytol TMS, Octadecanal, Heptadecanenitrile and Stearic acid TMS .These components were docked against TNF protein (PDB:4RSU).The compounds isolated exhibited ADME properties making it viable to be translated as an anti-inflammatory drug in future.

Keywords: *Casuarina equisetifolia*, Flavonoids, Terpenoids, Anti-Inflammatory Activity

INTRODUCTION

Casuarina equisetifolia L. (family - *Casuarinaceae*) is predominantly a monoecious species which distributed along the coastal region of Parangipettai, Southeast coast of India. It is commonly known as beach she-oak, coast she-oak, beefwood, common ironwood, Australian pine, whistling-pine and it's native to the tropical and subtropical coastlines of Australia, Southeast Asia, Malaysia, Melanesia, Polynesia and New Caledonia. This plant has the capability of growing in a wide range of soil conditions particularly on coastal and on limestone soils near the shore. It is a tall, fast-growing tree that can, in as little as 12 years, reach up to height of 20 m (66 ft.). *Casuarina sp*. is a versatile predominant plantation species in farm forestry, agroforestry and plantation forestry in India. This tree sp has an excellent nitrogen fixing ability with desirable characters such as bio shields, drought resistant, adaptability to varied edaphic conditions, resistance to blister bark disease and rehabilitating mine spoils and nutrient poor areas and therefore extensively planted along the coastal belts and inland regions of India[1]. Apart from these properties, the bark extracts of the plant exhibits anti-inflammatory property. Tumor Necrosis Factor (TNF-α) is a homotrimer protein comprising of 157 amino acids. It is known to be involved in the pathogenesis of some inflammatory and autoimmune diseases. Diseases like Rheumatoid arthritis doesn't have any curing medicine till date. The bioactive components isolated exhibited binding energies equivalent to the market drugs like Diclofenac and Aspirin. The physicochemical, pharmacokinetic and skin permeation ability were analyzed for the sample extracts. On enhancing it's nature it can be utilized as a viable drug to treat any inflammatory diseases[1].

MATERIALS & METHODS

Sample Properties

Casuarina equisetifolia is known to contain components like carbohydrates, alkaloids, proteins, glycosides, saponins, phenolics, flavonoids, tannins, steroids, gum, reducing sugars and triterpenoids. These phyto-components has the potential to exert pharmacological effects like antimicrobial, antioxidant, anti-inflammatory and many other pharmacological effects[2] .

Sample Extraction

The bark samples were obtained from the coastal side of Chennai. The samples were pounded into fine powder and then subjected to appropriate method of extraction in order to study about the bioactive component present in it. The samples were dissolved in Hexane, Acetone and Distilled Water for preliminary analysis and later in Ethyl Acetate and Hexane for final analysis

Peliminary Analysis: Phytochemical Analysis

The preliminary analysis were performed with the sample extracts prepared from acetone, hexane and distilled water as respective solvents. The method prescribed by Junaid R Shaik,MK Patil were performed to identify the phyto-components present in the seed sample. [3,7].

Antimicrobial Activity Analysis

The anti-microbial activity of the bark extracts were determined by the Agar Disc Diffusion method[4] The extracts were tested against Pseudomonas fluorescens, Bacillus coagulans and Trichoderma. The seed extracts of *Casuarina equisetifolia* (*Casuarinaceae*) showed the antibacterial and antifungal activity. This is indicative that plant based products can effectively be utilized as a source for antimicrobial compounds[5].

Antioxidant Activity Analysis

The bark extracts were subjected to anti-oxidant activity based on the method of *Phosphomolybdenum* Assay[6]]. *Phosphomolybdate* scavenging activity corresponding to high antioxidant potentials was shown by the extracts[8].

Bio-Active Compound Identification – GC MS

The bark of *C. equisetifolia* is a source of potential phytoconstituents exhibiting significantly various biological activities leading to the development of novel drug[9].

Thin Layer Chromatography & Column Chromatography

The preliminary bio active components belonged to the family of terpenoids. To further analyze and to isolate the bioactive component methods of thin layer chromatography and column chromatography were performed with the standard protocol.[10]

Anti-Inflammatory Assay

The further refined bark extracts exhibited anti-inflammatory effect, which was evaluated by the HRBC Membrane Stabilization Method.[13]).

Bio-Active Compound Identification – GC MS

Terpenes/terpenoids are known to posses anti-inflammatory effect. The refined bark extracts were analyzed with GCMS and the bio active components were obtained [12]

***In silico* Studies: Molecular Docking:**

The bioactive components obtained were docked against TNF protein (PDB:4RSU) and the binding energies were obtained. The samples exhibited anti-inflammatory effect[13].

Pharmacokinetic Studies

Pharmacokinetic properties were also tested for the identified phyto-compounds to evaluate the ADME properties. Pharmacokinetic properties of phyto-compounds were evaluated using Swiss ADME[14].

RESULTS AND DISCUSSIONS

The bark sample of *Casuarina equisetifolia* were dissolved in Hexane, Acetone and Distilled Water for preliminary analysis and later in Ethyl Acetate and Hexane for final analysis

Preliminary Analysis

The Phytochemical Analysis of bark of *Casuarina equisetifolia* in different organic solvents Are summarized in table 1. Tannins,Phenolic compounds and proteins are predominantly occur in bark.Alkaloids and terpenes are observed in actone extract.

Anti-Microbial Activity

The maximium zone of inhibition was observed in the acetone extracts of the bark sample[16] .against *Pseudomonas fluorescence* and *Bacillus coagulans* as shown in figure2, The high antifungal activity was observed in the acetone extracts of the bark sample .against *Trichoderma* in different media.

Anti-Oxidant Activity

The acetone bark extract exhibited **0.0028%** anti-oxidant activity at a concentration of **28.0mg/L.**

Bio-Active Compound Identification – GC MS

The acetone extracts of the bark sample gave 100 peaks. The GC– MS analysis also revealed the occurrence of nearly 100 bioactive compounds. In the preliminary analysis, bio-active component a *pentacyclic triterpene* such as β-amyrin was obtained. It is also known for it's anti- inflammatory activity[15,17].

***In silico* Studies: Molecular Docking:**

The bio-active components were docked against TNF protein (PDB:4RSU)-(fFig 4,5]) and the binding energies were obtained. Beta-amyrone was having a binding energy of -7.1 and the binding was found at (LEU105 THR106 GLY107 SER108 GLY109 GLY157 ALA159 THR161 ILE162 THR163 TYR167 ARG218 LEU220 ASP221 GLU222 ARG223 VAL225 ARG226). 24 Noroleana 3,12 diene was having a binding energy of -6.4 and the binding was found at (HIS97 THR99 GLY100 ALA101 ASN102 GLU115 LEU118 GLY119 LEU120 PHE122 TYR144 ARG228 ASP229 GLY230 THR231 TYR234).

ADME Analysis

The phyto-compounds obeyed the Lipinski rule and were found to be non-toxic. The XlogP3 value were ranging between 8 to 10 which is indicative of the compounds to be highly lipophilic in nature. This indicates higher rapid metabolic turnover, low solubility and negligible absorption in the intestine region. Based on the logS scale (insoluble < -10 < poorly < -6<moderately < -4 < soluble < -2 < very soluble <0<highly soluble) the compounds were found to be poorly soluble. The solubility is estimated based on the compound's molecular structure and molecular weight. Fractions of carbon sp3 hybridization were found to be higher than 0.25 which proves it to be efficient. The compounds had low HIA levels which is indicative that the potential of the compounds to be absorbed by the intestinal tract is less.(6) The compounds didn't have the potential to cross the BBB which can be considered for exerting lesser adverse effects in the region of central nervous system. The compounds are non substrates for PGP which indicates that the compounds are not affected by the efflux action of the Pgp, which in turn eliminates compounds from the cell. The compounds have the bioavailability of 0.55 which implies that the compounds adhere to Lipinski rule of five and have 55% probability of being bioavailable. The non- inhibitory action of these compounds against the enzymes specified indicates the compounds to be having high probability of being transformed and consequently being bioavailable upon oral administration. Since, both the compounds have skin permeation values ranging from -2.10 to -2.65, they have the skin permeation ability.

CONCLUSION

Casuarina equisetifolia a tree which was predominantly known for its salt tolerance level and generally used as a protection guard contains the potential to cure various incurable diseases. The plant is widely used in construction sites. The Beta amyrone and 24 Noroleana 3,12 diene were the bioactive components obtained in the preliminary analysis. These components belonged to the isoprenoid group. The isoprenoids exhibit anti-inflammatory effect. The bark extracts contained phytochemicals like Flavonoids, Phenols, proteins, amino acids, resins, alkaloids, tannins, phytosterols and terpenoids. The extract exhibited anti-bacterial activity anti-oxidant activity of 0.0028%. The preliminary components were docked against TNF protein (PDB:4RSU) the binding energies were obtained. Beta amyrone exhibited binding energy of -7.1 and 24 Norolena 3,12 diene exhibited binding energy of -6.4. Both the components had exhibited binding energy higher than the binding energies of the anti-inflammatory drugs found in market like Diclofenac (-6.4) and Aspirin (-5.4). The refined extracts exhibited anti-inflammatory effect with IC_{50} being 84.72 for ethyl acetate extract and 108.41 for hexane extract. The components obtained were Palmitic acid TMS, Dihydrophytol TMS, Octadecanal, Heptadecanenitrile and Stearic acid TMS .These components were docked against TNF protein (PDB:4RSU).The compounds isolated exhibited ADME properties making it viable to be translated as an anti-inflammatory drug in future.

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Table 1: Phytochemical Analysis of bark of *Casuarina equisetifolia*

Phytochemical Component	CeB Acetone	CeB Hexane	CeB Distilled Water
Glycosides	-	-	-
Flavonoids	+	-	-
Phenolic Compounds	+	+	+
Tannins	+	+	+

Saponins	-	-	-
Anthraquinones	-	-	-
Anthocyanins	-	-	-
Coumarins	-	-	-
Resins	+	-	-
Alkaloids	+	-	-
Proteins & Amino- acids	+	+	+
Carbohydrates	-	-	-
Phytosterols	+	-	-
Tri-Terpenoids	+	-	-

+ - Indicates Presence , - - Indicates Absence.

Table 2 : GCMS Analysis of bark of *Casuarina equisetifolia*

S.no	Peak	RT	Name	Area	Area%
1.	113	52.268	24-Norolena-3,12-diene	7891924	8.15
2.	111	51.780	Beta amyrone	6832210	7.05
3.	70	28.095	1,2-Benzenedicarboxylic acid, butyl-2- ethylhexy	5428874	5.60
4.	87	39.782	Bis (2-ethylhexyl)phthalate	2733074	2.82
5.	112	51.983	Lupeol	2704447	2.79



Fig 1: *Casuarina equisetifolia* -Bark



a, *Pseudomonas fluorescence* b. *Bacillus coagulans*
Fig 2 Ant-bacterial activity



a. *Trichoderma* in PDA b.*Trichoderma* in Nutrient Agar
Fig 3 Ant-fungal activity

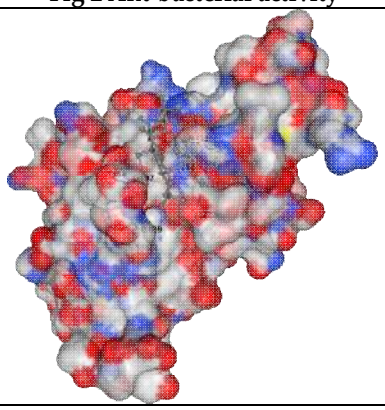


Fig 4 : 4RSU – Beta Amyrone

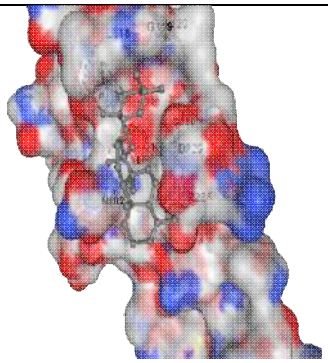


Fig 5 : 4RSU – 24 Noroleana 3,12 diene

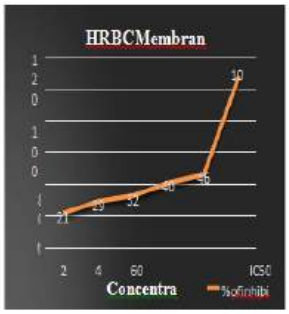




Fig 6: I C50 was obtained at for CeB ethyl acetate extract and hexane extract

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RESEARCH ARTICLE

Evaluation of Herbal Eye Shadow Cream using *Beta vulgaris* Peel

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ABSTRACT

Herbal cosmetics are composed entirely of herbs and shrubs; therefore there are no negative effects. Now a day the demand of herbal cosmetics in the world markets are growing and are inevitable gift of nature. There are a wide range of herbal cosmetics products to satisfy the needs of women (Semwal,N2021).In the current study, antimicrobial activity, formulation, and evaluation of herbal eye shadow cream is done using hydroethanolic extract of *Beta vulgaris* peel. *Beta vulgaris* peel extracts have shown strong antibacterial and antifungal activity. The focus of this study is to formulate an herbal eye shadow cream in *Beta vulgaris* peel.

Keywords: *Beta vulgaris* peel, antibacterial activity, antifungal activity, formulation of eye shadow cream, evaluation of eye shadow cream.

INTRODUCTION

Herbal cosmetics have an increasing demand in the world market and are in valuable gift of nature. There are wide range of herbal cosmetic products to satisfy beauty regimes, adding herbal in cosmetics is very safe for the skin. The word herbal is a symbol of safety in contrast to a synthetic one which has adverse effects on human health (Palle. & Dr. K.V.,2021).*Beta vulgaris* peel has nutraceutical potential, and can scavenge free radicals and inhibit microorganism activity (El-Beltagi, H. S *et al*.,2022). Eyeshadow is one of the decorative cosmetics that contains colour that is applied to the eyelids. Eyeshadows were generally blue, pink, dark red, silver, green, and brown. Natural dyes are derived

from plants, animals, and microorganisms (Yuniaty*et al.,* 2023).Eyeshadows are formulated in the form of cream or gel, stick and powders, either pressed or loose (Shweta A. Rathod., *et al* 2023).Cream Eyeshadows are available as oil or water emulsions containing two phases; the oily phase contains oils, thickeners and emollients and the aqueous phase contains pigments, pearls, and preservatives (Shweta A. Rathod., *et al* 2023).

METHODOLOGY

The materials and methods used for the present study are discussed below;

COLLECTION OF PLANT MATERIAL

Beta vulgaris was collected from the local market of Kalapatti town, Coimbatore district, India.

EXTRACTION

Beta vulgaris was gently washed and peeled. It was then shade-dried and grounded into a fine powder. Taken 2 g of peel powder and mixed with 20ml of solvent in a ratio of 1:10, covered and left for 1 day and stirred occasionally, and filtered using Whatman No.1 filter paper (Suryani*et al.,*2022).The Hydro-alcoholic extract was stored in the refrigerator for further use(S Keser*et al.,* 2012).

ANTIMICROBIAL ACTIVITY

The antimicrobial activity of *Beta vulgaris* peel extracts was assessed against *Staphylococcus aureus, Staphylococcus epidermidis, and Candida albicans* using the AgarWell Diffusion method (Salamatullah*et al.,* 2021).

WELL DIFFUSION METHOD

Antibacterial activity was performed by the agar well diffusion method (Van der Watt *et al.,* 2001). The stock culture of bacteria *Staphylococcus aureus* and *Staphylococcus epidermidis* were received by inoculating in nutrient broth media and grown at 37 % for 18 hours. The agar plates of the above media were prepared. MHA plates were prepared by pouring 20ml of molten media into sterile petriplates. After the solidification of the media, bacterial inoculums were swabbed uniformly. The sterile paper discs were dipped into the required solvents and then placed in agar plates. Then 10-50 µl of plant extract was poured into the wells. After that, the plates were incubated at 37°C for 24 hours. The assay was carried into triplicates and control plates were also maintained. The Zone of inhibition was measured from the edge of the well to the zone in mm. The tested cell suspension was spread on the Muller-Hinton Agar platewell were put into the agar medium using sterile forceps. Plant extracts were poured intowells. Then plates were incubated at 37°c for about 24 hours and control was maintained. Zone of inhibition was measured from the clear zone in mm.

ANTIFUNGAL ACTIVITY

AGAR WELL DIFFUSION METHOD

The Agar well diffusion method is widely used to evaluate the antimicrobial activity of plants or microbial extracts (Mounyr Balouiri *et al.,* 2015). Antifungal activities of all the plant extracts were tested using the agar well diffusion method with slight modification (Varaprasad *et al.,* 2009). The stock culture of fungi *Candida albicans* was received by inoculating in nutrient broth media and grown at 37 % for 18 hours. The agar plates of the above media were prepared. Potato dextrose agar plates were prepared by pouring 20ml of molten media into sterile petriplates. After the solidification of the media, the fungal inoculum was swabbed uniformly. The sterile paper discs were dipped into the required solvents and then placed inagar plates. Then 20-40 µl of plant extract was poured into the wells. After that, the plates were incubated at 37°C for 24 hours. The Assay was carried into triplicates and control plates were also maintained. The Zone of inhibition was measured from the edge of the well to the zone in mm. The tested cell suspension was spread on a potato dextrose agar plate. Well were put into the agar medium using sterile forceps. Plant extracts were poured on to wells. Then plates were incubated at 37°c for about 24 hours and control was maintained. The Zone of inhibition was measured from the clear zone in mm.

FORMULATION OF HERBAL EYESHADOW CREAM

FORMULATION PROCESS

The Eyeshadow Cream was formulated by weighing all the required herbal ingredients accurately by using a digital balance. First the beeswax and shea butter were melted together. Then the colour pigment and Arrow root powder (Binder) were sieved to form a fine uniform powder and to this mixture jojoba essential oil was added and heated. Both phases were mixed at the same temperature. Rose essential oil and edible glitters were added at 40°C.The creamy mixture was transferred into an empty eyeshadow container and left for 24 hours at room temperature (Ghongade*et al.,* 2021).

FORMULATION OF EYESHADOW CREAM

Table 1: Formulation of eyeshadow cream

Ingredients	Concentration of the components		
	A	B	C
Beta vulgaris peel powder	-	2g	4g
Jojoba oil	1 ml	1ml	1ml
Beeswax	1g	1g	1g
Shea butter	1.5g	1.5g	1.5g
Arrowroot powder	-	1g	1g
Rose essential oil	-	0.5ml	0.5ml
Edible glitter	-	0.5g	0.5g

A - Eyeshadow cream formulation as base

B - Eyeshadow formulation with concentration extract 2g

C – Eyeshadow formulation with concentration extract 4g

EVALUATION OF HERBAL EYESHADOW CREAM

ORGANOLEPTIC EVALUATION

The Formulated Eyeshadow cream was assessed for its organoleptic properties,such as colour, glossy and smooth texture, odour, and condition.

pH DETERMINATION

0.5g of Eyeshadow cream was taken and dispersed in 50 ml of distilled water and then pH was measured by using pH paper.

WASHABILITY

A small amount of cream was applied to the hand and it was then washed with tap water.

PERFUME STABILITY

The Eyeshadow cream formulation was tested after 30 days, to record thefragrance.

DISPERSION OF COLOUR PIGMENT

The homogenous dispersion of pearls and pigments is a critical parameter for quality eye makeup products. Pigments are used in higher concentrations for powder eye shadows and if any undispersed pigment is present that appears as streaks on application to the skin. Streakiness and colour uniformity are evaluated visually or by spectrophotometric and colorimetric techniques.

TRANSFER RESISTANCE

Transfer resistance of cosmetics refers to the ability of a product to resist abrasive removal. It is defined as resistance against transferring of product from skin to other surfaces like clothes, etc. The test transfer resistance is performed

by applying a known concentration of eye makeup product onto the backside of the handand allowed to set for a minute. Then, tissue paper is touched with slight pressure over the area for a minute without rubbing. The amount of makeup product transferred to tissue paper is analyzed visually.

WATER RESISTANCE

The water-resistant or waterproof properties of cream eyeshadows can be evaluated by applying a known concentration of the eye makeup product on the backside of the hand and is allowed to set for a minute. The hand is then immersed in water or held under running water again for a minute. The remaining amount left on the hand after removing the eye makeup product by water, is analyzed visually.

MICROBIAL GROWTH TEST

Well Diffusion method was used, were the prepared Eyeshadow creams were inoculated in a plate with the Muller-Hinton agar media and potato dextrose agar media, and a control was prepared by omitting the product. The plates were incubated for 24 hours at 37° C. Plates were taken out after the incubation time and checked for microbial growth.

RESULTS AND DISCUSSION

ANTIBACTERIAL ACTIVITY

AGAR WELL DIFFUSION METHOD

The Antibacterial potential of the extract of *Beta vulgaris* peel was assessed in the current study. The concentration of the samples were taken as 20 µl, 30 µl and 40 µl respectively. The highest antibacterial activity is seen at the highest concentration of 40 µl of the sample. The activity zone of inhibition increases with the increase in concentration of sample. The Zone of inhibition was found against, gram-positive bacteria. The maximum inhibitory concentration was shown against *Staphylococcus aureus* and the minimum zone of inhibition was shown against *Staphylococcus epidermidis*. The Hydro-ethanolic extracts of *Beta vulgaris* peel demonstrated the highest antibacterial potential against *Staphylococcus epidermidis* and *Staphylococcus aureus* is shown in the Figure 1 & 2

ANTIFUNGAL ACTIVITY

AGAR WELL DIFFUSION METHOD

The concentration of the sample was taken as 20 µl, 30 µl and 40 µl respectively. The highest antifungal activity is seen at the highest concentration of 40 µl of the sample. The activity that is zone of inhibition increases with the increase in the concentration of a sample. The Zone of inhibition was found against *Candida albicans*. Hydro-ethanolic extracts of *Beta vulgaris* peel demonstrated the highest anticandidal potential. The Hydro- ethanolic extract of *Beta vulgaris* peel against *Candida albicans* is shown in the Figure 3.

The antimicrobial activity of Hydro-ethanolic Beta vulgaris peel extract showed potential activity against gram positive bacteria and fungi.

FORMULATION OF HERBAL EYESHADOW CREAM

EVALUATION OF HERBAL EYESHADOW CREAM

SUMMARY AND CONCLUSION

In the present study,the hydro-ethanolic extracts of *Beta vulgaris* peel have shown high antimicrobial activity effective against gram positive bacteria and fungi by higher zone of inhibition. The formulation of herbal Eyeshadow cream using Beta vulgaris peel act as a natural colourant. The use of natural colour will provide a suitable alternative to synthetic colourants. The results of the evaluation test exhibited beneficial effects and the ingredients used in the preparation of Eye shadow cream are devoid of side effects and safe to use. Thus the herbal formulation was successfully prepared and evaluated by using herbal colour pigment from *Beta vulgaris* peel powder.

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Beeswax	1g	1g	1g
Shea butter	1.5g	1.5g	1.5g
Arrowroot powder	-	1g	1g
Rose essential oil	-	0.5ml	0.5ml
Edible glitter	-	0.5g	0.5g

Table 2: Antibacterial activity of *Beta vulgaris* peel against *Staphylococcus epidermidis* and *Staphylococcus aureus*

Sample extract	Name of the Organism	Zone of inhibition		
		20µl (mm)	30µl (mm)	40µl (mm)
Beta vulgaris peel	*Staphylococcus aureus*	9	11	15
	Staphylococcus epidermidis	8	10	12

Table 3: Antifungal activity of *Beta vulgaris* peel against *Candida albicans*

Sample extract	Name of the Organism	Zone of inhibition		
		20 µl (mm)	30 µl (mm)	40 µl (mm)
Beta vulgaris Peel	*Candida albicans*	3	5	6

Table 4 : Organoleptic characters of three formulations

Evaluation Parameters	Inference		
	A	B	C
Colour	Yellow	Raspberry red	Red
Odour	-	Fragrant	Fragrant
Texture	Smooth	Smooth	Smooth
pH	7	6.8	6.5
Water resistance	Yes	Yes	Yes
Transfer resistance	Yes	Yes	Yes
Dispersion of pigment	Good	Good	Good
Perfume stability	-	+	+
Microbial growth test	No signs of microbial growth noted	No signs of microbial growth noted	No signs of microbial growth noted

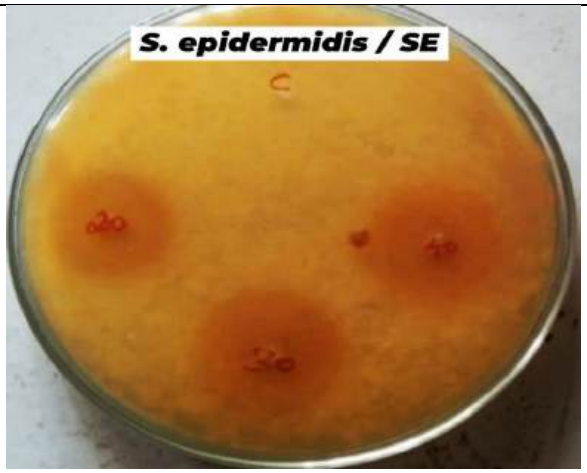


Figure 1: Sample against *Staphylococcus epidermidis*

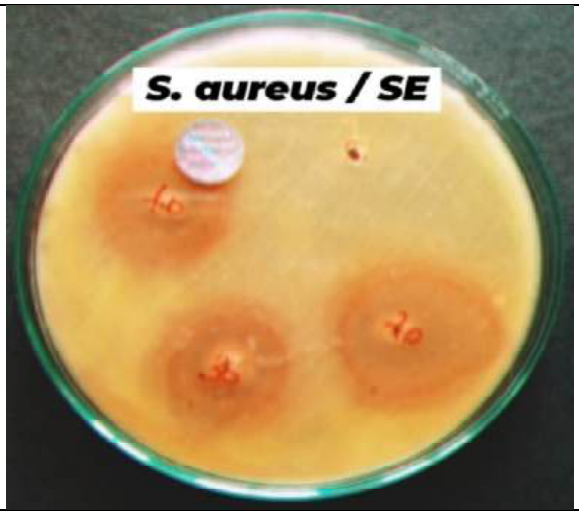


Figure 2: Sample against *Staphylococcus aureus*

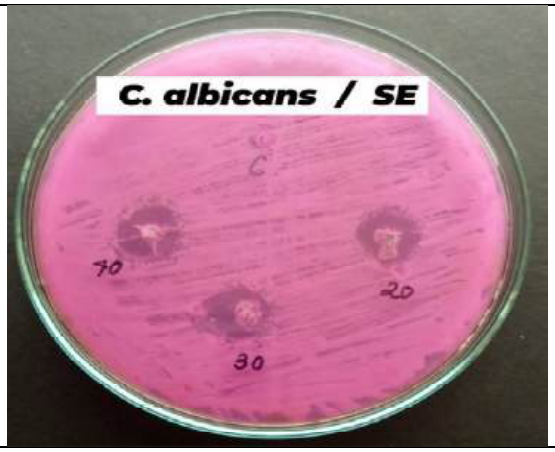


Figure 3: Sample against *Candida albicans*



Figure 4: Formultion of Eyeshadow cream as base



Figure 5: Formulation with 2g extract

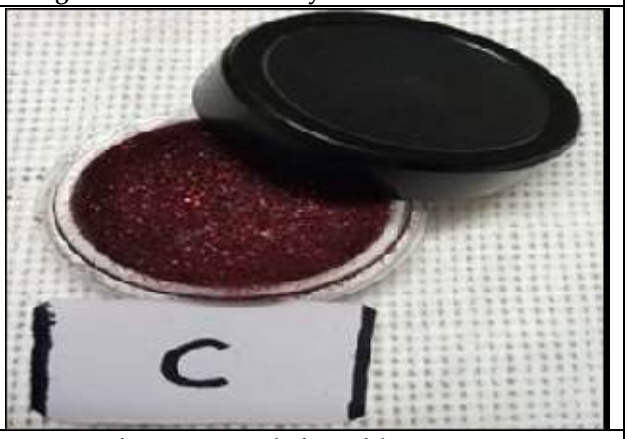


Figure 6:Formulation with 4g extract

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REVIEW ARTICLE

A Review on the Antioxidant and Nutritional Potential of Indigenous Lemons in Northeast India

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ABSTRACT

Lemon (*Citrus* spp.) is a globally cultivated fruit valued for its diverse culinary, nutritional and medicinal benefits. Various lemon species thrive in wild environments, cultivated orchards and homestead gardens. Rich in essential minerals such as potassium, magnesium, calcium, copper, zinc, manganese, sodium, and sulfur, lemons play a vital role in human nutrition. Despite their sour taste, they contain natural sugars like fructose, glucose, and sucrose, along with minor amounts of maltose and xylose. Their protein content is relatively low, but they are an excellent source of vitamin C and B-complex vitamins, including thiamine, niacin, vitamin B6, riboflavin, and pantothenic acid. Additionally, lemons are abundant in antioxidants, particularly flavonoids, limonoids, and phenols, which contribute to their health-promoting properties. This review provides an in-depth exploration of the nutritional and phytochemical composition of indigenous lemon varieties from Northeast India, emphasizing their antioxidant potential and possible therapeutic applications.

Keywords: Lemon, minerals, carbohydrates, proteins, vitamins, Antioxidants.

INTRODUCTION

Lemon plants belong to the family Rutaceae, genus *Citrus* encompassing small to medium-sized shrubs or trees having sharp axillary spines. According to Iwamasa (1976), the *Citrus* genus originated approximately thirty to forty million years ago in the vicinity of Assam, India. Lemon is a highly versatile fruit with both culinary and medicinal applications. It is primarily consumed fresh or as juice, providing a refreshing beverage option during hot summer days. In Norteast India, people also prepare pickles from lemon. Lemon juice is commonly paired with rice and curry

and features prominently in certain ethnic dishes. It is an ethnobotanically significant plant utilized by the local population for treating various ailments. For instance, tender leaves of *Golnemu* (*Citrus aurantifolia*) are used to treat diarrhoea (Borah *et al*., 2006). Ripe fruits of *Bira jora* (*Citrus medica* Linn.) are employed for sore throats, coughs, asthma, and numerous other health concerns. *Citrus* extracts exhibit potent antioxidant activity and antiulcer properties, adding to their medicinal appeal (Nagaraju *et al*., 2012). Beyond their nutritional value, *Citrus* fruits contain phenols, flavonoids, and limonoids, which have anti-carcinogenic (Rana *et al*., 2017) anti-inflammatory, and anti-allergic properties (Manthey *et al*., 2000). Moreover, they are recognized for their vitamin E (a-d Tocopherol) content, contributing to their overall health-promoting attributes (Newhall and Ting, 1965; Ting and Newhall, 1965).

Carbohydrate Content

Though lemon fruits are generally sour but they contain different types of sugar. Lemon fruits, like many other fruits, naturally contain sugars, primarily in the form of fructose, glucose, and sucrose (Namani *et al*., 2018). Asencio *et al*. (2018) reported that the sugar content can vary slightly depending on the specific type and ripeness of the fruit. Fructose is a natural fruit sugar and is the most common type of sugar found in *Citrus* fruits. It has a sweet taste and is the primary sugar responsible for the sweet flavour of these fruits. Another simple sugar found in *Citrus* is glucose.Although less prevalent than fructose it still contributes to the overall sweetness of the fruit. Disaccharide like sucrose is also reported in the fruit juice. In addition, small amounts of other sugars, such as maltose and xylose are found in minor quantities. Suja *et al*. (2017), also reported the presence of primary metabolites such as carbohydrates and proteins in lemon.

Proteins

Lemons are low in protein(1.1 grams of protein per 100 grams) but contain certain proteins that support the functioning of the plant and may influence human health (Healthline, 2023). One such protein, ribosomal protein ClRPS9-2, interacts with the coat protein of the *Citrus yellow vein clearing virus* (CYVCV), suggesting a role in the plant's defense mechanisms (PMC, 2023). The characteristic sourness of lemon juice is influenced by two proton-pumping proteins highly expressed in the juice vesicles of very sour lemon varieties, increasing proton accumulation and acidity (Chemistry World, 2023).

Vitamins

Vitamin C, also known as ascorbic acid, is abundant in lemon juice. The concentration of vitamin C varies across different *Citrus* species, with lemon containing 34.67 mg/ 100 ml of juice (Kumar *et al*., 2019). It is a powerful water-soluble antioxidant that plays a crucial role in neutralizing free radicals and regenerating other antioxidants in the body (Nagy, 1980). In a study conducted by Paul (2016), the vitamin C content of various *Citrus* fruits in the Dibrugarh district of Assam was analyzed. The study revealed that the *jora tenga* variety (*Citrus medica*) had the highest vitamin C content per 100 ml of juice, followed by the bira-jora variety (*Citrus medica*), and *kaji nemu* variety (*Citrus limon*).Lemons' vitamin C content is shaped by both soil composition and climate, flourishing with potassium and sunlight but diminishing with excess nitrogen, phosphorus, and heat. Apart from vitamin C they also contain notable amounts of B-complex vitamins, including thiamin, niacin, vitamin B6, riboflavin, and pantothenic acid (FAO, 1988). These vitamins support various physiological processes, such as energy metabolism, immune function, and the maintenance of healthy skin and tissues.

Mineral Content

Lemons are rich in mineral content. Almost all the vital elements like potassium, magnesium, calcium, potassium, copper, zinc, manganese, sodium are presentin it (Janati *et al*., 2012). Lemon fruits are a good source of potassium, an important mineral that helps regulate blood pressure, fluid balance, and muscle contractions. Calcium though not as abundant as in dairy products, lemons contain some calcium, which is essential for healthy bones and teeth, as well as muscle function and nerve transmission. Lemons contain small amounts of magnesium, which is involved in hundreds of biochemical reactions in the body and is important for muscle and nerve function, blood sugar regulation, and bone health. Phosphorus is another mineral present, albeit in smaller amounts. It plays a role in bone health, energy metabolism, and various cellular processes. Copper is a trace mineral found in lemon. It is essential for

the formation of red blood cells, connective tissues, and the functioning of enzymes. While lemons are not particularly high in iron, they do contain some non-haem iron, which is less easily absorbed by the body compared to haem iron found in animal sources. Nonetheless, vitamin C in lemon can enhance the absorption of non-haem iron. Lemons also contain small amounts of zinc, which is necessary for immune function, wound healing, and DNA synthesis. Manganese is present in Lemon at low levels and is involved in bone formation, blood clotting, and the metabolism of amino acids, cholesterol, and carbohydrates. Sulphur is found in the form of sulphur-containing compounds in *Citrus* fruits, and it is essential for the structure of proteins and enzymes. The sodium content in lemon is negligible and can be useful to specific dietary conditions involving low sodium intake. These are the major minerals found in lemon but it should be noted that the mineral content can vary depending on the specific type of lemons and its growing conditions (Idamokoro *et al*.,2022 ; Czech *et al*., 2020;Ichado *et al.*, 2020 ; Jiao *et al*., 2023).

Antioxidants

According to Halliwell and Gutteridge (1989), antioxidants are substances that prevent oxidation even when present in small amounts.The body has a natural antioxidant defense system made up of enzymes like superoxide dismutase, catalase, and glutathione peroxidase, as well as non-enzymatic antioxidants like vitamins C and E, glutathione, and polyphenols. Lemons are rich in antioxidants and can help reduce oxidative stress and support health. They are rich sourcesof antioxidants, including flavonoids, limonoids, and polyphenols. **Flavonoids**, a diverse class of water soluble plant compounds, which have strong antioxidant and anti-inflammatory properties. The primary flavonoids in lemon juice are flavanones, flavones, and flavanols.

Flavanones

Flavanones are the most abundant flavonoids in lemons, contributing significantly to their antioxidant properties. The key flavanones present in lemons include eriodictyol, hesperetin, and naringenin. Eriodictyol is primarily found in lemon peels, with concentrations reaching up to 79.27 μg/g fresh weight (FW) (Zou *et al*., 2016).Hesperetin is predominantly located in the peel (5.79 to 88.12 μg/g FW) but is also found in whole fruits (1.45 to 24.49 μg/g FW) and juice (0.83 to 4.71 μg/g FW). It is absent in the pulp and seeds (Zou *et al*., 2016).Naringenin is mainly present in lemon peels and seeds, with its highest concentrations observed in certain cultivars (Zou *et al*., 2016). In their glycosylated form, these flavanones exist as flavanone glycosides, which are more water-soluble and bioavailable.Neoeriocitrin (eriodictyol-7-rhamnoglucoside), eriocitrin (eriodictyol-7-rutinoside), and narirutin (naringenin-7-rutinoside) are the major flavanone glycosides in lemon (Miyake *et al*., 1997b).Eriocitrin exhibits the strongest antioxidative activity among the flavonoid glycosides in lemon fruit, followed by neoeriocitrin and DGD (6,8-di-C-β-glucosyldiosmin) (Miyake *et al*., 1997b).

Flavones

Flavones, another class of flavonoids, are present in lemons primarily as flavone glycosides. The key flavones found in lemons include apigenin and luteolin, which are known for their antioxidant and anti-inflammatory properties. Diosmin (diosmetin-7-rutinoside) is a flavone glycoside present in lemon peels and juice, contributing to its vascular-protective effects (González-Molina & Moren, 2012).6,8-di-C-β-glucosyldiosmin (DGD) and 6-C-β-glucosyldiosmin (GD) are C-glucosyl flavones found abundantly in lemons and limes but only in trace amounts in other *Citrus* fruits (Miyake *et al*., 1997b; Pham *et al*., 2022).

Flavanols

Flavanols, also known as flavan-3-ols, are present in lemons in smaller amounts. The major flavanols found in lemons include Kaempferol, Myricetin and Quercetin. These flavanols contribute to the overall antioxidant properties of lemons and may provide health benefits such as cardiovascular protection (González-Molina & Moren, 2012). The flavonoid content in lemon juice varies based on extraction methods. Miyake *et al*. (1997b) found that lemon juice obtained using an in-line extractor contained higher levels of eriocitrin and hesperidin compared to juice extracted manually. The increased pressure applied in mechanical extraction allows for greater incorporation of flavonoids from the pulp and albedo into the juice. This finding is commercially relevant as it suggests that optimizing extraction techniques can enhance the nutritional value of lemon juice.

Limonoids are highly oxygenated triterpenoid compounds found in lemon juice that exhibit potent antioxidant properties. These bioactive compounds have gained significant attention due to their potential health benefits, including anticancer, anti-inflammatory, and antimicrobial activities. The limonoids found in lemon are limonin, nomilin, nomilinic acid, obacunone, limonexic acid and ichangensin.

Limonin

Limonin is one of the most extensively studied limonoids in *Citrus* fruits. It has been reported to exhibit strong anticancer, antioxidant, and anti-inflammatory properties, making it a key component of lemon's bioactive profile (Manners, 2007; Roy & Saraf, 2006). Limonin's role in cancer prevention is particularly notable, as it has demonstrated the ability to inhibit tumorigenesis in various experimental models.

Nomilin

Nomilin is another prominent limonoid in lemons, recognized for its broad-spectrum bioactivity. Research has highlighted its anticancer and antiviral effects, suggesting its potential therapeutic applications (Manners, 2007; Roy & Saraf, 2006). Nomilin has been found to modulate immune responses and interfere with viral replication, further emphasizing its significance as a natural health-promoting compound.

Nomilinic Acid

Nomilinic acid, a derivative of nomilin, is known for its antioxidant and anti-inflammatory effects (Manners, 2007; Roy & Saraf, 2006). These properties contribute to its potential use in managing oxidative stress-related diseases. The presence of nomilinic acid in *Citrus* fruits reinforces the nutritional and medicinal value of lemons.

Obacunone

Obacunone is another bioactive limonoid found in lemons, with demonstrated anticancer and antimicrobial properties (Manners, 2007; Roy & Saraf, 2006). Studies have shown that obacunone can inhibit the proliferation of cancer cells and exhibit antibacterial effects, suggesting its potential role in developing natural therapeutic agents.

Limonexic Acid

Limonexic acid, primarily found in *Citrus* seeds, remains an area of ongoing research. While its specific biological activities are still under investigation, preliminary findings indicate that it may contribute to the overall health benefits of *Citrus* fruits (Manners, 2007). Further studies are needed to fully elucidate its physiological effects.

Ichangensin

Ichangensin is a lesser-known limonoid present in certain *Citrus* species. Although its precise health benefits have yet to be fully determined, it has been suggested to possess therapeutic properties (Manners, 2007).

Polyphenols present in lemon juice and peels play a crucial role in their antioxidant activity, offering various health benefits. The polyphenols found in lemons include phenolic acids such as chlorogenic acid, p-coumaric acid, ferulic acid, gallic acid, tannic acid, cinnamic acid, caffeic acid, and o-coumaric acid. Each of these compounds possesses unique health-promoting properties and contributes to the antioxidant capacity of lemons.

Chlorogenic Acid

Chlorogenic acid is one of the dominant phenolic acids found in both the peel and fruit of lemons. It is well known for its strong antioxidant properties, which help protect cells from oxidative stress and reduce the risk of chronic diseases (Czech *et al.*, 2021; Xi *et al.*, 2017). The presence of chlorogenic acid in lemons enhances their nutritional value and potential therapeutic applications.

p-Coumaric Acid

p-Coumaric acid is predominantly located in the albedo, the white inner layer of lemon peels. This polyphenol plays a crucial role in enhancing the antioxidant capacity of lemons, making them beneficial for overall health (Gabriele *et*

al., 2024; Czech *et al*., 2021). Due to its potent antioxidant effects, p-coumaric acid contributes to the fruit's ability to combat oxidative damage.

Ferulic Acid

Ferulic acid is distributed throughout different parts of the lemon fruit and is recognized for its significant antioxidant effects (Czech *et al*., 2021; Singh *et al*., 2014). This phenolic compound has been studied for its potential role in protecting against oxidative stress, inflammation, and age-related disorders.

Gallic Acid

Gallic acid, present in both the peel and fruit, is another vital polyphenol with strong antioxidant potential. It has been recognized for its ability to promote health by combating oxidative stress and reducing the risk of various chronic diseases (Xi *et al*., 2017; Singh *et al*., 2014). The presence of gallic acid enhances the overall bioactivity of lemon.

Tannic Acid

Tannic acid, primarily found in the pulp of lemons, is an important contributor to the fruit's antioxidant properties. It plays a role in neutralizing free radicals and has been studied for its health-promoting benefits (Singh *et al*., 2014). The inclusion of tannic acid further supports the potential of lemons as a functional food.

Cinnamic Acid

Cinnamic acid is another polyphenol predominantly located in the pulp of lemons. This compound has been associated with various health benefits, including its antioxidant and anti-inflammatory effects (Singh *et al*., 2014). The presence of cinnamic acid enhances the overall nutritional value of lemons.

Caffeic Acid

Caffeic acid is a dominant phenolic acid found in the peel and whole fruit of lemons. It is widely recognized for its strong antioxidant capacity and protective effects against oxidative stress (Xi *et al*., 2017). Caffeic acid's presence in lemons contributes significantly to their health benefits and potential therapeutic uses.

o-Coumaric Acid

o-Coumaric acid, primarily present in the albedo and peel, plays a key role in enhancing the antioxidant properties of lemons. Its presence further supports the fruit's role as a natural source of beneficial polyphenols (Gabriele *et al*., 2024). Lemon juice is a readily available and affordable source of antioxidants, making it an attractive addition to a balanced diet. It can be enjoyed on its own as a refreshing beverage or used as a flavour enhancer in various culinary preparations, such as salad dressings, marinades, and beverages. The potential health benefits of lemon juice's antioxidant activity are numerous. Regular consumption of lemon juice or incorporation of lemon juice into the diet may help reduce the risk of chronic diseases, enhance immune function, support cardiovascular health, and promote healthy aging. Northeast India particularly Assam being a hotspot of lemon diversity, a lot of work need to be done particularly the quantitative aspect of the nutraceutical and antioxidants. Also, extensive in vivo tests have to be carried out evaluating the antioxidant capacity of lemon extracts. Work can also be done to study lemon's free radical scavenging activity and its impact on oxidative stress markers.

CONCLUSION AND FUTURE PERSPECTIVES

Lemons, especially the indigenous varieties of Northeast India, are a powerhouse of essential nutrients and antioxidants, offering substantial health benefits. Their rich composition of vitamins, minerals and bioactive compounds makes them valuable not only as a dietary component but also for medicinal applications. However, despite their known benefits, much remains to be explored. Future research should focus on a deeper analysis of their phytochemical composition, bioavailability, and therapeutic potential. Additionally, extensive in vivo studies

are required to validate their antioxidant efficacy and potential applications in functional foods or nutraceutical formulations. By advancing our understanding of these citrus fruits, we can unlock their full potential for promoting human health and well-being.

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RESEARCH ARTICLE

Exploring the Medicinal and Therapeutic Potential of *Digitaria* Spp: Phytochemical Composition, Pharmacological Activities and Future Bioprospecting Opportunities

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ABSTRACT

Digitaria genus is the widely used for its medicinal and fodder since ages. It is originated in Asia but widely distributed in the tropical and temperate regions of all over the world like china, India and Africa etc. It is widely used in food preparations, cookies, crackers, Non-conventional food products, such as low bulk density weaning foods and high-fiber breakfast cereal, are being explored for their potential health benefits, animal fodder medicines and paper making. *Digitaria* genus are well known for having diverse secondary metabolite compositions that include cardiac glycosides, alkaloids, flavonoids, terpenoids, saponins, and phenolics. It is used to treat gonorrhea, including wound healing, malaria, yellow fever, hernias, liver diseases and flu. Secondary metabolites of this plant exhibit a wide range of pharmacological activities including antioxidant activity, anthelmintic activity, acaricidal activity, wound healing, antifungal activity,Methicillin-resistant *Staphylococcus aureus* activity, antibacterial activity, antiviral activity, antimutagenic activity, and cytotoxic activity etc. This study presents a comprehensive and up-to-date taxonomy, phytochemical composition, and pharmacological actions and offers a justification for additional bioprospecting of this plant. Due to the great therapeutic significance of this, clinical research is necessary.

Keywords: Phytochemical, Pharmacological, Antioxidant, Cytotoxicity

INTRODUCTION

Plants are the principal source of food and medicine. There has been a major function for plants in human lives from prehistoric times. People have been educated about their culinary and medicinal properties over the ages and across many cultures. Traditional herbal treatments provide primary healthcare for around 25% of the global population[1]. A noteworthy statistic is that, either directly or indirectly, 25% of contemporary pharmaceuticals are also derived from plants, indicating the robust basis for plant-based drug development. The natural resources of India, both plant and animal-based, have long been used as dietary supplements and therapeutic treatments. An estimated 250,000 higher plant species are thought to exist on Earth, of which around 70,000 are thought to have medicinal properties, according to the data now available. India is the 12th global hotspot for biodiversity, home to over 45,000 plant species[2].The prevalence of alternative medicinal systems like Siddha, Ayurveda, Unani, Naturopathy, and homeopathy, along with the abundance of flora and fauna in India, led to the official establishment of a very long, safe, and continuous usage of herbs[3].The term "*Digitaria*" comes from the Latin "*digitus*," which means "finger." This refers to the plant's appearance of spreading inflorescence branches. There are around 260 species of *Digitaria*, commonly mentioned to as "finger grass" [4].*Digitaria* is a monocotyledonous plant belongs to Poaceae family, originated in Asia but found throughout the world's tropical and temperate zones. Crabgrasses were among the first cereals to be farmed and it was cultivated for food in China, India, and Africa thousands of years ago, they are now considered relatively major grains in many parts of the world. The weedy *Digitaria* spp. are annual, perennial (in favourable condition) and germinate in late spring to late summer when temperature range between 20°C to 30°C [5].There are numerous species within *Digitaria,* which can be with or without stolons, rhizomes, erect or prostrate. The inflorescence structure of this genus varies in terms of spikelet scale length and spikelet indumentum type. *Digitaria* is a mesophytic or xerophytic plant that thrives well in open environments. *Digitaria* differ in terms of hair density and leaf morphology. *Digitaria*, often called crabgrass, yields an enormous quantity of seeds-up to 1,88,000 seeds may be produced by a single plant[6]. Primary metabolites are vital chemical substances that serve critical functions in human development. Phytochemicals are found in many parts of plants, such as the roots, stems, leaves, flowers, fruits, and seeds. The accumulation of bioactive phytochemicals, including primary and secondary metabolites, contributes to the pharmacological effects and potential therapeutic benefits of plants Alkaloids, flavonoids, saponins, terpenoids, steroids, glycosides, tannins, and volatile oils are only a few of the many secondary metabolites that are produced by plants[7,8]. Phytochemicals and pharmacologically active compounds make up secondary metabolites, which are important in the treatment of a number of diseases and have therapeutic potential.

Alkaloids, which possess analgesic, antispasmodic, antimalarial, and diuretic qualities; Terpenoids, with their anthelmintic, antibacterial, antiviral, anticancer, and antimalarial qualities; Glycosides, known for their antimicrobial and antifungal properties; It is believed that phenols and flavonoids have antibacterial, anti-allergic, and antioxidant qualities; saponins, on the other hand, have antiviral, anti-inflammatory, and plant defense capabilities[9].**(Fig.1).**Fonio is traditionally a helpful diet for those with diabetes or mothers after delivery[10].The edible seeds of *Digitaria sanguinalis* have been consumed as a grain throughout Germany, particularly in Poland, where it was given the nickname Polish millet. Iron, protein, B vitamins, calcium, potassium, and fiber may all be found in millets[11]. *Digitaria exilis* grain is generally eaten by humans as food, but it's also a good, nutritious meal that the poorest people can eat, as well as people who are celiacs[12].*Digitariaexilis* and *Digitariaiburua* (Iburu) are said to have been used for a very long time as a diabetic meal and to regulate blood sugar levels in the body in the northern portion of Nigeria. These plants may be used to make non-alcoholic and alcoholic drinks, as well as traditional dishes including thick and thin porridges and steam-cooked goods like couscous[13]. Additionally, it has been demonstrated that grains of *Digitaria exilis* lower the risk of stroke and heart disease[14].In previous studies,have all reported on the physiochemical properties, fatty acid, amino acid, and mineral element contents, as well as the antioxidant activities of *Digitariaexilis* grains[15,16].*Digitaria* has been shown in numerous reports to possess strong biological activities that affect the central nervous system, including analgesic, antiviral, anti-inflammatory, anticancer, and anthelmintic action[6]. *Digitaria* is the predominant C4 weed[6]. .*Digitaria abyssinica* plant has historically been used to treat a variety of ailments, including wound healing, malaria, yellow fever,

hernias, liver diseases, and flu[17,18].The Gonorrhea and candidiasis are two urinary tract illnesses that have historically been treated using *Digitaria abssinica* rhizomes in some regions of Kenya[19].The reduced leaf area ratio of *Digitaria ciliaris* suggests that it is more adept at converting solar energy into carbohydrates. *Digitaria ciliaris* develops more quickly in environments with abundant food and water because of its higher leaf count and accumulation of dry matter per plant[20]. This study provides detailed information on the pharmacological properties, phytoconstituents, and traditional applications of *Digitaria* spp. The structure-activity connection, potential mechanisms of action, and toxicity and safety features of this plant have also been attempted to be explained.

Botanical description

Taxonomy

There are 260 species of weeds and plants belong to the genus *Digitaria*[21].The *Digitaria* are members of Poaceae family. It goes by the names fonio, finger-grass, and crabgrass as well. Some are frequently regarded as lawn pests. They are slender, monocotyledonous annual and perennial grass, pasture, and fodder plants. *Digitaria*, whose name is derived from the Latin word *Digitus*, which means "finger," are identified by the tall inflorescences that resemble fingers. The *Digitaria* genus may grow up to 50 cm to 1 m in length. Its leaves are slender, flat blades that droop slightly from the stem and have a delicately corrugated edge. Prefoliation is rolled and alternates with the first leaves. Lamina is 2.5-3.5 mm length and 1.0-1.5 mm broad. It is oval and hairy. It is a membrane-bound ligule. The inflorescence is made up of one to three whorls that rise obliquely from the end of the stem and are formed of digitate, 2-11 thin spikes that are 6-11 cm long[22].In pairs, the spikelets are arranged. The first is short pedicellate (0.5 mm) and sterile, whereas the second is significantly more fruitful (2 mm). The roots have fibrils. accidental roots growing from the plant's lower nodes are present. The rectangular seed is present in the lemma and palea of the external flower and measures 2.5 to 3.3 mm in length[23].

Distribution

In addition to its native Asia, the *Digitaria* genus is found across the world's tropical and temperate zones, including China, India, Madagascar, and West Africa. It typically thrives on well-drained soils, in marshy areas, and in tropical rain forests. It is a plant that can grow on nutrient-poor and low fertility acidic and sandy soils without the need for fertilization and has the potential to help prevent problems such as erosion and desertification in areas with insufficient annual rainfall of 200-500 mm. The seeds germinate within a week after sowing. The grain is harvested after 60 to 120 days. Due to its short growth cycle, it is harvested during the critical famine season, which precedes the main food crops of the region . Due to low cultivation inputs, *Digitaria* can be harvested three times a year under favorable climatic conditions, making it an early food source[24].

Ethno-medicinal uses

Farmers claim that *Digitaria exilis*, often known as fonio, has certain therapeutic benefits. Blood clots from trauma and other injuries, as well as those that build up in the uterus during childbirth, can be treated or removed with it (12.3% of responders). In addition, 1.1% of respondents reported using fonio to cure stomachaches, 1.1% reported having asthma, 2.3% reported having dysentery, 2.3% reported having chickenpox, 5.7% reported having chronic diarrhoea, and 5.7% reported feeling unappealing. According to some, fonio is a beneficial diet for diabetics[25].

Phytochemical analysis

The genus *Digitaria* is a reservoir of phytocompounds since its individual phytocompounds may now be identified and isolated because to advancements in analytical methods. *Digitaria* contain naturally occurring, physiologically active substances known as phytochemicals. In addition to giving plants their color, flavor, and scent, phytochemicals also function as a plant's natural defense system and have the ability to ward off illness[26]. Alkaloids, saponins, anthraquinones, phlobatannins, volatile oils, alkaloids, flavonoids, terpenoids, tannins, flavones, hydroxycinnamic acids, steroids, and cardiac glycosides are some of the main phytochemicals present in the genus *Digitaria*[6].*The phytochemicals alkaloids, saponins, tannins, steroids, terpenoids, and flavonoids were present in Digitaria exilis but Phlobatannin and anthraquinone were not found*[10]. The 10 secondary metabolites found in *Digitariaexilis* (grain): alkaloids, flavonoids, saponins, anthraquinones, terpenoids, tannins, phlobatannins, phenolics, cardiac glycosides,

and cardenolides. Notably, steroids were absent[14]. Among these compounds, alkaloids were the most abundant (30.20 mg/ml), while phlobatannins were the least prevalent (0.22 mg/ml).Small quantities of alkaloids, saponins, steroids, trepenoid, flavonoid, and cardiac glycosides were detected by the phytochemical screening in *Digitaria exilis* (white flour) [10]. In *Digitaria exilis* (fonio) flour C-glycosylflavones were absent in the crude methanolic extract as determined by HPLC analysis. Amounting toclean grains containing 500 mg/kg, the total flavonoid content extracted from aqueous extracts was expressed as aglycone equivalents. Spectral and chromatographic examination of the purified extracts revealed that luteolin (L = 350 mg/kg) had 80% in free form and 20% bound as O-glycosylflavones, whereas apigenin (A = 150 mg/kg) had 10% present in free form and 90% bound as O-glycosylflavones [27]. Lypophilic compounds (fatty acids, fatty acid esters, and terpenes) were identified using the GC analysis of Fr2. The percentages of palmitic acid (29.86%), linolenic acid (19.95%), ethyl linolenoate (15.07%), and ethyl hexadecanoate (19.77%) are the main compounds identified in *Digitaria insularis*[28]. GC/MS analysis of the *Digitariaciliaris* flower absolute was used to identify 15 chemicals[23].These included the following: hexadecanoic acid (4.98%), multiflora-7,9(11)-dien-3β-ol (2.46%), pristinone (2.33%), cyclooctacosane (6.31%), stigmasterol (4.35%), sitostenone (7.77%), and linolenic acid (56.78%). Hexadecanoic acid, or palmitic acid, has been demonstrated to be a significant stimulant of fibroblast and keratinocyte proliferation[29,30].These findings raise the possibility that the absolute bloom of *Digitariaciliaris* may influence the mechanisms involved in skin wound healing.

Pharmacological activity

Different plant parts of *Digitaria* genus are predominantly used different types of food preparation, Cookies, crackers and breakfast cereal with good fiber content. Their low bulk density makes them suitable for use as food additives in a variety of non-traditional food items, such as weaning meals. One of the powerful medicinal plants utilized for healthcare purposes is the *Digitaria*genus, which is also used as a food additive[6]. The pharmacological effects of this compound are diverse and include anti-inflammatory, anti-bacterial, anti-fungal, anticandidal, anticancer, antiallergic, antihypertensive, antidiabetic, anti-inflammatory, central nervous system, analgesic, anthelmintic action and anesthetic activities, etc[6].Additionally, reports of its beneficial usage during diarrhea, gonorrhea, including wound healing, malaria, yellow fever, hernias, liver diseases and flu[17,19,18].In some parts of Kenya, *Digitaria abssinica* rhizomes have long been used to treat gonorrhea and candidiasis, two urinary tract diseases[19]..*Digitaria sanguinalis* possesses fractions and isolated compounds with potential as novel therapeutic agents due to their robust antimicrobial, anti-MRSA, antiviral, and cytotoxic activities[31].Several of *Digitaria's* primary phytochemical endeavors are characterized as under**(Table 1).**

Acaricidal Activity

The in vitro research has demonstrated the possibility of using medicinal plants, particularly plant extracts and their isolated *Digitariainsularis* components, to control ectoparasites in cattle. *Digitaria insularis* was used to test the active extracts' and fraction's anticholinesterase activity[28].The oviposition and larval hatchability, or reproductive characteristics, of *Rhipicephalus* (Boophilus) *microplus* females were found to be significantly affected by the in vitro acaricidal actions of *D. insularis*[28].The anti-tick properties of a plant of the genus *Digitaria* have been documented for the first time in scientific studies. According to the categorization, Fraction 2 may be categorized as a robust inhibitor (>50% inhibition), and 30%–50% inhibition) was seen in the HE and EA extracts.

Acaricidal Activitymechanism of action

Due to their ability to pass through the adult *Riphicephallus (Boophilus) microplus* cuticle and function inside the cells, the Fraction 2 components' high liposolubility probably increases their acaricidal efficacy. Higher liposolubility chemicals can more readily pass through the tick's epicuticle, which is the outermost layer of its cuticle and is mostly made of waxes and lipids[28].The capacity of the active extracts and fractions to inhibit acetylcholinesterase (ACHE) was evaluated in order to investigate potential correlations between the acaricidal impact and anticholinesterase activity. Pesticides including organophosphate and carbamate target this enzyme, and when it is inhibited, acetylcholine's excitatory effects are prolonged, resulting in The demise of the parasite and neuromuscular paralysis**(Fig.2).**

Wound healing

Living things will always sustain wounds; they are not preventable but are treatable. *Digitaria ciliaris* flower extract's ability to heal wounds in humans was studied by[23].It has been observed that the extract intervention has induced fibroblasts' production of collagen, keratinocytes' proliferation, wound contraction, and other essential processes. Skin wound healing and regeneration may be aided by *D. ciliaris* flower absolute. With regards to natural cosmetics or medications that try to speed up skin wound healing, *D. ciliaris* flower absolute is a promising option. The *D. ciliaris* flower's ability to promote wound healing in Synthetic human epidermal growth factor (purity > 97) was studied by[23].Utilizing a WST test, they evaluated the cytotoxicity of *D. ciliaris* absolute at various doses (0.1-100 μg/mL) in order to determine its effect on fibroblast and keratinocyte viability. The results show that *D. ciliaris* absolute did not, at any of the measured doses, show cytotoxic effects on HaCaT or CCD986sk cells.

Wound healing mechanism of *Digitaria* genus

Skin wound healing comprises three sequential stages: inflammation, proliferation, and remodeling [32]. This process involves intricate tissue regeneration events including matrix production, re-epithelialization, angiogenesis, cell migration, and proliferation [33]. *D. ciliaris* flower absolute was shown to have impacts on skin wound healing and associated processes in human fibroblasts and keratinocytes, including proliferation, migration, and collagen production. The absolute promoted proliferation in keratinocytes and fibroblasts, as well as fibroblast migration, without impacting cell viability. Additionally, fibroblasts rather than keratinocytes saw a selective increase in type I and type IV collagen formation. The floral absolute of *D. ciliaris* induced fibroblasts to phosphorylate extracellular signal-regulated kinase 1/2 and p38 mitogen-activated protein kinase**(Fig.3)**.

Antimicrocial activity

When prescribed medicines do not have the desired pharmacological effects, antibiotic resistance develops. Chemotherapeutic medications such as paclitaxel and adriamycin are a well-known example of this resistance. Globally, pathogenic microbes cause profound cellular and molecular alterations that are difficult to identify[34]. Antibiotic resistance in bacteria is on the rise, and this is a serious worldwide problem. As a result, herbal formulations are frequently used in the creation of novel medicinal agents due to their generally safe character. Researchers are therefore focusing on discovering novel antibiotics from natural sources that can penetrate bacterial cell membranes and inhibit their growth without causing adverse effects. The seven identified chemicals and active fractions of the alcohol extract from *Digitaria sanguinalis* aerial parts have antimicrobial activity[5].The investigated strains of bacteria and fungus, such as *Staphylococcus aureus, Bacillis subtilis, Escherichia coli, Pseudomonas aeruginosa, Aspergillus fumigates*, and *Candida albicans*, were significantly inhibited by the n-hexane and ethyl acetate fractions.

The n-hexane fraction included p-coumaric acid and p-hydroxybenzoic acid, while the ethyl acetate fraction contained β-sitosterol-3-O-β-glucoside and tricin-7-O-βD-glucopyranoside. which have been shown to have antimicrobial activity in the past, may be the cause of this [35].

Antimicrobial Activity Mechanism of action

The effective antibacterial inhibitory actions of phenolic compounds may be due to hydrogen bonding with vital proteins such as microbial enzymes or iron shortage [36]. Terpenes may have the capacity to break microbial membranes, which may account for their antibacterial activities, in contrast to lipophilic flavonoids [37].

Methicillin-resistant *Staphylococcus aureus* (MRSA) Activity

Study on the alcohol extract's active fractions from *Digitaria sanguinalis* aerial parts is the first to identify tricin, tricin-7-O-β-D-glucopyranoside, and β-sitosterol-3-O-βglucopyranose as having anti MRSA activity[31]..

Antifungal activity

The traditional usage of *Digitaria abyssinica* to treat *candidiasis* was confirmed that the rhizome preparations exhibited antifungal activity [38]. Antifungal activity against *Candida albicans* was demonstrated by the rhizome preparations of *Digitaria abyssinica*. the zone of inhibition at 500 mg/ml was 16.33 ± 0.82 mm, the microbial fuel cell (MFC) was 62.5 mg/ml, and the minimum inhibitory concentration (MIC) was 31.25 mg/ml.were the greatest antifungal activity

values for the aqueous extract. The aforementioned study provides support for the traditional usage of *D. abyssinica* rhizome aqueous and methanol extracts as a treatment for *candidiasis* by suggesting that they may exhibit antifungal activity against *C. albicans* [38].

Antibacterial Activity

The disc diffusion method was used to assess *Digitaria redicosa* antibacterial efficacy against foodborne pathogens by looking at the zone of inhibition[39].To evaluate the Silver nanoparticles inhibitory activity, the zone of inhibition was assessed following incubation[40]. For Silver nanoparticles, there was a small zone of inhibition at 80 µgml in *S. aureus*, whereas for *E. coli*, the activity started at 20 µg ml and increased as the Silver nanoparticles concentration increased. It was discovered that the silver nanoparticles' lowest inhibitory concentrations against *S. aureus* and *E. coli* were 50 µg/ml and 40 µg/ml, respectively.

Antibacterial Activity mechanism of action

Nanoparticles might readily infiltrate bacterial cells because of their small size. When compared to thin-layered Gram-negative bacteria, the inhibitory action of Gram-positive bacteria is much lower due to their thicker peptidoglycan[41].The Silver nanoparticles are expected to breach their inner barrier by causing the outer membrane to become less permeable, which will allow biological stuff to seep out. By causing harm to respiratory chain dehydrogenases, they stop bacteria from breathing and proliferating[42].**(Fig.4).**

Antimutagenic activity

Digitaria sanguinalis aqueous extract is an effective antimutagenic agent [43]. Additionally, the aqueous extract of *D. sanguinalis* inhibited methyl methanesulfonate (MMS)-induced mutations by decreasing the number of micronucleated polychromatic erythrocytes(MPCEs) in mice and the number of *S. Typhimurium* revertant bacterial colonies in a concentration-dependent manner. However, dosages of extracts alone often didn't reveal any significant changes towards the test organisms, however the higher concentration of the extract reduced the mutation generated by methyl methanesulfonate (MMS).

Antiviral Activity

Digitaria sanguinalis' aerial components were studied[31].Hepatitis A virus (HAV) and oral herpes simplex virus (HSV-1) were both significantly inhibited by the n-hexane and ethyl acetate fractions' antiviral activities because they included tricin in the n-hexane fraction and tricin 7-O-β-D-glucopyranoside inside the fraction of ethyl acetate. Tricine shown considerable inhibition of the genital herpes simplex virus (HAV, HSV-1, and HSV-2). This finding is consistent with research that has been published demonstrating tricin's antiviral efficacy against influenza viruses[44]. This study was first to exhibit tricin-7-O-β-D-glucopyranoside's antiviral properties and explore stigmasterol's antiviral properties. Strong antiviral activity was demonstrated by tricin-7-O-β-D-glucopyranoside against HAV and HSV-1[31]. This was the first investigation into the antiviral characteristics of isoorientin, β-sitosterol-3-O-glucoside, and p-hydroxybenzoic acid. P-hydroxybenzoic acid was shown to have weak antiviral activity against HSV-1 and HSV-2, isoorientin was found to have a mild impact against HAV, while β-sitosterol-3-O-glucoside had poor antiviral activity against HSV-1.

Cytotoxic Activity

Investigated the alcohol extract of *Digitaria sanguinalis* aerial parts' cytotoxicity in fractions of n-hexane, n-ethyl acetate, and n-butanol [31]. Three human tumor cell lines were investigated with the separated chemicals as well:typical fibroblasts (L929In addition) HepG-2, MCF-7, and HCT-116 cells related to colon, breast, and hepatocellular carcinoma are included. The n-hexane fraction included tricin and p-coumaric acid, while the ethyl acetate fraction contained β-sitosterol-3-O-βglucoside and tricin-7-O-β-D-glucopyranoside. These compounds may have contributed to the significant cytotoxic activity against the HepG-2 and MCF-7 cell lines.Significant cytotoxic effects were seen by P-coumaric acid on the HepG-2 and MCF-7 cell lines. This outcome is consistent with other research that shown the cytotoxicity of p-coumaric acid to neuroblastoma and H9c2 cadiomyoblasts [45]. Significant cytotoxic activity was shown by tricin and tricin-7-O-glucosid against HepG2 and MCF-7, supporting

earlier research on the robust cytotoxic action of these substances in vitro[46].As this chemical is known to have significant cytotoxic activity against the Caco-2 cell line, β-sitosterol3-O-glucoside once again showed strong cytotoxic effect, supporting earlier findings[47].A study revealed that β-sitosterol and its glycoside derivatives can impact several facets of tumor development, including the generation, stimulation, and induction of cancerous cells, in addition to impeding cell invasion and metastasis [48].

Anthelmintic Activity

An anthelmintic's effectiveness is guaranteed when its ability to fight parasites reaches or surpasses 90% [49]. Established criteria that indicate a plant extract with substantial anthelmintic potential if its EC50 is less than 6 mg/mL [50]. All extracts, including *D. insularis's* FR2 and FR3, had low EC50 values (0.27–0.96 mg/mL and EC90 0.6 and 1.3 mg/mL) demonstrated remarkable effectiveness against gastrointestinal nematode eggs taken into consideration[28].The conducted research that examined the anthelmintic efficacy of *D. insularis* leaf aqueous extract (138.75 mg/mL) using goat gastrointestinal nematodes in an in vitro coproculture assay[51].The variations in the extraction procedure and techniques may account for the disparity in the concentrations employed.

Antioxidant Activity

D. iburua had higher levels of phenolic compounds in the same amount of sample than did *D. exilis* [52]. The analysis on the proximate chemical composition of the grains delicately revealed this variance between the two fonio species [15]. The effective concentration of extract needed to scavenge 50% (EC50) of stable DPPH radicals is used to gauge how well fonio extracts can scavenge DPPH radicals. *D. iburua* accessions scavenged at a lower range of 0.278 to 0.816 mg/ml, whereas D. exilis accessions scavenged 50% of the DPPH radicals in the concentration range of 0.916 to 2.325 mg/mL [52]. Comparing the methanol extracts to the crude powder and water extracts, the best total flavonoid concentration (38.75 ± 9.76 mg quercetin equivalency/g dried weight) and total phenolic content (57.96 ± 6.84 mg gallic acid equivalency/g dried weight) were discovered. According to these results, grains of *Digitaria exilis* may have antioxidant qualities, which might explain why the grains are used in conventional medical systems [54].

Future Aspects Study

- **Pharmacological and Toxicological Testing Safety and Efficacy:** The safety and therapeutic efficacy of *Digitaria* species in humans must be guaranteed by pharmacological and toxicological investigations, despite the fact that numerous research emphasize their potential as medicines.
- **Ecological and Environmental Effects Sustainability and Conservation:** As interest in *Digitaria* species increases, questions may arise regarding how sustainable it is to collect these plants in the wild. Research on the best growth circumstances (temperature, soil type, etc.) for these plants can assist prevent environmental damage while guaranteeing a consistent supply for use in pharmaceuticals in the future.
- **The Development of Regulation and Intellectual Property Regulation of Herbal Medicine:** Regulatory agencies may need to develop particular frameworks for assessing and approving herbal remedies as interest in *Digitaria* species increases. Creating standards for safety testing, active ingredient standardization, and quality control is part of this.
- **Antimicrobial and Antibacterial Development:** Since bacteria such as Methicillin-resistant *Staphylococcus aureus* (MRSA) are causing antibiotic resistance, *Digitaria* species are a desirable source of new antimicrobial medicines. It may be possible to create new classes of antibiotics or adjuvants for already-approved ones by investigating the precise processes by which these plants work against bacteria (e.g., by interfering with the creation of cell walls or blocking the synthesis of proteins).

CONCLUSION

The phytochemical profiles and antibacterial qualities of several *Digitaria* species are examined in this review using a variety of extraction techniques. Alkaloids, flavonoids, terpenoids, saponins, phenolics, cardiac glycosides, and other secondary metabolites were found in a variety of species, including *D. sanguinalis, D. exilis, D. abbasyica, D. eriantha,*

D. horizontalis, D. ciliaris sand *D. insularis.* These substances showed strong antibacterial action, especially against infections like MRSA that are resistant to many drugs.The plant's acaricidal action and wound-healing capacity have been the main subjects of investigation, with supplementary studies examining its antibacterial, antioxidant, anti-MRSA, and antimutagenic qualities. In addition to its anthelmintic and acaricidal qualities, the present study emphasizes the plant's substantial medical potential in areas including wound healing, microbial infection prevention, antioxidant effects, and more. The plant may be used to treat a variety of illnesses, including as the flu, gonorrhea, wound healing, malaria, yellow fever, hernias, and liver diseases, according to ethnomedical research. The plant's acaricidal qualities and wound-healing capacity are its most researched features, followed by its antibacterial, antioxidant, anti-MRSA, and antimutagenic benefits. The study highlights *Digitaria* species as prospective candidates for the development of new antimicrobial treatments, given the growing concerns regarding antibiotic resistance. Nevertheless, pharmaceutical trials have not yet produced enough data to support these preventive advantages.

Conflicts of Interest: The authors have no conflicts of interest.

Author Contribution: All authors read and approved the final version of manuscript.

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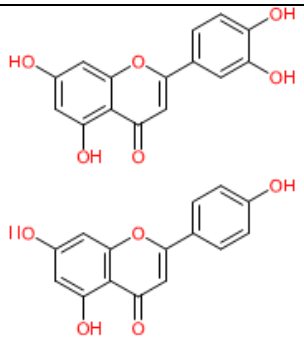
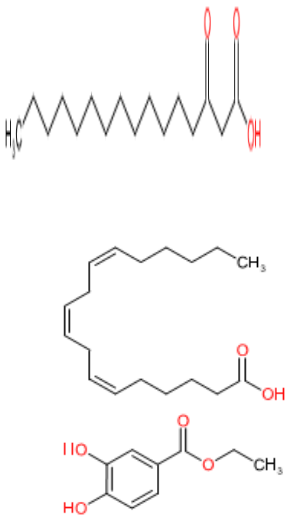
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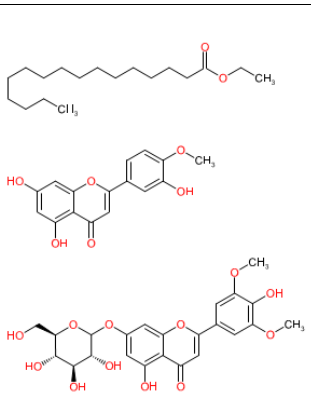
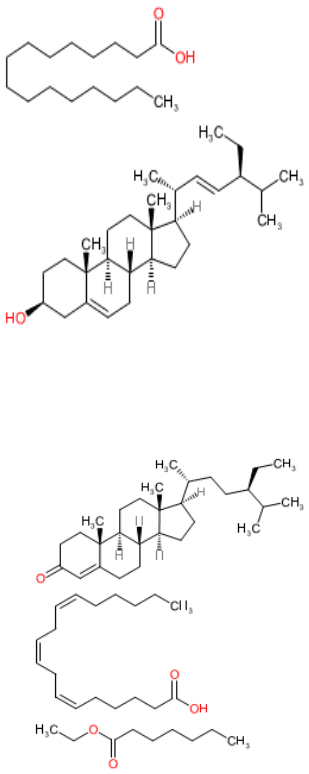
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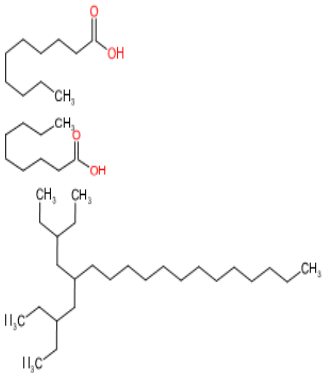
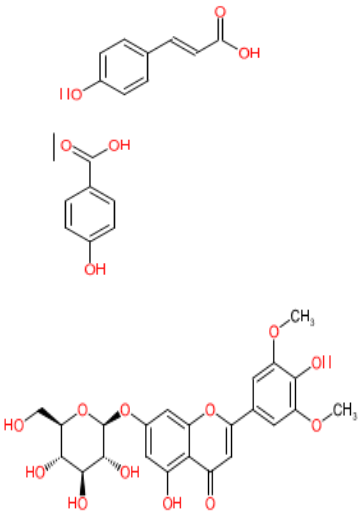
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Table.1 Summary of phytochemical activity by the various active constituents of *Digitaria* spp.

Class of Compound	Name of Compound	Plant species	Plant part used	Structure	References
Luteolin Apigenin	Flavonoid	*Digitaria exilis*	Flour		Sartelet *et al.* (1996)
Palmitic acid Linolenic acid Ethyl linolenoate Ehy lhexadecanoate Diosmetin Tricin	Fatty acid,Fatty acid Esters	*Digitaria insularis*.	Leaves		Santos *et al.*(2017)

	Flavonoid				
Hexadecanoic acid, Stigmaserol Sitostenone Linolenic acid Heptanoic acid, ethyl ester Decanoic acid, ethyl ester Nonanoic acid, ethyl ester Octadecane, 3-ethyl-5-(2-ethylbutyl)-		*Digitariaciliaris*	Flower Leaves		Park *et al.*(2020) Warghat et al. (2024)

					
p-coumaric acid phydroxybenzoic acid Tricin-7-O-β D-glucopyranoside	Phenolic Steroidal glycoside Flavonoids	*Digitariasanguinalis*	Aerial parts		Khelawan (2023)

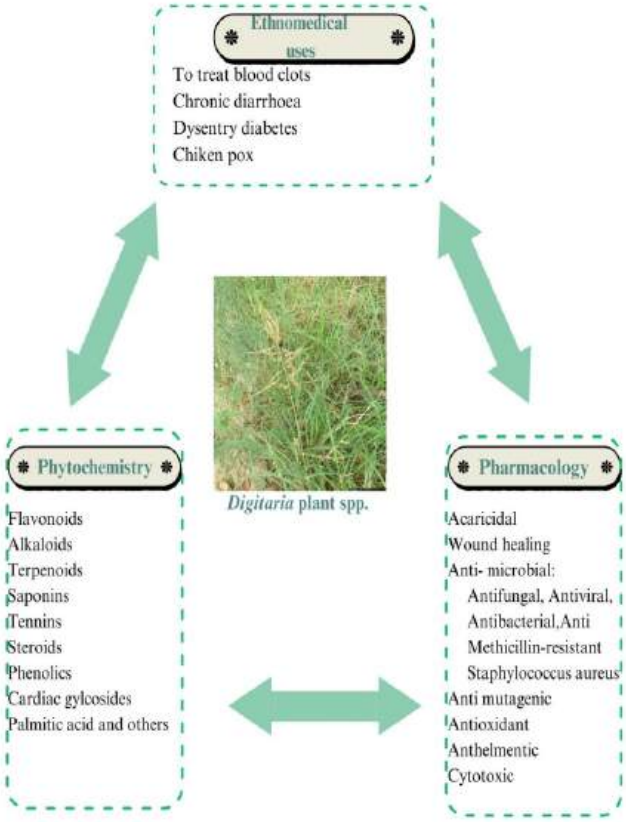
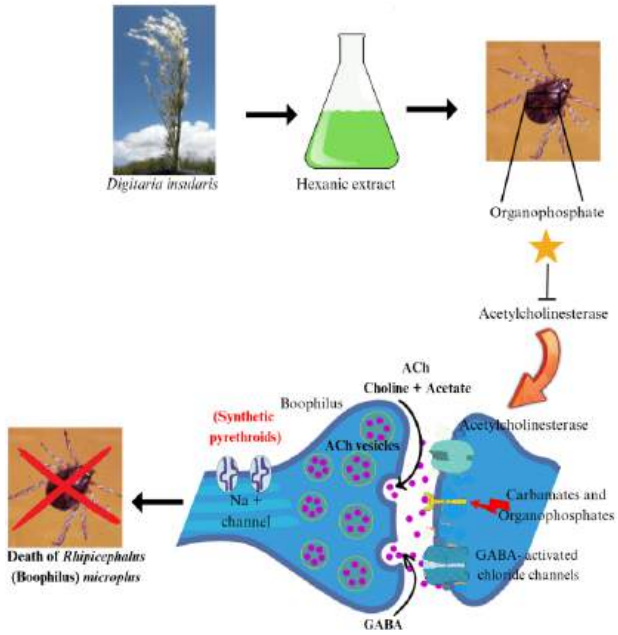


Fig 1: Graphical representation of review



Mechanism of action of Acaricidal Activity in *Rhipicephalus* (Boophilus) *microplus* (cattle tick) using hexanic extract and ethyl acetate of *Digitaria insularis* leaves

Fig 2: Acaricidal activity mechanism of action

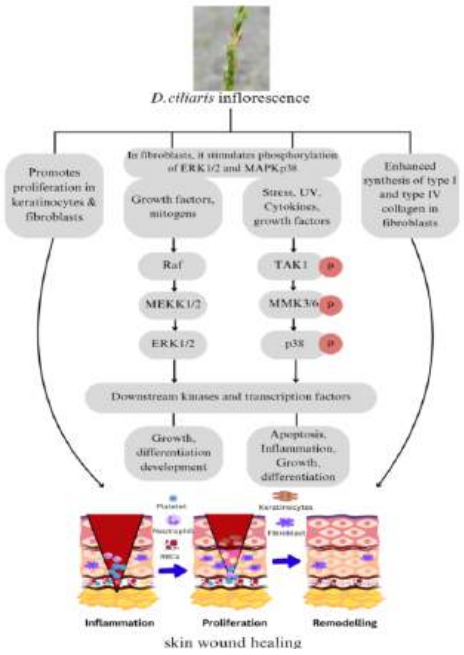
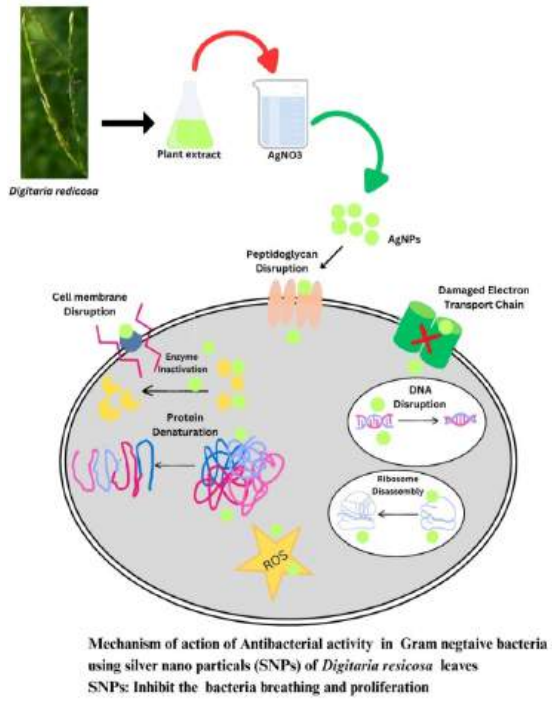


Fig 3: Wound healing activity mechanism of action



Mechanism of action of Antibacterial activity in Gram negtaive bacteria using silver nano particals (SNPs) of *Digitaria resicosa* leaves
SNPs: Inhibit the bacteria breathing and proliferation

Fig 4: Antibacterial activity mechanism of action

RESEARCH ARTICLE

The Impact of Panchakarma Therapy as an Adjunct to *In vitro* Fertilization in Improving Pregnancy Outcomes and Reproductive Health in Women with Recurrent Implantation Failure

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ABSTRACT

Female infertility, particularly Recurrent Implantation Failure (RIF), significantly impacts women's physical and emotional well-being. While conventional treatments like IVF have been successful for many, certain patient groups require complementary approaches to enhance reproductive outcomes. Panchakarma, an Ayurvedic therapy, offers a holistic approach that may enhance fertility when combined with conventional treatments. This study aimed to evaluate the efficacy of Panchakarma as an adjunct to IVF in improving pregnancy outcomes, body weight, endometrial thickness, and menstrual health in women with RIF. Twenty-five women with RIF were enrolled. Panchakarma therapy, including detoxification and nourishment protocols, was combined with IVF treatments. The primary outcome was clinical pregnancy, while secondary outcomes included changes in body weight, endometrial thickness, and menstrual health. Anti-Müllerian Hormone (AMH) levels and Doppler ultrasound findings for uterine blood flow were also assessed. Paired t-tests and chi-square tests were used for statistical analysis. A total of 76% of participants achieved a positive pregnancy outcome. The mean body weight significantly decreased from 73.8 kg to 68.5 kg ($t = 2.29$, $p = 0.031$). Endometrial thickness increased from 7.115 mm to 9.595 mm ($t = 6.54$, $p = 9.10 \times 10^{-7}$). Doppler ultrasound findings showed improved uterine blood flow and endometrial perfusion. AMH levels remained stable post-treatment, with no significant

changes (p = 0.82). Menstrual regularity and flow improved significantly following therapy. Panchakarma therapy, when combined with IVF, may significantly improve pregnancy outcomes, reduce body weight, increase endometrial thickness, and enhance uterine blood flow in women with RIF. Further studies are needed to confirm these findings and explore underlying mechanisms.

Keywords: Recurrent Implantation Failure (RIF), Panchakarma Therapy, In Vitro Fertilization (IVF), Endometrial Thickness, Menstrual Health, Uterine Blood Flow

INTRODUCTION

Female infertility is a major global health issue that affects millions of women and their physical, emotional, and social well-being(Ali et al. 2023). One of the most challenging types of infertility is Recurrent Implantation Failure (RIF), a condition characterized by the inability to achieve a successful pregnancy after multiple attempts using assisted reproductive technologies (ART), such as in vitro fertilization (IVF)(Franasiak *et al.* 2021a). For women with RIF, this can lead to significant emotional and psychological strain along with the physical challenges of infertility treatment(Ni *et al.* 2021). Conventional treatments for Recurrent Implantation Failure (RIF), such as hormonal therapies, surgical procedures, and repeated ART cycles such as IVF, have played a pivotal role in helping many women achieve successful pregnancies(Ma, Gao, and Li 2023). These treatments have been widely used and are often the first line of treatment for infertility. However, certain groups of patients may not respond as effectively to conventional treatments alone. Factors such as age, underlying medical conditions, genetic predispositions, or specific infertility diagnoses can influence how well a patient responds to these interventions(Franasiak et al. 2021b).
In these instances, the efficacy rates of conventional treatments may not achieve their maximum potential, and attaining desired reproductive outcomes can become increasingly complex. As a result, healthcare practitioners and patients are exploring additional modalities to enhance treatment effectiveness and improve overall fertility outcomes. This has led to increased interest in investigating complementary therapies that can be integrated with conventional approaches to optimize success(Cioroba *et al.* 2021).

Complementary therapies, when incorporated into traditional ART protocols, may address factors that conventional treatments alone may not fully mitigate(Yang *et al*. 2024). One such complementary approach garnering attention is Panchakarma, a traditional Ayurvedic purification therapy that aims to detoxify the body, restore dosha balance, and promote overall well-being (Suman and Bharathi 2021). When integrated with conventional ART treatments, Panchakarma may enhance reproductive health by supporting hormonal equilibrium, improving metabolic function, and fostering a more favorable environment for embryo implantation(Singh *et al*. 2022). By offering a holistic approach, Panchakarma may benefit patients who have not achieved success with conventional therapies alone by providing an additional avenue for improving fertility outcomes(Asmabi, Jithesh, and Govindan 2024). Panchakarma, a core therapeutic practice of Ayurveda, offers a holistic approach that aims to cleanse the body, balance doshas (biological energies), and promote overall health. Panchakarma includes five purification therapies:vamana (therapeutic vomiting), virechana(purgation), basti (medicated enema), nasya (nasal administration of medications), and raktamokshana (bloodletting). These therapies have been suggested to support fertility by improving the hormonal balance, reproductive health, and overall vitality. By enhancing blood circulation, detoxifying the body, and restoring internal balance, Panchakarma may create a more favorable environment for embryo implantation and pregnancy. This study aimed to evaluate the potential benefits of panchakarma as an adjunctive therapy to IVF in women with RIF. By combining the purification benefits of Panchakarma with the established IVF protocols, we aimed to investigate its effects on key factors such as endometrial thickness, ovarian reserve, hormonal balance, and overall reproductive health. Furthermore, we will assess its influence on pregnancy outcomes, including implantation success and pregnancy maintenance, to determine whether panchakarma can enhance the effectiveness of IVF treatment. This study provides evidence-based insights into the benefits of integrating Panchakarma with conventional IVF procedures. Our goal was to highlight

the therapeutic potential of combining these two approaches, offering women with RIF a more comprehensive and effective fertility treatment option.

METHODOLOGY

Ethical Approval

The study underwent ethical review and received approval from the Sat Kaival Hospital, Pvt. Ltd. Ethics Committee, with reference number SKHPL/EC/MARCH-24. This approval ensured that the research adhered to the requisite ethical guidelines and standards for conducting studies involving human subjects, prioritizing patient safety, and ethical integrity throughout the investigation.

Patient Selection Criteria

Inclusion Criteria

- Patients diagnosed with either primary or secondary infertility.
- Age range: 21-45 years old.
- Infertility stemming from the
  - Polycystic Ovarian Disease (PCOD)
  - Cervical conditions (cervicitis, erosion, or insufficient cervical mucus)
- Male partners with confirmed fertility.
- Medically cleared for participation in Virechana, Uttar Basti, and Basti therapies.
- Informed consent and willingness to complete the full month-long study.

Exclusion Criteria

- Infertility is related to surgical complications (including fibroids, cervical polyps, stenosis, or congenital anatomical abnormalities).
- Presence of severe infection or chronic systemic illness.
- Diagnosis of Malignancy.
- Complete blockage of the fallopian tubes.
- Infertility is also associated with peritoneal factors.

Procedure for Panchkarma

The Panchkarma therapeutic protocol was initiated with a preparatory phase (Poorvakarma), consisting of Snehana (internal oleation) with medicated substances to soften and dislodge toxins, followed by swedana (fermentation) to mobilize them further. Subsequently, primary purification procedures (Pradhanakarma) were implemented, including Virechana (therapeutic purgation) for toxin elimination through the gastrointestinal tract and Basti (medicated enema).Basti administrations comprised Anuvasana Basti (oil-based) for nourishment and lubrication, and Niruha Basti (decoction-based) for deeper cleansing. To directly address female reproductive health, Uttar Basti, which involves the administration of medicated substances into the reproductive tract, was used. Vaman (therapeutic emesis) was excluded because this procedure primarily addresses Kapha-Dosha imbalances. Finally, the Paschat Karma (rejuvenation) phase commenced, utilizing Samsarjana Krama (graduated dietary reintroduction) and Rasayana therapy (rejuvenating herbs and nutritional protocols) to restore normal physiological functions and promote overall well-being(Bhushan, Sharma, and Puri 2020).

Outcome Measures

The primary outcome measure was clinical pregnancy, which confirmed successful ovulation. The secondary outcomes focused on menstrual cycle dynamics (duration, regularity, flow, and associated symptoms), cervical mucus assessment (quality, consistency, and volume during the periovulatory phase), folliculogenesis monitoring via ultrasound (from approximately day 12 to day 18 or as clinically indicated), and ultrasound measurement of

endometrial thickness to evaluate implantation potential. Additionally, weight reduction and levels of Anti-Müllerian Hormone (AMH) and other relevant hormones such as progesterone and estradiol were assessed.

Statistical Analysis

Descriptive statistics were used to summarize the baseline characteristics and outcome measures within the Panchkarma treatment group. Paired t-tests (parametric data) and chi-square goodness-of-fit tests were used to evaluate pre- and post-treatment changes in continuous variables. Statistical significance was set at a p-value of <0.05.

RESULTS AND DISCUSSION

Pregnancy Outcome

The study demonstrated a promising success rate, with 19 of 25 participants (76%) achieving a positive pregnancy outcome. This included successful deliveries, ongoing pregnancies, and miscarriages, all of which reflected successful implantation and early pregnancy development following treatment. The 95% confidence interval for the success rate ranged from 59.26% to 92.74%, indicating that the true success rate in a broader population is likely to fall within this range.A chi-square goodness-of-fit test was conducted to evaluate whether the observed success rate significantly differed from the expected baseline of 50%.The test yielded a chi-square statistic of 6.76 and a p-value of 0.0093, suggesting that the observed success rate was significantly higher than the baseline. This result supports the potential efficacy of this treatment in improving pregnancy outcomes in women with Recurrent Implantation Failure (RIF).These findings provide a robust foundation for further research on the use of complementary therapies, such as Panchakarma, in conjunction with conventional IVF treatments, as the combination may lead to improved reproductive outcomes.

Reduction in Overall Body Weight

This study evaluated the effect of panchakarma therapy on body weight in patients with Recurrent Implantation Failure (RIF).A total of 25 patients were included in this analysis. The baseline mean weight was 73.8 kg (SD = 12.07 kg), which significantly decreased post-treatment to a mean weight of 68.5 kg (SD = 11.0 kg). The paired t-test revealed a significant reduction in weight, with a mean difference of 5.3 kg ($t = 2.29$, $p = 0.031$), indicating that panchakarma therapy had a positive effect on reducing body weight in these patients. This significant reduction in body weight suggests that panchakarma therapy may be an effective intervention for weight management in patients with RIF, potentially improving overall health and reproductive outcomes. A visual representation of the mean weights with standard deviations illustrated this significant change. These findings support the potential role of Panchakarma as a complementary therapy to manage body weight and enhance reproductive health. However, further studies with larger sample sizes and control groups are necessary to confirm these results and to elucidate the underlying mechanisms. Several factors may have contributed to the observed reduction in body weight. Panchkarma therapy involves a series of detoxification procedures, dietary regulations, and lifestyle modifications that collectively promote metabolic balance and reduce body fat. The emphasis of therapy on cleansing the body of toxins can enhance digestive efficiency and improve metabolic rates, leading to weight loss. Additionally, specific dietary restrictions and recommendations during Panchkarma therapy, which often include light and easily digestible foods, can contribute to a caloric deficit. The holistic approach of panchkarma, which combines physical, mental, and dietary interventions, likely plays a critical role in achieving sustainable weight reduction. Future research should explore these mechanisms in more detail to provide a comprehensive understanding of how panchkarma therapy influences body weight.

Effect on Endometrial Thickness

This study evaluated the effect of panchakarma therapy on endometrial thickness in patients with Recurrent Implantation Failure (RIF).A total of 25 patients were included in this analysis. The baseline mean endometrial thickness was 7.115 mm (SD = 1.90 mm), which significantly increased to a mean thickness of 9.595 mm (SD = 1.89 mm) post-treatment. The paired t-test revealed a significant increase in endometrial thickness, with a mean difference

of 2.48 mm (t = 6.54, p = 9.10 × 10^-7), indicating that Panchakarma therapy had a positive effect on improving endometrial thickness in these patients. Several factors may have contributed to the observed increase in endometrial thickness. Panchkarma therapy involves detoxification procedures, dietary regulation, and lifestyle modifications that promote overall reproductive health. Detoxification can improve metabolic function and nutrient absorption, whereas improved blood circulation enhances oxygen and nutrient delivery to the endometrial lining. Specific dietary recommendations provide essential nutrients for endometrial health and stress reduction practices such as meditation and yoga to balance hormones and reduce inflammation. These combined effects likely play a critical role in improving endometrial receptivity. Future research should explore these mechanisms in more detail to confirm the long-term benefits of panchkarma therapy.

AMH Levels

This study also examined the effect of Panchkarma therapy on Anti-Müllerian Hormone (AMH) levels.The cohort consisted of 25 patients with an initial mean AMH level of 3.583 pg/ml (SD = 1.96 pg/ml).Post-treatment, the mean AMH level increased slightly to 3.601 pg/ml (SD = 1.98 pg/ml), with the paired t-test indicating no significant change (t = -0.23, p = 0.82).These results suggest that Panchkarma therapy does not significantly affect AMH levels, which remained stable after treatment.AMH, a marker of ovarian reserve, tends to be stable over short periods, and the benefits of Panchkarma may not translate into immediate changes in AMH levels. Instead, the positive effects of therapy may be observed in other reproductive health parameters or overall hormonal balance over a longer period.

Changes in Menstrual History

This study evaluated the effect of Panchkarma therapy on the menstrual history of patients with Recurrent Implantation Failure (RIF).After undergoing Panchkarma therapy, all patients reported significant improvements in menstrual health, encompassing various aspects of their menstrual history.

Cycle Regularity

Prior to treatment, many patients experience irregular menstrual cycles, with intervals varying widely from one cycle to the next. Post-therapy, patients reported a notable shift towards regular menstrual cycles, with intervals stabilizing within the normal range of 21 to 35 days. This regularity indicates a balanced hormonal environment and an improved reproductive health.

Menstrual Flow

Patients also showed significant changes in the volume and duration of menstrual flow. Before treatment, several patients reported either heavy bleeding (menorrhagia) or scanty periods (oligomenorrhea). Following Panchkarma therapy, menstrual flow normalized, with most patients experiencing a balanced flow. Additionally, the duration of menstruation became more consistent, averaging between three and five days, which was within the normal range.

Color Doppler Ultrasound Findings After Panchkarma Therapy

Uterine Blood Flow

Baseline Assessment

Before Panchkarma therapy, the average pulsatility index (PI) and resistance index (RI) of the uterine arteries were measured at 3.2 ± 0.4 and 0.8 ± 0.1, respectively. These values indicate suboptimal blood flow, which may be associated with inadequate endometrial perfusion and poor uterine health.

Post-Treatment Evaluation

Following Panchkarma therapy, significant improvements were observed in the uterine blood flow. The average PI decreased to 2.5 ± 0.3, and the RI decreased to 0.6 ± 0.1. These reductions in PI and RI suggest an enhanced blood flow to the uterus, potentially supporting a more receptive endometrial lining.

Endometrial Perfusion

Baseline Assessment

Initial measurements of endometrial blood flow showed limited perfusion, with only 40% of patients displaying adequate endometrial vascularization. Doppler flow indices suggested restricted blood flow, with an average endometrial PI of 3.0 ± 0.4.

Post-treatment evaluation

After therapy, there was a significant increase in endometrial perfusion.The percentage of patients with adequate endometrial vascularization increased to 80%. The average endometrial PI decreased to 2.3 ± 0.3, indicating improved blood flow within the endometrial lining, which is crucial for implantation and menstrual health. Quantitative measures obtained from Color Doppler ultrasound demonstrated that Panchkarma therapy significantly enhanced blood flow to the uterus and ovaries, leading to improved endometrial perfusion and overall menstrual health. These vascular improvements likely contribute to the observed clinical benefits, including regularized menstrual cycles and reduced menstrual symptoms. Panchkarma therapy shows promise as an effective complementary treatment for improving menstrual health and addressing issues related to Recurrent Implantation Failure (RIF). Future studies should continue to explore these findings with larger sample sizes and longer follow-up periods to confirm the long-term benefits of panchkarma therapy.

CONCLUSION

This study demonstrates the potential benefits of panchakarma therapy as an adjunctive treatment for women with Recurrent Implantation Failure (RIF).The therapy significantly improved pregnancy outcomes with a success rate of 76%, along with notable reductions in body weight and increased endometrial thickness. Doppler ultrasound findings also showed enhanced uterine blood flow and endometrial perfusion, which contributed to better reproductive conditions. While AMH levels remained stable, the therapy positively affected menstrual regularity and flow. Overall, Panchakarma offers a promising complementary approach to conventional IVF to improve reproductive health and outcomes. Further research with larger sample sizes is needed to confirm these results and to explore the mechanisms involved.

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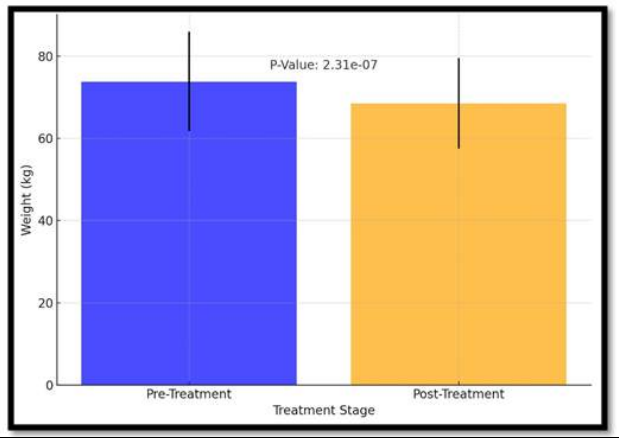


Fig.1: Weight Reduction Before and After the Panchkarma

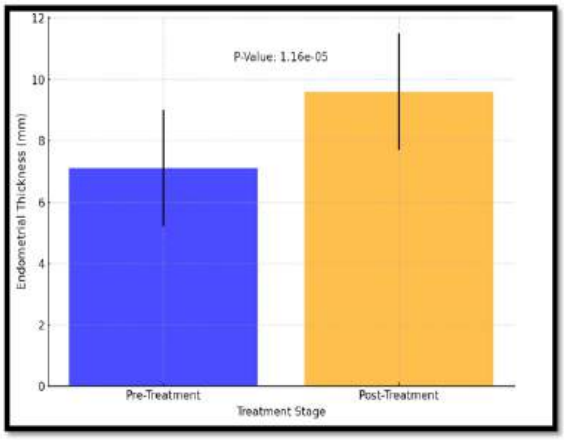


Fig.2: Endometrial Thickness before and After Panchkarma

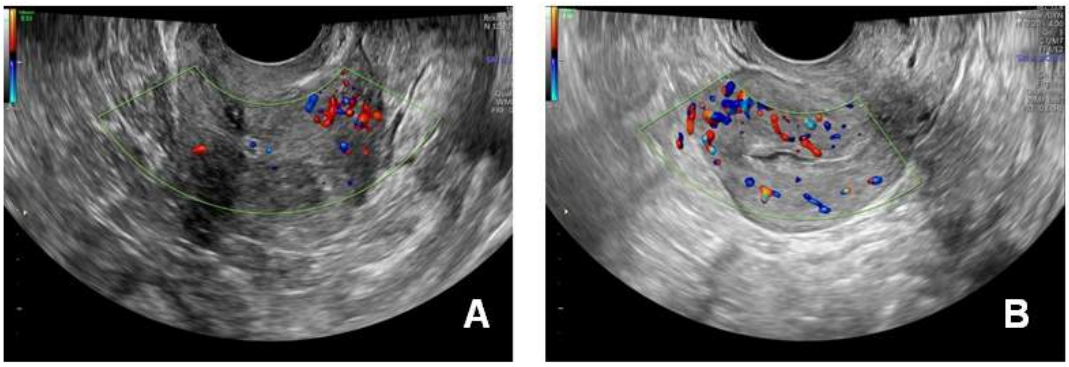


Fig.3 Color Doppler (A) Before (B) After Panchkarma

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RESEARCH ARTICLE

Examination of Phytochemical Properties and Antioxidant Potential of Peel, Pulp, and Seed of *Trichosanthes dioica* Roxb

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ABSTRACT

The use of vegetable components for purposes other than food preparation has great potential for waste management and biomedical research. Their function in biological activities and post-culinary waste management, this study explores the pharmacological potential of vegetable pulp, peel, and entire forms. pharmacological activities are the prospect of transforming post-culinary waste into highly nutritious food additives or supplements. This waste can be recovered at a low cost and have a high value. These components' pharmacological profiles were studied, with an emphasis on their antioxidant properties by an extensive examination of the literature and experimental investigation. In order to identify each component's various biological functions, the study also investigates the extraction methods and bioactive substances that are present in each. According to the research, the Biochemical assay of *T. dioica* also estimated and found that in total and reducing sugar peel has the highest reading. And in starch peel is at the top in reading. For Quantitative analysis TFC and TPC is estimated.TFC of *Trichosanthes dioica* Roxb. in methanol solvent is 203.0±0.04mgQE/g in peel.TPC was 327.3±0.019 mgGAE/g in methanol solvent, when mixed in distil water the results are 278.6±0.013mgGAE/g. According to the result peel consist of enormous amount of flavonoid and phenolic content which can be used in pharmacological studies. IC_{50} value in peel 716.52 ppm in methanol and 14.76 ppm in aqueous solvent in DPPH. FRAP is recorded in range between 177 to 386 mM $FeSO_4$/g. So, it is crucial to use vegetable waste for medicinal purposes as a means of reducing waste and improving human health. This work explains about innovation in waste management and biomedical science by adding to the information on the use of vegetable by-products in pharmacological studies.

Keywords: Antioxidant, DPPH, Food waste management, Phytochemicals, *Trichosanthes dioica*.

INTRODUCTION

Food is very crucial for living beings. Food plays a vital role in providing energy from breaking down complex to simple food. Food production is growing exponentially, and waste management is becoming a major social concern. The more food is produced the more waste is generated. Waste food which is generated has to be managed properly. Food loss refers to the reduction in the mass of edible food (apart from seeds and inedible portions) during the portions of the supply chain that specifically result in food fit for human consumption, i.e., during the stages of production, postharvest, and processing. (Okawa, 2015). Food waste comprises leftover meal portions as well as trimmings from restaurants' and kitchens' food preparation. Food waste is mostly caused by suppliers, retailers, and consumers acting improperly and making poor decisions, which leads to the disposal of food that is still nutritionally sound and might have been eaten (Parfitt *et al.,* 2010). According to the Food and Agriculture Organization (FAO) of the United Nations, 32% of the total food produced in 2009 was lost (Gustafsson *et al.,* 2013). Approximately one-third of the world's food supply, or 1.3 billion tons of food at a cost of $1 trillion USD, is wasted annually, according to IFCO. There are two categories of food waste in the kitchen: qualitative losses and quantitative losses. Food losses attributed to superficially perceived quality in terms of colour, size, form, flavour, etc. are referred to as qualitative losses (Dsouza, 2020). The stiff cores, stems, leaves, husks, shells, peels, seeds, etc., may be among them are some of the wastes. According to Gowe (2015), Banana peel produce 2378 tonnes and mango peel and seed produces 6987 tonnes are produced. Food waste which is firstly observed in the home. According to Edjabou *et al.* (2016) Vegetable food waste made up 145 kg of the 434 kg gross total of residual home garbage in Denmark. The cucurbitaceae family is also known as vegetable family. that includes 800 species and 130 genera, according to Jeffrey (1980). Another name for it is cucurbits. According to Mukherjee *et al.* (2022), this family is well-known for its economic significance. It is made up of numerous vegetables that are typically utilized in kitchens and are referred to as kitchen garden crops (Chauhan et al., 2021). Cucurbits are important crops all throughout the world and are well known for their economic, cultural, and culinary worth (Rolnik & Olas, 2020). According to Robinson and Decker-Walters (1999), this family is generally very adaptive, has quick-growing vines and tendrils, and many produce comparatively larger fruits. Many fruits in the Cucurbit family have multiple uses: Many are eaten raw while they're young (summer squash, cucumber) or old (musk-melon, watermelon). They can be candied (ash gourd, pointed gourd, watermelon), baked (squash), or fried (bitter gourd). (Decker-Walters and Robinson, 1999).

Rich family nutrition and therapeutic properties are well known (Pandit and Hazra 2008). Cucurbitaceae fruits and vegetables have a large economic impact because they are used in so many different food products. Cucurbits can be used as a food source and in the beauty industry, among other things. Cucumber has cooling, calming, and healing properties, which make it a popular addition to skin care products, according to research by Rahman and others (2008). It's a typical component of natural soaps as well. Mature fruits of *Luffa aegyptiaca* have long been used as natural sponges because of their structure (Prabhu, 2021; Salehi *et al.,* 2019). During the cucurbit food production cycle, a lot of fruits and vegetables are intended for disposal. The bulk of this waste, according to Asif *et al.* (2017), is made up of peels, seeds, and fruits, which don't meet aesthetic standards but are nevertheless useful for the cosmetics industry because they contain antioxidants and polyphenols, which also have anti-inflammatory and anti-inflammatory properties. There are several ways to recycle a lot of fruit and vegetable waste, such as throwing it in the trash right away, drying it out to a stable condition (humidity 10%) for use as off-season feed, or using biotechnology to process it into superficial chemical peels. The leafy foods industry's byproducts include vinegar, citrus extract, and acidic corrosive. According to Kheedkar and Singh (2014), waste from plants that process wheat and potatoes into starch can develop into ethanol and other supplements. There are several waste products produced while treating foods that are cultivated in the ground, including fluids, molasses, seeds, and skins. These waste materials are a good source of carbohydrates, proteins, fibres, nutrients, and minerals. According to (Singh *et al.,* 2019), the waste may be utilized to create natural blooms by maturing. One of the healthiest fruits is the pomegranate, which has a high phenolic component content. Kaderides *et. al.,* (2021), from the extraction of pomegranate juice generates large amounts of byproducts, such seeds and peels, which pollute the environment and

provide disposal issues. Pomegranate peel is a byproduct of the fruit juice processing business and makes up around 30% to 40% of the fruit component. It is significant source of flavonoids, particularly anthocyanins, tannins, and phenolic acids. Cuevas (1999) studied that the majority of fruits and vegetables are solely eaten in their flesh or pulp; however, research has shown that the seeds, peels, and other parts of the plant that are not often eaten contain substantial amounts of phytochemicals and important nutrients (Rudra and colleagues 2015). According to Gorinstein and colleagues (2001) and Soong and Barlow (2004), the phenolic concentrations in the peels of citrus fruits such as lemons, grapes, and oranges, as well as the seeds of avocados, jackfruits, longans, and mangoes, are almost 15% greater than those in the fruit pulp. The secondary metabolites of plants called phenolic compounds are responsible for sensory qualities and, among other things, improve the nutritional value of fruits and vegetables (Tomas-Barbera and others 2000; Lapornik and others 2005). According to Popa et al. (2008) and Ignat *et al.,* (2011), phenolic compounds are one of the biggest groups of bioactive substances with a variety of significant biological roles. In their basic structure, they have one or more aromatic rings and one or more hydroxyl groups (Balasundram *et al.,* 2006); some of them additionally show antioxidant activity. As per Gowe, (2015) table 2, shown that various phenolic compounds are mentioned from each of the fruits and vegetables according to their waste part. Guenther and other (2006) has been noted in recent years that 43.7% people are consuming more fruits and vegetables in their diets because they are more aware of their health benefits. A diet high in fruits and vegetables is directly associated with a lower incidence of degenerative diseases, including some forms of cancer, cardiovascular diseases, macular degeneration, aging, etc. Michels *et. al.,* (2000) studied that women who regularly consume 16-17 healthy food had 42% lower all-cause mortality than to those who consume 0-8 healthy foods. According to Kris-Etherton *et al.* (2002), a variety of bioactive substances, such as flavonoids, carotenoid, and other substances, have a number of anti-inflammatory qualities in addition to assisting in the reduction of malignant cells and the inhibition of carcinogenesis. Due to their shown biological activity and associated health advantages, several compounds included in meals known as phytochemicals or bioactive substances have been related to this effect (Liu and others 2003). Byproducts from fruits and vegetables can be used in a variety of ways, but one of the most significant uses is as food additives (Ayala-Zavala *et al.,* 2011). These consist of thickeners, colorants, flavourings, antioxidants, and antimicrobials.

MATERIALS AND METHODS

Collection and Preparation of Plant Materials

The sample is collected from the Kalupur vegetable market, Ahmedabad. The Peel, Pulp and Seed of a robust plant were obtained. The plant was on exhibit by Smit Bhavsar of Gujarat University's Botany department. Plants components and fruit were collected and stored in Whirl-Pak a standard sterilized bags for subsequent use. The peel, pulp, and seed of the plant were isolated from the fruit of the parent plant. In order to remove dirt and other contaminants, the harvested plant portion was carefully cleaned three times using tap water. The plant components were then ground into a powder using an electric mixer after being shade-dried for 72 hours at a moderate temperature.

Extract Preparation

After that, the slurry was sieved to produce fine extract. That will be used later, the extracted material was preserved on sterile petri dishes. Two solvents were chosen based on their polarity and employed to make the plant extract, which was made from the dried extract. The solvents that were selected were methanol and distilled water. Two methods are hot and cold extraction method. According to Nelly *et. al.,* (2008) we have used the traditional method in which the extract was create using a solvent. 100ml of two solvent methanol, and aqueous solution are taken. In which 50mg of plant extract were added. After then the Watman filter paper was taken to filter the produced extract. The solvent was allowed to evaporate in Petri dish for a full day before being refrigerated for later use. The samples are filtered, and extracts prepared in two different solvents – Methanol and Aqueous.

Biochemical Assay

Reducing and total sugar

The Nelson-Somogyi method (Nelson, 1944 and Somogyi, 1952) is used to estimate the reduction of sugar and total sugar. Test tubes are prepared in the triplicate and then 1ml volume of an aliquot was pipetted out of the sample (Peel, pulp, and seed). After that 1ml of Somogyi's copper reagent was added to this. Subsequently, the mixture was submerged in a boiling water bath and allowed to heat for 20 minutes. Nelson's Arseno-molybdate reagent (1.0 ml) was introduced and immediately mixed in with tap water after chilling, and the volume was increased to 10 ml with distilled water. Using a UV-VIS spectrophotometer, the colour intensity was determined at 620 nm from appropriate samples.

Starch

Starch is estimated according to Chinoy, 1939. To dissolve the starch, aqueous hydroxide is applied to the plant material when it is cool. When aqueous hydroxide interacts with Lugol's solution which is also known as iodine-potassium iodine, then a coloured complex is produced after incubating it for 10min. The developed color corresponds to the starch concentration, and a spectrophotometer set at 600 nm is used to measure the starch content.

Quantitative Analysis

Total Phenolic Content

The Folin-Ciocalteu technique (Zheng & Wang, 2001) was modified to quantify TPC of Pulp, peel and seed component extracts can be evaluated. Phenolic compounds of plants form the complex structure with oxidizing agents such as phosphomolybdate and develop the blue color. Dense color of solution records the higher content of phenols. Take 1ml extract of peel, pulp and seed each in different test tube. Add 10ml distilled water. And then Add 1.5ml F-C reagent in a triplicate via micropipette. Shake it well by covering it with aluminum foil paper. Incubate it for 5min in room temperature. Now add 4ml of 20% sodium carbonate solution. After that make a final volume up to 25ml with distilled water. Again, shake it well and incubate it for 30min at room temperature by covering it with aluminum foil. A Spectrophotometer is used to calculate the absorbance at 765nm. With gallic acid as standard, a calibration curve is created. The following formula can be used to calculate the quantity of phenolic content in an unknown plant sample.

Total Phenolic Content=GAE x V/ m

GAE= Galic acid equivalent (mg/ml), V= volume of plant extract

Total Flavonoid Content

TFC was investigated, as (Saeed *et. al.,* 2012). The aluminium chloride colorimetric method works on the basis that aluminium chloride forms acid-stable complex with flavones and flavanol's C-4 keto group and either C-3 or C-5 hydroxyl group (Kariyone & Matsuno 1953 & Naghski J *et. al.,* 1951). The extract was diluted to a 1.5 mg/mL concentration in methanol. Following that, add 1.5 mL of methanol to 0.5 mL of the sample solution (seed, peel, and pulp, respectively). Now, 0.1 mL of aluminium chloride (10% in methanol) and 0.1 mL of potassium acetate (1 M) were put to a test tube containing 10 mL of pure water and stirred. After thorough mixing, it was allowed to sit at room temperature for half an hour. In a spectrophotometer, the OD is measured at 415 nm. Consequently, the total flavonoid content was determined. With Quercetin as standard, a calibration curve is created. The flavonoid content of an unknown plant sample can be estimated using the following formula:

Total Flavonoid Content = QE x V/ m

QE=Quercetin equivalent(mg/ml), V=volume of plant extract

Antioxidant Analysis

FRAP

The standard method by Benzie and Strain (1996) utilized the ferric reducing activity test (FRAP) to determine the extracts' ability to reduce ferric iron. The sample extract and standard of 0.1 ml is taken in the test tube from the stock solution. Then 3ml The FRAP reagent was mixed and shake well. The mixture is placed for 30min during the

incubation period. Later the absorbance was recorded at 593 nm by using spectrophotometer. The standard curve was plotted using $FeSO_4 \cdot 7H_2O$ as standard, then result is recorded as mg Fe (II) equivalent/g extract.

DPPH

According to Magalhaes et al. (2006), the crude extract's capacity to scavenge free radicals was assessed. The 2,2-diphenyl-1-picrylhydrazyl (DPPH) test was used to measure the free radical scavenging activity. The methanol solvent was employed to dissolve the freeze-dried extracts. A 1 mg/1 ml stock solution was made. Dissolve the methanol into the plant extract (0.2, 0.4, 0.6, 0.8 ml and 1.0 ml) to get a final volume of 1 ml. Plant extracts were added to newly made DPPH solution in test tubes with aluminium foil seals. A series is made at various concentrations and left in the dark for 30 minutes. The absorbance of a UV-visible spectrophotometer is measured at 517 nm. The standard was ascorbic acid, a well-known antioxidant. As a blank, methanol was utilized, and the controlled sample maintained the same value without any plant extract. The measurement was made three times over. The absorbance value decline was contrasted with the positive control. The following formula was used to compute the inhibition ratio (%) and the IC_{50} values.

%inhibition = absorbance of control – absorbance of sample / absorbance of control X 100

RESULTS

Biochemical Analysis

Total and reducing sugar

The total sugar result ranged from 120 to 215mg/ml from the graph 1, indicating that Peel, seed, had modest trace of sugar then in Pulp in aqueous solvent when compared to standard. It was evident from Chandrasekhar *et. al.,* (1988) study that *T. dioica* possessed the ability to reduce blood sugar level. The outcome of reducing sugar content revealed that the peel had a lower level of glucose then the pulp and seed. When compared to a typical glucose standard, the *T. dioica* peel's aqueous extract revealed greatly reduced amount of glucose. Proks *et. al.,* (2002) reported that their study shown that insulin levels were lowered in type-2 diabetes model rats, with a drop of around 54% in blood insulin levels compared to the control group.

Starch

T. dioica starch content analysis shows that, when compared to a standard of glucose, the seed had the greatest starch content. *T. dioica* has trace levels of starch granules, according to Manda *et. al.,* (2018). He also added that the existence of compound starch is thought to give it a special quality.

Quantitative Analysis

Total Phenolic Content

From the regression equation from calibration curve of gallic acid, TPC content was obtained. According to these findings, TPC values were determined from two distinct extracts, with the methanol extract having a greater phenolic concentration then the aqueous solution. Peel from methanol extract had a greater content (327±0.019 µg/ml) than the Pulp and Seed sample. A study by Yadav *et. al.,* (2016) found that one of the Cucurbitaceae family, *C. pepo* (533.60±0.05) has higher phenolic content in methanol extract then all other cucurbit species. The result they obtained showed that the phenolic content of *T. dioica* was (118.82±1.11 mg/ml) higher than our fruit sample in aqueous extract.

Total Flavonoid Content

From the regression equation from calibration curve of quercetin, the TFC of methanol of different sample was expressed. According to these finding flavonoid content was quite similar in Seed (113±0.003 µg/ml) and Pulp (127±0.008 µg/ml) and higher in the Peel (203±0.004 µg/ml) of methanolic extract. According to Shrivastava *et. al.,* (2021) Total flavonoid content of methanolic extract of *T. dioica*. has recorded (219±58.573 µg/ml) in which was quite

higher than our finding. Quercetin does not dissolve in aqueous solution so only methanol extract's flavonoid content was recorded by the quercetin as standard.

Antioxidant Analysis

FRAP assay

As indicated by the result of FRAP assay in given table 3, significant differences were observed in Peel, pulp and seed. Ferric reducing antioxidant power based on the $FeSO_4$ absorbance and concentration and from the standard curve of it, results were range between 177 to 386 mM $FeSO_4$/g. The findings were quite similar in the aqueous solution then in methanol. According to Yadav *et. al.,* (2016) *T. dioica* FRAP value (936.14±13.34) obtained higher than our extract methanolic extract, as he recorded the whole fruit FRAP absorbance the finding was nearly similar in term of *T. dioica* whole fruit.

DPPH

The DPPH method is used to estimate the radial scavenging activity of antioxidant compound. IC_{50} value is obtained through a regression analysis that describes the concentration of a test solution that can reduce 50% free radical and represents antioxidant activity (Widyasanti *et. al.,* 2016). DPPH radical was expressed as IC_{50} value shown in table 4. The results of DPPH free radical scavenging power are shown in table 5. Among the three different ethanolic extract Pulp exhibited the highest value of DPPH scavenging activity test with IC_{50} 716ppm in peel then pulp and seed. Both in methanolic and aqueous extract. According to Singh *et. al.,* 2016 found that the antioxidant activity of Cucurbitaceae species were significantly higher in peel than pulps. According to the Li'aini, *et. al.* 2022 *Trichosanthes tricuspidate* Lour. IC_{50} value of peel was 78.029 ppm. The result of our finding is also similar to their findings.

CONCLUSION

These results highlight the important presence of different phytochemicals in every section of fruit, suggesting their possible use in areas other than conventional cooking. Remarkably, the peel extract showed a higher concentration of bioactive substances such as tannins, flavonoids and phenolics, indicating a potential use in the pharmaceutical and nutritional supplement sectors. The TPC values are resulting higher values from the peel part(327µg/ml) in compared to pulp(204µg/ml) and seed(13µg/ml). TFC values are also find higher in peel part (0.203 µg/ml). Additionally, the pulp and seed extracts showed strong antioxidant activity, suggesting possible use for them in products that promote health. Similarly, waste generated by a single hotel of a metro city New Delhi named Radisson Blu Plaza hotel generates about 27,000 kilogram of waste every month. Likewise, IFCO has mentioned in 2021, that around 2.5billion tons are food waste produced in every year. Around 45% of all fruits and vegetables are not eaten globally every year. That results 10% of the greenhouse gas emission caused by food lose which cause carbon dioxide and other greenhouse gases. The post culinary waste can be generated, and it can be generated around 936 billion USD globally every year. The private sector pledge by 2030 in line with UN sustainable goal target 12.3, which has predicted up to 50% reduction in food loss and waste by 2030. These finding highlight the significance of implementing a comprehensive waste management strategy that allows post culinary waste to be recycled for their fundamental nutritional and therapeutic qualities. By maximizing the values of agricultural byproducts, using this extract might offer economic benefits to reduce environmental problems related to trash disposal. This study is to find out and utilize agricultural byproducts' bioactive properties in order to promote sustainability and innovation across a range of sectors like Waste management, Economic opportunities, Innovation and Sustainability and Healthcare and pharmaceutical development.

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Table 1: Total sugar from Peel, pulp and seed from *T. dioica*

Sr. no.	Total sugar					
1.	Methanol			Aqueous		
	Peel	Pulp	Seed	Peel	Pulp	Seed
	145	215	180	120	203	164

Table 2: Reducing sugar from Peel, pulp and seed from *T. dioica*

Sr. no.	Reducing sugar					
1.	Methanol			Aqueous		
	Peel	Pulp	Seed	Peel	Pulp	Seed
	134	188	226	111	154	213

Table 3: Starch from Peel, pulp and seed from *T. dioica*

Sr. no.	Starch					
1.	Methanol			Aqueous		
	Peel	Pulp	Seed	Peel	Pulp	Seed
	633	707	1007	703	842	1137

Table 4: - Total Phenolic Content in Peel, Pulp, and Seed of *T.dioica* Roxb.

Sr. no.	Total Phenolic Content					
1.	Methanol			Aqueous		
	Peel	Pulp	Seed	Peel	Pulp	Seed
	327.3±0.019	204±0.009	87±0.008	278.6±0.013	252±0.029	13.05±0.010

Table 5: - Total Flavonoid Content in Peel, Pulp, and Seed of *T.dioica* Roxb

Sr. no.	Total Flavonoid Content		
1.	Methanol		
	Peel	Pulp	Seed
	203.0±0.04	127.0±0.08	113.0±0.03

Table 6: - Ferric Reducing Antioxidant Power (FRAP) Assay in Peel, Pulp, and Seed of *T.dioica* Roxb

Sr. no.	Ferric Reducing Antioxidant Power (FRAP)					
1.	Methanol			Aqueous		
	Peel	Pulp	Seed	Peel	Pulp	Seed
	250±0.03	367±0.03	177±0.04	481±0.10	326±0.04	386.5±0.03

Table 7: - IC_{50} Values of Antioxidant activity (DPPH) of sample

Sr. no.	IC_{50} Value(ppm)					
1.	Methanol			Aqueous		
	Peel	Pulp	Seed	Peel	Pulp	Seed
	716.52	2.85	9.04	14.76	2.26	26.25

Table 8: - DPPH Scavenging Activity (%) in Peel, Pulp and Seed of *T. dioica* Roxb

Sr.no.	Concentration (µg/ml)	DPPH Scavenging Activity (%) of Methanol					
		Methanol			Aqueous		
		Peel	Pulp	Seed	Peel	Pulp	Seed
1	200	36.86±2.37	33.89±2.95	29.71±0.68	32.91±0.55	69.69±0.58	22.24±1.03
2	400	43.0±2.87	40.99±0.31	31.02±1.26	34.81±0.58	73.26±0.79	23.32±0.87
3	600	49.04±2.44	55.64±1.54	33.03±1.54	36.71±1.33	74.62±0.87	24.64±0.40
4	800	52.62±2.57	61.28±0.49	35.45±1.01	36.98±1.16	75.48±1.05	25.46±0.87
5	1000	55.04±0.49	63.90±0.91	0.74±0.78	37.83±0.69	76.68±1.17	26.66±1.04

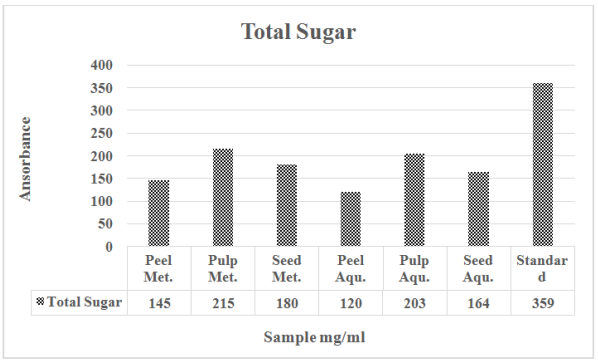


Chart 1: - Total sugar from peel, pulp, and seed using standard of glucose

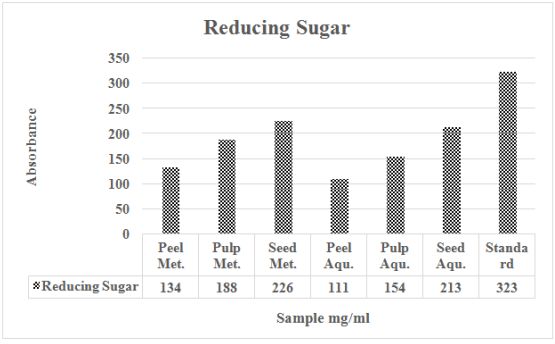


Chart 2: - Reducing sugar from peel, pulp, and seed using standard of glucose.

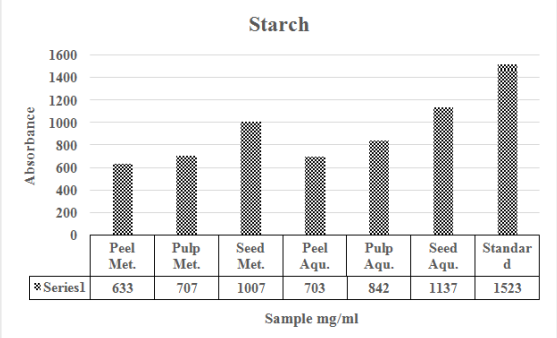


Chart 3: Starch from Peel, pulp and seed from *T. dioica*

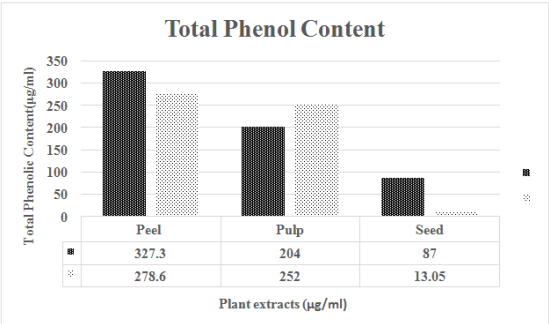


Chart 4: - TPC from peel, pulp, and seed of *T. dioica*.

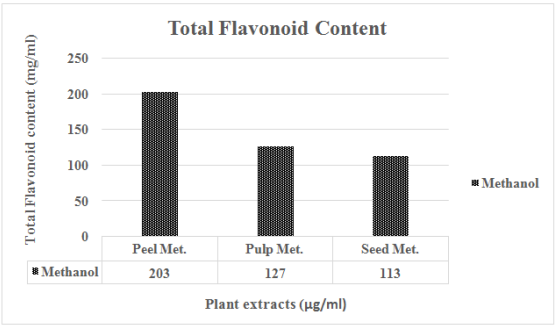


Chart 5: - TFC from peel, pulp, and seed of *T. dioica*.

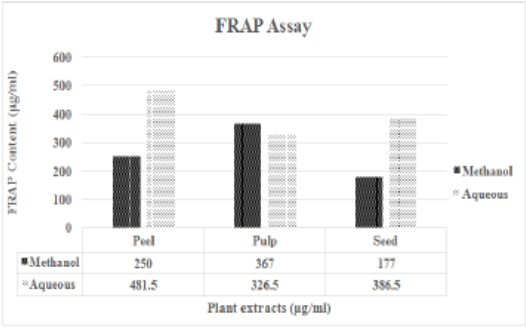


Chart 6: - FRAP Assay from peel, pulp, and seed of *T. dioica*

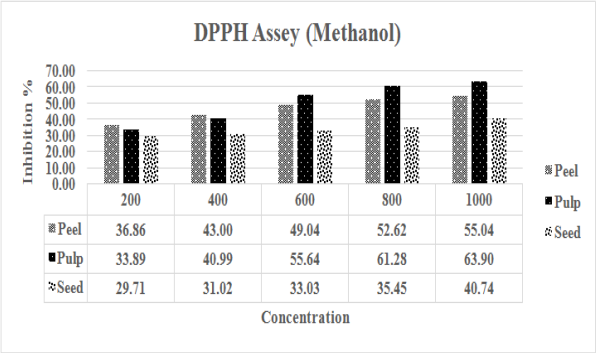


Chart 7: DPPH Assay (Methanol) from peel, pulp and seed of *T. dioica*

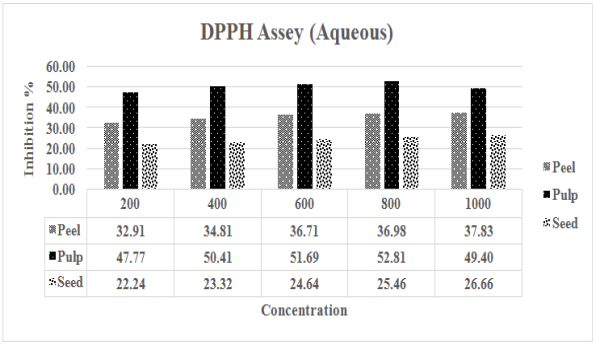


Chart 8: DPPH Assay (Aqueous) from peel, pulp and seed of *T. dioica*

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RESEARCH ARTICLE

Analysis of Composition and Antibacterial Activity of Essential Oil of *Rosa brunonii* Linn. From Garhwal Himalayas

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ABSTRACT

Essential oil, widely produced by nature, these are complex mixture of volatile secondary metabolites. Its composition varies due to multiple factors, that can lead to misunderstanding regarding their efficacy, safety and remarkable pharmacological property. In continuation, present study explores the composition of volatile oil constituents of Rosa brunonii Linn.and was analyzed by GC and GCMS. Twenty-five compounds represent 99.7 % of the total oil. The main components of the oil were, Linalool acetate (53.6%), Linalool (9.6%), NN (m/z 91, 105, 117, 145, 79, 43,160) (7.3 %), (E)-8-Hydroxy geraniola (4.1%), Verbanol acetate or piperitol acetate? (3.7%), (Z)- 8-Hydroxygeraniola (3.6%), Geranyl acetate (2.2 %) and α-Terpineol (1.9 %). The oil was subjected for its antibacterial activity with four pathogenic bacterial strains i.e. Staphylococcus aureus, Escherichia coli, Bacillus subtilis and Pseudomonas aerugenosa, and found to be more active against Escherichia coli with 8 mm (zone of inhibition) activity.

Keywords: *Rosa brunonii*Linn., Volatile oil constituents, Linalool acetate, (Z)-8-Hydroxy geraniol[a], *Pseudomonas aerugenosa*

INTRODUCTION

Rosa brunonii Linn.(Rosaseae) is known as Himalayan Musk Rose (Wild rose), Sewati (Kubjak) in Sanskrit and kujju, kunja and kujji in Hindi. Rosa brunonii is strong rambling shrubby plant approximately 5-10 m tall. Stem are dark brown, rough, exploiting in papery pieces [1][2] with stout prickles and imporipinnate 0.5-1.2 Cm long leaves. Flowers are white with a characteristic fragrance. Fruit is orange-red to brown in colour ovoid 1-1.5 Cm long, viccid, and may seeded. Rosa brunonii is wildly distributed in western Himalaya, Bhutan, Afghanistan, Europe, and China. It is commonly found in open places, pine-oak fresh edges at a height of 600-2000 m. there are some medicinal properties associated with this plant. Its roots are known as "Rajatarini" and said to be used as medicine in some eye diseases. Flowers and leaves are also used in the treatment of wounds and ophthalmic. Powdered of dried flowers is used in diarrhea. Flowers of Rosa brunonii are suitable substitute of Damask rosa for preparation of rosa water and attar. It is an important source of rose hips also [3][4]. The species of Rose extensively studies for essential oil composition seems to be *Rosa damascene* [5][12]. Surprisingly there is no any report on phytochemical investigation of *Rosa brunonii*. This prompted us to find out the detailed phytochemical investigation of *Rosa brunonii* wildly growing in Dhanolti region, Tehri Garhwal at an altitude of 1650 mtrs.

MATERIAL AND METHODS

The fresh plant material of *Rosa brunonii* (600 kg) was collected from the Dhanolti region of Tehri Garhwal and was Authenticated by Dr. J.K. Tiwari, Taxonomist, from the Department of Botany, HNB Garhwal University Srinagar Garhwal. The essential oil was extracted from the plant and was subjected to hydro distillation method for continuous 5-7 hrs., using Cleavenger type apparatus. The essential oil was obtained and further dried over anhydrous sodium sulphate. The GC-MS analysis of essential oil (0.2µl) was performed by using gas chromatograph HP 6890 with mass selective detector MS 5973 (Agilent Technologies, USA) which is fitted with a HP-5ms and fused with silica column (30 m × 0.25 mm; 0.25 µm film thickness), further with the electronic pressure control and split-splitless injector. Helium flow rate through this column was 1 ml/min in regular constant flow mode. The initial column temperature was 50^0C, rising with 250^0C at a rate 5^0C/min. The MS detector acquisition parameter was transfer line held at 260^0C and detector was held at 280^0C as well. Detection was executed in the full scan mode ranged from *m*/*z* 41 to 450.A hexane solution of C_8-C_{28}*n*-alkanes was also separated under the above-mentioned conditions, and their retention times was also determined. Linear temperature programmed retention indices (LTPRI) was also calculated from the results of the separation of essential oiland *n*-alkanes according to following equation:

$LTPRI = 100(t_x - t_n)/ (t_{n+1} - t_n) + 100n$,

Where t_x, t_n and $t_{n+1}$are the retention times of component *x*as mentioned, and *n*-alkanes with the number of carbon atoms in the molecule *n* and *n*+1, respectively. After integration of the fraction of each component by which the total ion current (TIC) was calculated. Components of extracted essential oilwas identified with the help of an automatic system of processing data of GC-MS supplied by NIST mass spectra library. Identification was considered reliable if the calculated values of LTPRI confirmed the results of computer search at mass spectra library ($LTPRI^{Calc} - LTPRI^{Lit} \leq$ 5 index units), ($LTPRI^{Lit}$) [13] [14]. The essential oil of *Rosa brunonii* was also tested for antimicrobial activity by using agar disc diffusion method on solid media [15] [16]. Luria agar was used as basal medium for both *Escherchia coli* and *Bacillus subtilis*; and nutrient agar was used as basal medium for both *Pseudomonas aeroginosa*, *Staphylococcus aureus*. 5 gm of luria broth and 4 g of agar powder; 3.25 g of nutrient broth and 4 g of agar powder was weighed and 250 ml of water was also added separately. Then the mixture was heated to dissolve the components. Luria agar and nutrient agar were sterilized in an autoclave [17]. Luria agar and nutrient agar were poured in the sterile Petri plates. Mother culture of each organism was set up for 24 hrs. before the assays, in order to reach stationary phase of growth [18]. The tests was assessed by inoculating Petri dishes from the mother cultures which had been spread on the surface with 0.1 ml of each bacterium, with the aim of obtaining microorganism concentration of 10^5 colony forming units (CFU/ml) [19]. Sterile dilutions of essential oil was deposited on the sterile Whatmann filter paper No.1 discs (5mm disc diameter), which was subsequently placed in inoculated Petri plates. Therefore the Petri plates were than

incubated at 37° C for24 hrs. The antibacterial activity was evaluated by measuring the diameter of zone of inhibition surrounding bacterial growth [20].

RESULTS AND DISCUSSION

Volatile oil extracted from *Rosa brunonii* was analyzed by GC and GC-MS. Twenty five compounds were identified by Retention Index, Relative Composition (Table-1). The major components were determined as Linalool acetate (53.6%), Linalool (9.6%), NN (m/z 91, 105, 117, 145, 79, 43,160)(7.3 %), (E)-8-Hydroxy geraniol[a] (4.1%), Verbanol acetate or piperitol acetate (3.7%), (Z)-8-Hydroxy geraniol[a] (3.6%), Geranyl acetate(2.2 %) and α-Terpineol (1.9 %).The present oil was found more or less similar with the other in respect of the presence of Geranyl acetate, Geraniol but differs in respect of α-Muurolene and (E)-γ-Himachalene, which is not reported. These variations in the chemical composition may be due to chemical races, geographical variations and other differences in maturity. The GC-MS and MS traces of essential oil of *Rosa brunonii*are given in Fig-1 and Fig.-2. The essential oil was identified as active agent against *Staphylococcus aureus*, *Escherichia coli* and *Bacillus subtilis*. It is most sensitive against *Escherichia coli* with 8mm zone of inhibition while is least sensitive against *Staphylococcus aureus* with 4mm of inhibition. Antibacterial activity of the oil was shown in Fig-3 (Table-2).

CONCLUSION

Essential oil of *Rosa brunonni Lin.* has so many potential as antibacterial agents. Many more medicinal plants have health benefits, including antimicrobial, antioxidant, and therapeutic properties. This investigation are very useful for further researchers.

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Table-1. Chemical composition of the essential oil of *Rosa brunonii*

Compound	LTPRI^{Calc}	LTPRI^{Lit}	Relative composition, %	Identification
Linalool oxide, *cis*-	1074	1068	1.0	MS, GC
Linalool oxide, *trans*-	1088	1083	0.7	MS, GC
Linalool	1098	1098	**9.6**	MS, GC
Camphor	1135	1043	2.3	MS, GC
α-Terpineol	1186	1187	1.9	MS, GC
2,6-Dimethyl-3,7-octadiene-2,6-diol	1191	1190	trace	MS, GC
Linalool acetate	1257	1257	**53.3**	MS, GC
Verbanol acetate or piperitol acetate?	1339	1340	3.7	MS, GC
Terpin-4-ol acetate	1344	1340	1.2	MS, GC
α -Terpineol acetate	1350	1351	trace	MS, GC
Citronellyl acetate	1353	1354	0.6	MS, GC
Neryl acetate	1363	1366	0.6	MS, GC
Carvacrol acetate	1375	1371	trace	MS, GC
Geranyl acetate	1382	1386	2.2	MS, GC
8-Hydroxy linalool, isomere 1[a]	1406	-	0.5	MS
8-Hydroxy linalool, isomere 2[a]	1410	-	0.8	MS
NN (m/z 91,105,117,145,79,43,160)	1420	-	7.3	MS
(Z)-8-Hydroxy nerol[a]	1495	-	1.8	MS
(Z)-8-Hydroxy geraniol[a]	1511	-	3.6	MS
(E)-8-Hydroxy geraniol[a]	1516	-	4.1	MS
Eudesmadiene	1541	1540	trace	MS, GC
Sesquiterpenoid $C_{15}H_{24}O$ (m/z 91,105,145,159,205)	1567	-	1.5	MS
Sesquiterpenoid $C_{15}H_{26}O$ (m/z 91,93,41,79,161)	1571	-	trace	MS
Spathulenol	1575	1576	1.7	MS, GC
(E,E)-Farnesyl acetate	1838	1843	1.2	MS, GC
[a] Tentative identification.			Total = 99.7	

Table- 2. Antibacterial activity of Essential Oil of *Rosa brunonii* L.

SN.	Bacterial strain	Group	Zone of Inhibition
1.	*Bacillus subtilis*	Gram (+)	--
2.	*Staphylococcus aureus*	Gram (+)	3mm
3.	*Escherichia coli*	Gram (-)	**8mm**
4.	*Pseudomonas aerugenosa*	Gram (-)	4mm

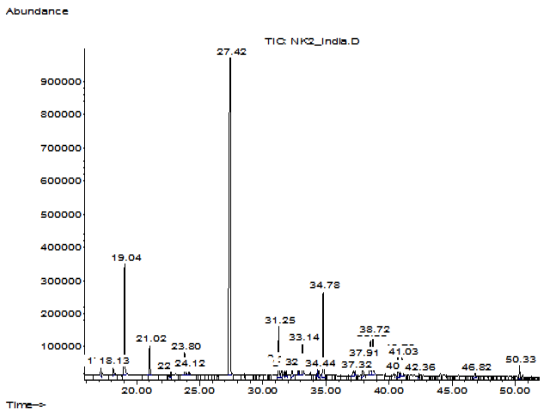


Fig.-1: GC-MS spectra of essential oil of *Rosa brunonii* L.

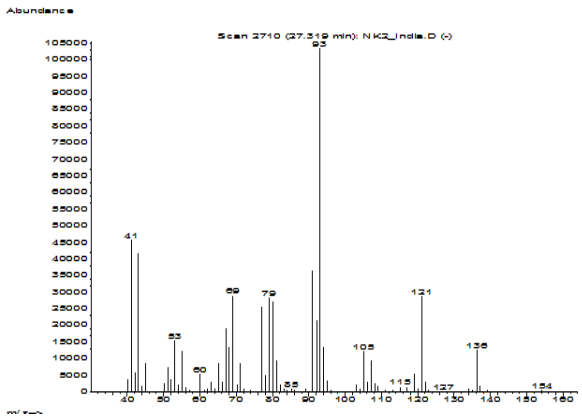


Fig.- 2: Mass spectra of linalool acetate, main peak with retention time27.42 min



Fig. 3: Antimicrobial activity of essential oil of *Rosa brunonii* Linn. Against *E.Coli and Pseudomonas aerugenosa*

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RESEARCH ARTICLE

A Study on Constraints in Utilizing the Information and Communication Technology (ICT) among Farmers in Tirupathur District

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ABSTRACT

In the current state of Indian agriculture, public extension cannot potentially supply more competent staff to fully satisfy the farmer's complicated need by reaching millions of farmers. Farmer's demands are increasingly more diverse, and the expertise necessary to satisfy them exceeds the capabilities of grass-root extension workers. These flaws or disadvantages are focused on the utilization of alternate ways of value addition and demand-driven information to the agricultural community. The utilization of current and rapid communication channels, such as ICTs, is critical for disseminating and creating knowledge about the latest farm technology among the rural masses. Major constraints encountered by the majority of respondents in using ICT services were fluctuating telecommunication network, erratic power supply, inability to understand the language of service provider, lack of practical knowledge about given new recommendation, inability to purchase recharge cards, high cost of multimedia mobile phones, high cost of telecommunication network services, and busy network of kisan Call Centre. The aim of this education is to bridge the gap. Think about it, most of the agriculture related information were transformed to farmers with the help of ICT. This study shed lights on the major constraints in accessing and utilizing ICT by farmer in Tirupathur district.

Keywords: ICT in Agriculture, Farmer Constraints, Communication Channels, Agricultural Information Dissemination, Agricultural Technology Adoption.

INTRODUCTION

Agriculture is a significant component of the Indian economy, accounting for over 17% of gross domestic product (GDP). Only earnest efforts in agricultural research and extension would be able to meet the rising demand for food grains. Despite the size of the Indian economy, agriculture lags behind in many ways, including weak market connectedness and fragmentation, inaccurate and delayed information to farmers, tiny land holdings, non-acceptance or limited adoption of modern technologies, and so on. It has become critical to investigate various methods of keeping our farmers up to speed on contemporary technology and important knowledge in order to maintain pace with the present technological era. ICT has the potential to change the Indian farming sector, benefiting all farmers, especially small landholders. Agriculture is the most significant sector, employing the bulk of the rural people in developing nations. ICT has the potential to transform all parts of our life, including knowledge distribution, social interaction, economic and commercial operations, political involvement, media, education, health, leisure, and entertainment. Through the creation of information-rich societies and the support of livelihood, ICT may play a vital role in eliminating rural and urban poverty and encouraging sustainable development. There are around 120 million farm holdings in India, with the number rising year after year. It offers at least one village extension staff per 800-1000 farm families, the field level extension personnel required is anticipated to be between 1.3 and 1.5 million, compared to the current availability of just approximately 0.1 million (1,00,000) personnel [1]. A supplemental service is a non-negotiable demand of the country's farmers with this level of interaction intensity; information needs are quickly increasing with the introduction of contemporary technology, hybrid seeds, and changing climatic circumstances. As a result, farmers frequently discover that their conventional expertise, experience, and efficiency are no longer relevant. As a result, farmers frequently discover that their conventional knowledge, expertise, and efficiency in making day-to-day decisions are ineffective under changing situations. The lack of information separating rural and urban regions has put rural resident's capacity to make improvement in their economic, social, and environmental circumstances at jeopardy. The effects on the rural populace were threefold, including lost opportunities, time, and money. India has the technological resources to provide farmers with the knowledge they require, enabling them to increase their output and standard of living. Furthermore, a 2022 World Bank survey found that only 23.4% of adult Indians in rural areas possess basic digital literacy, making it challenging for farmers to effectively utilize digital tools and access vital information [2].

RESEARCH METHODOLOGY

The current study was designed to investigate the constraints in utilizing ICT services for information seeking. The research was conducted in 10 villages in the Tirupathur block of Tamil Nadu's Tirupathur district. The proportionate random sampling approach was used to choose a fixed sample size of 120 respondents. A well-structured and pre-tested interview schedule was used to obtain data from respondents. Using proper statistical methods, the acquired data was analyzed and tallied. Respondents were asked to mention the constraints experienced by them while utilizing ICT in agriculture. Based on the responses from farmers, the different constraints in dissemination of agricultural Information technologies and accessing information through ICT were enlisted. The enlisted constraints were categorized. The suggestions for improvement of the usage of ICT were also obtained. Using proper statistical methods, the acquired data was analyzed and tallied. Simple per cent analysis was employed to make simple comparisons wherever necessary.

Data Collection

A well-structured interview schedule was constructed to meet the objectives of the present study. Out of several techniques of collecting data, the interview schedule was found to be the most feasible and suitable instrument. Interview schedule is a form containing a series of questions asked by the interviewer, where the respondent answers it. Interview method was chosen considering the fact that all the respondents were distributed geographically in a wide area in the district.

Data Processing

The data collected from the respondents were scored, tabulated, categorized and fitted into tables to facilitate the interpretation of findings. The master table formed the basis for subsequent analysis. After subjecting the data to statistical analysis, relevant inferences and conclusions were drawn and interpreted objectively.

RESULTS AND DISCUSSION

The results depict lack of training were reported as major constraints (87.50 per cent). And also 85.00 per cent of the respondents reported that High cost for internet Service was represented as a major constraint. High cost of gadgets in existing systems is also a major constraint faced 79.17 per cent of the respondents. Lack of skill to use modern IT gadgets was reported as a constraint by 75.00 per cent of respondents. Lack of access to internet and Lack of updated Information were reported as a constraint by 72.50 per cent and 70.83 per cent of respondents as the major constraints. Lack of practical knowledge in implementing the obtained information were reported as a constraint by 68.33 per cent of respondents. Lack of interest in using ICT were reported as a constraint by 66.67 per cent of respondents. Complex nature of ICT usage process were reported as a constraint by 65.00 per cent of respondents. Language barriers in accessing gadgets were reported as a constraint by 62.50 per cent of respondents. Poor connectivity of Network were reported as a constraint by 60.00 per cent of respondents. Low IT literacy was reported by 55.83 per cent of respondents. 50.00 per cent of respondents reports traditional belief in existing systems as a constraint, 54.17 per cent of the respondents reported time consumption as a constraint. Fluctuating telecommunication network was reported by 47.50 per cent of the respondents. The internet band width might be shown in rural area may be the reason for the above constraint.

CONCLUSION

The study highlights significant constraints faced by small farmers in accessing and utilizing Information and Communication Technology (ICT) for agricultural purposes. The primary challenges include a lack of training (87.50%), high internet service costs (85.00%), and expensive ICT gadgets (79.17%), making digital adoption difficult. Additionally, lack of skills (75.00%), poor internet access (72.50%), and outdated information (70.83%) further hinder effective ICT utilization. Practical implementation issues (68.33%), lack of interest (66.67%), and the complexity of ICT processes (65.00%) also contribute to the digital divide. Language barriers (62.50%), poor network connectivity (60.00%), and low IT literacy (55.83%) exacerbate these difficulties. Traditional beliefs (50.00%), time constraints (54.17%), and fluctuating telecommunication networks (47.50%) further discourage ICT adoption among farmers. The findings emphasize the urgent need for targeted interventions, including affordable ICT solutions, capacity-building programs, localized digital content, and infrastructure improvements to bridge the digital divide. Enhancing rural digital literacy and making ICT more accessible and affordable can significantly empower small farmers, improving their decision-making and agricultural productivity.

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Table 1. Constraints Faced by Farmers in Utilizing ICT

S.NO	CONSTRAINTS	NUMBER OF REPONDENTS	PER CENT ANALYSIS	RANK
1	Lack of updated information	85	70.83	**VI**
2	Poor connectivity of Network	72	60.00	**XI**
3	High cost for internet Service	102	85.00	**II**
4	High cost of gadgets	95	79.17	**III**
5	Low IT literacy	67	55.83	**XII**
6	Lack of skill to use modern IT gadgets	90	75.00	**IV**
7	Fluctuating telecommunication network	57	47.50	**XV**
8	Lack of access to internet	87	72.50	**V**
9	Lack of training	105	87.50	**I**
10	Lack of practical knowledge in implementing the obtained information	82	68.33	**VII**
11	Time consumption	65	54.17	**XIV**
12	Language barriers in accessing gadgets	75	62.50	**X**
13	Complex nature of ICT usage process	78	65.00	**IX**
14	Lack of interest in using ICT	80	66.67	**VIII**
15	Traditional belief in existing systems	60	50.00	**XIII**

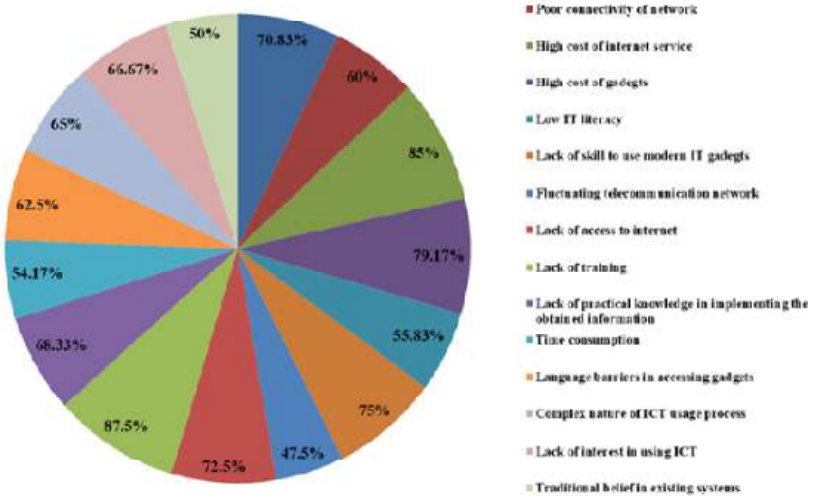


Fig 1. Constraints Faced by Farmers in Utilizing ICT

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RESEARCH ARTICLE

Exploring the Anti Cancer Properties of *Dracaena trifasciata* and *Eclipta prostrate*

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ABSTRACT

This study investigates the anticancer potential of *Dracaena trifasciata* and *Eclipta prostrata*, two medicinal plants with traditional applications. Cytotoxicity assays were conducted to evaluate their effects on cancer cells. *Dracaena trifasciata* exhibited moderate cytotoxicity, while *Eclipta prostrata* demonstrated greater potency, aligning with previous studies. Both plants were found to induce apoptosis and regulate cell cycle progression through mechanisms involving mitochondrial pathways and the inhibition of key signaling pathways such as NF-κB and PI3K/Act. These findings suggest that *Dracaena trifasciata* holds promise as a potential source of novel anticancer agents, warranting further research for its therapeutic potential and potential synergistic effects with conventional chemotherapies.

Keywords: Dracaena *trifasciata; Eclipta prostrata*; MTT Assay; Anti-Cancer Activity; Phytochemical Analysis

INTRODUCTION

Despite significant advancements in medical research and the availability of numerous treatment options, cancer remains a leading cause of death and disability worldwide. Current cancer treatments, such as surgery, radiation therapy, and chemotherapy, often encounter challenges including substantial side effects, non-selective damage to healthy cells, drug resistance, and high relapse rates [1]. These limitations underscore the urgent need for innovative and safer therapeutic approaches. In response to these challenges, there has been a growing interest in exploring natural products, particularly medicinal plants, as potential sources of novel anticancer agents [2]. Numerous chemotherapy drugs, including paclitaxel and vincristine, were originally derived from plant-based compounds,

highlighting the rich potential of medicinal plants in cancer treatment [3]. Traditional medicine systems around the globe, from Ayurveda and Traditional Chinese Medicine (TCM) to African herbal medicine, have long recognized the therapeutic properties of medicinal plants [4]. These plants contain a diverse array of phytochemicals, including alkaloids, flavonoids, saponins, and terpenoids, many of which exhibit potent anti-inflammatory, antibacterial, antioxidant, and anticancer activities [5]. The vast diversity of plant species and their unique chemical compositions offer a promising reservoir for the discovery of novel anticancer compounds. This study focuses on two medicinal plants, *Dracaena trifasciata* and *Eclipta prostrata*, which have shown promising anticancer potential in preliminary investigations. *Dracaena trifasciata*, a popular houseplant, has been traditionally used in Asian and African medicine for various ailments [6]. While its anticancer properties are less explored, it contains bioactive compounds known to regulate cellular processes involved in cancer development. *Eclipta prostrata*, also known as Bhringraj, is a well-established medicinal plant in Ayurvedic and Traditional Chinese Medicine [7]. It has been traditionally used for its hepatoprotective, anti-inflammatory, and hair-growth promoting properties. Recent studies have highlighted its potential anticancer effects, particularly in targeting cancer cells through mechanisms involving apoptosis and the inhibition of key signaling pathways [8]. By investigating the cytotoxic effects of *Dracaena trifasciata* and *Eclipta prostrata* on cancer cells and comparing their efficacy, this study aims to contribute to the growing body of evidence supporting the use of medicinal plants in cancer treatment. Understanding the underlying mechanisms of action and identifying potential synergistic effects with conventional chemotherapies could pave the way for the development of novel and more effective anticancer therapies.

MATERIALS METHODS

Fifty grams of dried, powdered leaves of *Dracaena trifasciata* and *Eclipta prostrata* were used for the extraction process.HeLa cells, obtained from the National Centre for Cell Science (NCCS), Pune, were cultured in Dulbecco's Modified Eagle Medium (DMEM) supplemented with 10% Fetal Bovine Serum (FBS) and 100 µg/mL of penicillin and streptomycin. These cells were maintained in a humidified incubator at 37°C with 5% CO_2 to ensure optimal growth conditions. HeLa cells were seeded into a 96-well plate at a density of 1×10^5 cells/mL and treated with various concentrations of 3: 1 ratio of *Dracaena trifasciata* and *Eclipta prostrata* extracts. After 24 hours of incubation, MTT solution was added to each well, followed by incubation for 2-4 hours. DMSO was then added to dissolve the formed formazan crystals, and the absorbance of each well was measured at 570 nm. the percentage cell viability was calculated using the formula: Cell viability (%) = (Test OD/Control OD) × 100. The IC50 value, representing the concentration of the extract required to inhibit cell growth by 50%, was calculated using Graph Pad Prism 6.0 software. This procedure allowed for the assessment of the cytotoxicity of *Dracaena trifasciata* and *Eclipta prostrata* extracts on HeLa cells, providing insights into their potential therapeutic or adverse effects.

RESULT AND DISCUSSION

The results from the cytotoxicity assay demonstrate a concentration-dependent cytotoxic effect of the *Dracaena trifasciata* and *Eclipta prostrata* extract on the tested cell line. This is consistent with findings from other plant extracts known for their bioactive properties, which also exhibit cytotoxic effects in a dose-dependent manner [16].At concentrations of 300 µg/mL and above, there is a marked reduction in cell viability, with a significant decrease to 59.51% at the maximum concentration of 500 µg/mL. This suggests strong cytotoxic effects at higher doses, which could be valuable in therapeutic contexts, such as cancer treatments where inhibition of cell proliferation is crucial [11]. The observed IC50 value of 73.3 µg/mL confirms moderate cytotoxic activity, aligning with previous studies that have reported similar IC50 values for plant-based extracts with anticancer potential [12] Table :1. Interestingly, at the lowest concentration (10 µg/mL), cell viability exceeded 100%, indicating a possible homesick effect. A phenomenon where low doses of a substance stimulate cell growth while higher doses inhibit it, has been observed in various natural compounds [9]. This suggests that the extract may have biphasic properties, stimulating cell growth at very low doses, which could have implications for its application in different therapeutic scenarios. As the concentration decreases below 300 µg/mL, cytotoxicity diminishes, with cell viability progressively increasing. At concentrations

like 40 µg/mL, the cell viability is around 82.63%, indicating a reduced cytotoxic impact. Fig: 1. this trend is consistent with the general understanding that plant extracts exert cytotoxic effects more strongly at higher doses, as shown by other medicinal plants [14].The cytotoxicity observed could be attributed to the presence of secondary metabolites like flavonoids, saponins, and other bioactive compounds in the extracts, which are known for their antiproliferative effects [15]. Previous studies on *Dracaena* species have highlighted their potential as sources of anticancer agents due to their rich phytochemical profiles [13]. However, further research is needed to isolate and characterize these compounds to better understand their mechanisms of action. The IC50 value found in this study is comparable to other reports on *Dracaena* species, which have been shown to exhibit IC50 values in a similar range [10]. This consistency with previous findings strengthens the hypothesis that *Dracaena trifasciata* could be a valuable source of medicinal compounds with therapeutic potential.

CONCLUSION

The combination of *Dracaena trifasciata* and *Eclipta prostrata* extracts exhibited moderate cytotoxicity against HeLa cells in a concentration-dependent manner. The extracts demonstrated a hormetic effect at low concentrations, promoting cell growth. Further research is needed to elucidate the underlying mechanisms of action and explore the potential therapeutic applications of these extracts.

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Table: 1 OD Value at 570 nm

S. No.	Tested sample concentration (µg/ml)	OD value at 570 nm (in triplicates)		
1	Control	0.334	0.397	0.3655
2	500 µg/ml	0.21	0.225	0.2175
3	400 µg/ml	0.227	0.249	0.238
4	300 µg/ml	0.261	0.241	0.251
5	200 µg/ml	0.232	0.264	0.236
6	100 µg/ml	0.258	0.247	0.242
7	80 µg/ml	0.258	0.286	0.272
8	60 µg/ml	0.287	0.287	0.284
9	40 µg/ml	0.306	0.308	0.292
10	20 µg/ml	0.294	0.339	0.33
11	10 µg/ml	0.374	0.298	0.336

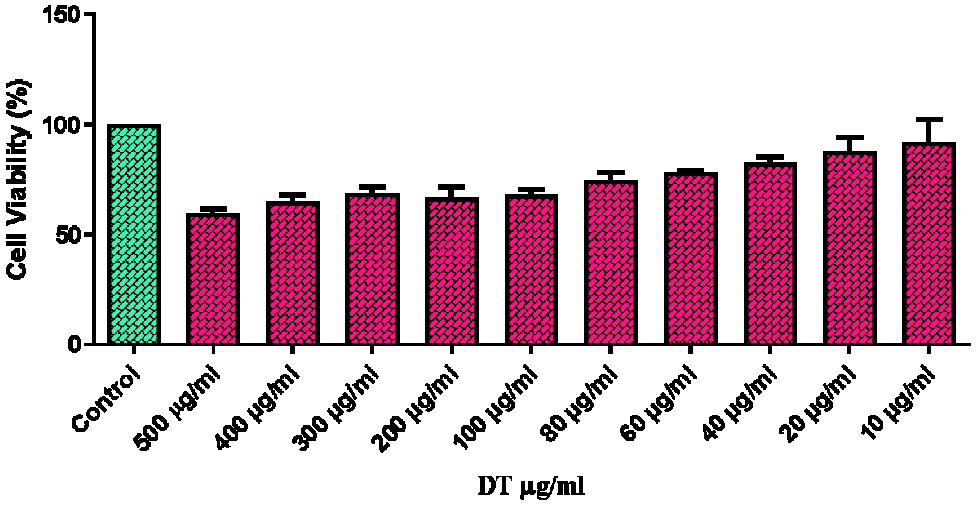


Fig 1: Cell viability from control

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RESEARCH ARTICLE

Key Aspects of Organic Agriculture: A Case Study

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ABSTRACT

Soil fertility is crucial for optimizing agricultural productivity; however, the indiscriminate application of chemical fertilizers poses numerous environmental risks. To promote sustainable agricultural practices, organic farming emerges as a vital strategy, facilitating ecological conservation while mitigating climate change impacts. In this study, we focused on the large-scale production of vermicompost at the Narendrapur Ramkrishna Mission Dairy Farm, examining both the possibilities and challenges associated with its production. Despite facing some obstacles, our findings indicate that the quality of the vermicompost produced is commendable, with nitrogen, phosphorus, and potassium (NPK) concentrations measured at 125 kg/hectare, 3 kg/hectare, and 80 kg/hectare, respectively. Additionally, they have established a biogas plant, which successfully generates significant amounts of gas suitable for cooking, providing an ancillary benefit to the farming operations. Furthermore, our subsequent investigation at the Organic Haat—a market initiated by the local government to promote organic products—revealed critical insights. The survey indicated a general lack of awareness among consumers regarding organic products, compounded by their reluctance to pay the premium that such products command. Only a limited number of informed consumers were identified, highlighting the need for intensified outreach and education efforts. To advance organic agriculture adoption, policymakers should enhance public awareness and offer incentives that encourage farmers to transition to organic methods. This includes educational initiatives and financial support for conversion and certification costs.

Keywords: Vermicompost, agriculture, organic, sustainable

INTRODUCTION

Sustainable agriculture represents a form of organic farming that strives to mitigate environmental pollution, enhance production, preserve soil health, minimize chemical fertilizers and pesticides, effectively conserve water resources, and eliminate health hazards for humans. The integrity of the soil, particularly its organic matter amount, is crucial for ensuring the sustainability of agricultural productivity. Organic matter enhances the soil's physico-chemical and organic properties, thereby improving its capacity to retain water and facilitating the exchange of cation. However, it is widely recognized that applying chemical fertilizers poses significant risks to both environmental health and human well-being. These considerations necessitate the adoption of biological fertilizers or soil enhancers to improve food quality and yield within the framework of sustainability. Vermicomposting is a traditionally practiced method of producing compost using natural waste of biological origin. Production of nutrient-rich compost from organic waste is performed by the utilization of certain species of earthworms and microbes. A moderate temperature is required to produce vermicompost, wherein earthworms consume organic waste and subsequently excrete it as granular compost. The coaction of earthworms and microbes is the key factor in this production along with suitable physical conditions, *viz.,* temperature and water availability. Furthermore, organically produced fertilizers benefit cohesive soil productivity parameters by supplying essential nutrients, humic acids, growth regulators, nitrogen-fixing and phosphorus-solubilizing microbes, enzymes, and vitamins [1, 2]. Vermicompost in general includes nitrogen (N) in the range of 1.5% to 2.2%, phosphorus (P) from 1.8% to 2.2%, and potassium (K) from 1.0% to 1.5%. The organic carbon content differs between 9.15% and 17.98%, and the mass of the compost is enriched with essential micronutrients such as sodium (Na), calcium (Ca), zinc (Zn), sulfur (S), magnesium (Mg), and iron (Fe). Furthermore, it contains crucial chemical and microbiological properties for the crop field. It is reported that the worms, along with microorganisms, can convert organic waste up to 60% by mass.

An annelid used for this purpose, generally of 0.5 grams, consumes organic waste equivalent to its body weight, and produces compost of the same. The moisture content of these end products ranges from 32% to 66%, with approximately neutral pH. Additionally, various enzymes, including amylase, lipase, cellulase, and chitinase, are available in the vermi-fertilizers, which facilitate the bioavailability of nutrients to crop roots.[3]. In India, vermicomposting has been practiced intermittently for over three decades. The adverse effects of soil degradation caused by using chemical fertilizers, as well as the health risks associated with pesticide usage, have contributed to the rise in the popularity of organic farming, wherein vermicompost serves as a fundamental component. In recent years, particularly within the last decade, there has been a remarkable increase in attention focused on this practice. Numerous research institutes and non-governmental organizations (NGOs) are investigating viable options for vermicompost production, ranging from small-scale backyard units to larger commercial operations. Individual farmers are also increasingly adopting this method to meet their agricultural needs. Nevertheless, commercial production has yet to achieve significant traction. Farmers involved in vermicomposting receive subsidies and financial assistance from several missions initiated by the government, such as, National Mission for Sustainable Agriculture (NMSA), the National Food Security Mission (NFSM), the Mission for Integrated Development of Horticulture (MIDH), and the RKVY - Remunerative Approaches for Agriculture and Allied Sector Rejuvenation (RKVY-RAFTAAR). To promote organic farming, NMSA offers financial support covering half of the total cost of setting up vermicomposting units, in amounts of INR 5000 (USD 70) per hectare and INR 10,000 (USD 140) per payee[4]. According to the National Centre of Organic Farming (NCOF), approximately 3.5 million hectares of agricultural land across 19 states are currently used for vermicomposting [5].

METHODS

Study Area

1. The field-level study was conducted at the Ramakrishna Mission Residential College (Autonomous) campus in Narendrapur (22.4373° N, 88.4016° E), Kolkata, West Bengal.

2. The market analysis was performed at the Organic Haat (22°35′55″N 88°28′03″E), a market initiative established by the state government to promote organic farming and facilitate the distribution of organic products.

Sampling

Three samples of vermiwash, vermicompost, and manured soil (topsoil up to 5 inches in depth) from the first study area were collected for analysis.

Sample analysis

The samples were analyzed using soil color charts from the soil testing kit, and a digital pH meter was used to measure the pH of the samples.

RESULTS AND DISCUSSIONS

The ambient temperature during sampling was approximately 29°C, while the laboratory temperature during the test was around 30°C. The mean pH values of the collected soil sample and the vermiwash were approximately 7.51 and 7.01, respectively (Table 1). The compost sample contains approximately 125 kg of bio-available nitrogen per acre, while the soil sample measures about 75 kg per acre (see Fig 1). Both samples exhibit low phosphorus levels, ranging from approximately 1 to 3 kg per acre (see Fig 2). In terms of potassium, the quantities are good, with the compost sample at approximately 80 kg per acre and the soil sample at around 100 kg per acre (see Fig 3). Items available at the Organic Haat(market) tend to be more expensive than those in local markets. There are several reasons why organic food is generally priced higher than conventionally produced food. Firstly, organic farming often relies on more costly and labor-intensive methods compared to established agricultural practices, such as hand weeding and natural fertilizers uses and pest control. Additionally, organically produced products often look less attractive as they are devoid of chemical enhancements. As of now, organic farms are fewer in area, hence, lesser yields are produced and a smaller economy-generating sector of agriculture in India. This decreases production, leading to higher costs of organic agricultural products. The costs associated with organic certification are also substantial, as adherence to firm guidelines and regular inspections further increases the final price of organic products. Moreover, the supply chain for organic products tends to be less cost-effective and prompt due to the need for specific handling, storage, and transportation to avoid degradation of quality. Retailers are often able to set raised prices influenced by the market's perception of organic goods as healthier, eco-friendly, or ethically produced. When all these factors are counted, it becomes clear why organic foods are more expensive compared to their conventional counterparts.

CONCLUSIONS

From the study, it can be estimated that vermicompost made from vegetable waste is more efficient than that made from manure. Additionally, commercially available chemical fertilizers may contain higher levels of NPK (Nitrogen, Phosphorus, and Potassium) but have harmful impacts on the ecosystem. Prolonged application of such chemicals can lead to soil degradation, disrupt beneficial microbial communities, and pollute water bodies. Besides, uncontrolled use of chemical fertilizers contributes to greenhouse gas emissions, intensifying climate change. Indian farmers still prefer chemical fertilizers over vermicompost for manifold reasons, such as chemical fertilizers provide immediate and assured results, offering a quick nutrient boost to plants, which demand rapid growth and high yields. Chemicals are widely available, easy to apply, and have been profoundly marketed by industries. On the other hand, vermicompost plays an important role in enhancing soil fertility by enhancing the bioavailability of nutrients. Moreover, it improves soil structure, aeration, and water retention capacity, influencing healthier root systems and intensified crop yields. Vermicompost suppresses dependency upon chemical fertilizers, thus contributing to sustainability, and facilitates waste management by recycling organic waste. Despite their significance in modern agriculture, a balanced and sustainable approach is the need of the hour to alleviate these hostile effects and promote sustainable agricultural practices. In contrast, vermicomposting, while eco-friendly and sustainable, demands well-developed strategies, management, operation, execution, and awareness to fill the gap between knowledge, theory, and real-life practices. The method of vermicompost production might be strenuous and

time-consuming, but good quality compost can replace toxic chemicals efficiently. An effective financial investment supported by a massive education and awareness drive is crucial to organic farming, especially when earthworm composting can make an incredible difference in sustainable farming. Although there are a few drawbacks, including space crunch, temperature management, moisture balance, and the uncertain activity range of the worms, it can potentially bring a huge difference in earnings for a single farmer and up to a country. In the future, organic farming will be one of the major ways towards sustainability. Organic fertilizers derived from natural sources will substantially reduce dependency on chemical fertilizers, thereby enhancing soil health and biodiversity and reducing pollution. Governments play a fundamental role in promoting the use of organic products through policies, subsidies, and educational campaigns that encourage both farmers and consumers to adopt organic practices. By implementing stringent regulations and offering financial incentives, governments can drive the organic movement, ensuring long-term environmental profits and adopting sustainable agricultural practices.

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Table 1. pH values of the samples

Sample types	pH values			
	Sample 1	**Sample 2**	**Sample 3**	**Mean**
Soil	7.4	7.8	7.5	7.6
Vermi-wash	7.1	7.3	7.2	7.2

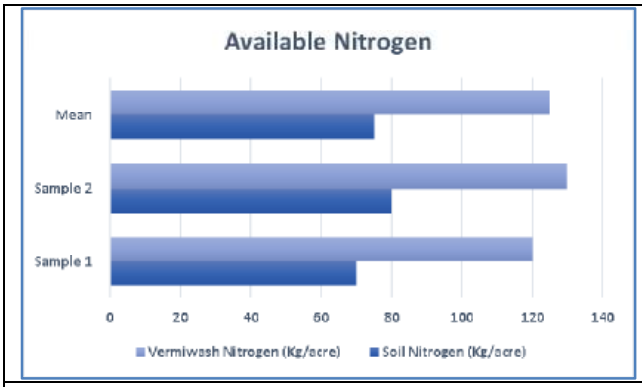


Fig 1. Available nitrogen in the vermi-wash and soil samples

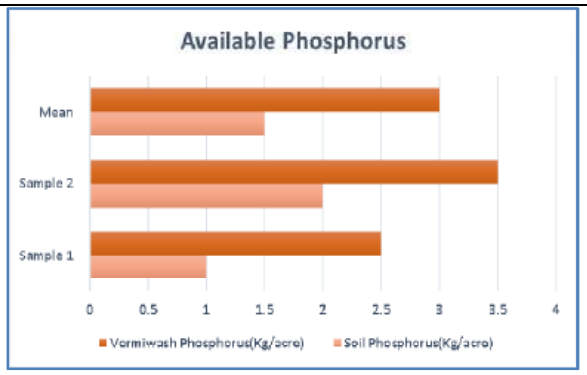


Fig 2. Available phosphorus in the vermi-wash and soil samples

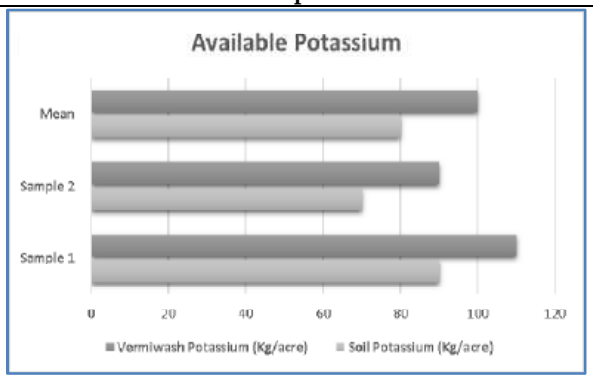


Fig 3. Available potassium in the vermi-wash and soil samples

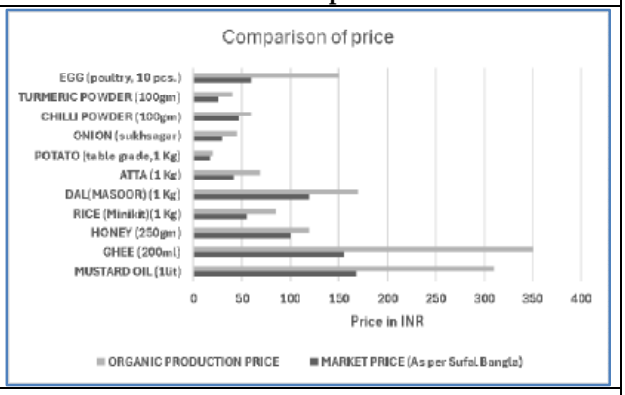


Fig 4. Comparison of the price of daily commodities

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RESEARCH ARTICLE

Marma-based Therapeutic Approach in Gridhrasi Management: An Alternative to Conventional Sciatica Treatments

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ABSTRACT

Gridhrasi is one of the most troublesome *Vyadhi* with commonest complain of lower backache with or without radiating pain to unilateral/ bilateral lower legs. The symptomatology of the disease Gridhrasi closely resembles Sciatica in Allopathy system of Medicine. Marma Therapy is the art of treating very special vital points. Marma Therapy is a Simple Self-treatment having non invasive technique with elaborated Clinical Therapy. Ayurveda believes that Marmas are the Vital Points through which the Positive Prana (vital energy) flows. Marma Therapy is the art of treating very special vital points. Marma Therapy is a Simple Self-treatment having non invasive technique with elaborated Clinical Therapy. *Marma chikitsa* done with the adequate digital pressure of thumb or finger, (as per the indication) on *Kshipra, Gulf* and *Indrabasti, Kukundara & Katiktarun Marma* in rhythm of respiration. The Marma points are pressed 12-14 times in a single sitting. The position for Marma stimulation is supine and prone positions. Symtomatically relief were observed in (1) SLR 2.Radiatting pain. *Marma chikitsa* is a promising therapy with Less time consuming, cost effective, easy to use and non-invasive alternative method for treatment of *Gadhrasi*.

Keywords: *marma therapy*, *Gridhrasi*, Sciatica, Ayurveda treatment, Lower back pain.

INTRODUCTION

Sciatica refers to pain, weakness, numbness, or tingling in the leg. The most important symptom of sciatica is lumbosacral radicular leg pain that follows a dermatomal pattern radiating below the knee and into the foot and toes.

The pain worsens with coughing, patients may report sensory symptoms, limited forward flexion of the lumbar spine, gait deformity and unilateral spasm of the paraspinal muscles

EPIDEMIOLOGY

The lifetime incidence of this condition is estimated to be between 13% and 40%. Fortunately, the majority of cases resolve spontaneously with simple analgesia and physiotherapy. However, the condition has the potential to become chronic and intractable, with major socio-economic implications. Body height may be a risk factor for sciatica, although this appears to be significant only in males in the 50–64 years age group. The incidence of sciatica is related to age. Rarely seen before the age of 20.

PATHOPHYSIOLOGY

The intervertebral disc was implicated in the pathophysiology of sciatica and with the assumption that the protruding disc exerted pressure on sciatic nerve roots; the Treatment was surgical removal of the disc. Any subsequent improvement in symptoms was attributed to relief of pressure on the nerve roots. however, suggested that pressure on a nerveresults in loss of function and is rarely associated with pain.

SYMPTOMS:

"स्फिक्पूर्वाकटिपष्ठोरुजवनुजन्घवपदंक्रमवत।गधृसीफतम्भरुकोदैगहृणवततफपन्दतेमुहुः॥

र्वतवद्र्वतकिवततन्नवगौरर्वरोचकवस्न्तव॥"(च०चच०२८)

The symptoms of *Gridhrasi* can be compared with Sciatica, in which a form of radicular pain in the peripheral nervous system is defined. *Gridhrasi* (Sciatica) is one out of eighty types of *Vata Nanatmaja Roga* under severe distressing syndromes among all neurological disorder. Marma therapy is original system of healing in the body. "Marma" word come from sanscrit "mru" and which means to kill. Marma plays a significant clinical role and may be correlated to the Acupressure/Acupuncture. Marma are the critical points of body associated with different organs and nerves. Ayurveda describe use of Marma therapy for various diseases and identification of Marma points which is to be cured, since injury to these Marma points may causes serious harmful effect. It is an art of treating 107 marma and rechannelize the pran (vital force in the body).

CASE REPORT

A Case of 50 years old female patient came to OPD of shalyatantra department parul institute of ayurveda with complains of severe radiating pain since last 3years, stiffness since last 2.5 years in right leg. There is no history of any trauma or physical injury, Mild pain decreases after hot fermentation but no relief found in stiffness and ROM, in general examination patient was not k/c/o HTN and DM. This patient was on regularly heavy work load as occupation was laborour. Past family medical history was non-contributory. Now since few months patient having aggravation of pain during weight lifting. She was unable to perform even small movement and daily routine activities like forward bending. for that she was consulted with allopathic doctor and taken NSAIDS but didn't get any relief.

On examination

SLR: 30 degree.

In radiological examination xray AP and lateral lumbar back no Any major abnormality was found. no e/o fracture or dislocation. No soft tissue swelling.

Muscle tone – normal.

Deformity- Not found.

Swelling-Absent.

Temp – increased.

Crepitus – Present.

Tenderness- Present.

No any Scar, Sinus, Hyper laxity of joints.

CRITERIA OF ASSESEMENT
Pain(VAS SCALE)

- SLR
- Muscle power
- Crepitus
- Stiffness

METHOD OF MARMA CHIKITSA
Purva karma
Detailed procedure informed to patient.
Supine position Was given to the patient.

Pradhan karma
Marma therapy done with the adequate digital pressure of thumb or finger, (as per the indication) –
onKshipra, Gulf, Indrabasti, Kukundara & Katiktarun Marma in rhythum of respiration. The Marma points are pressed 12-14 times in a single sitting. The position for Marma stimulation is supine and prone positions. This procedure repeated for 7 day.

Paschat karma
Patient observed for 20 minutes.

OBSERVATION AND RESULTS

During *marma* stimulation it has been observed that SLR improved just after procedure radiating pain and stiffnes decreaseses gradually in 7 day after *marma chikitsa*. There is no significant changes seen in crepitus sound. Muscle power was normal before and after marma chikitsa. No radiological changes found after study.

CONCLUSION

The *Marma chikitsa* is effective in *Gridhrasi*. It gives symptomatic relief. parameters viz, SLR improved just after procedure radiating pain and stiffnes decreases gradually in 7 days after *marma chikitsa*. No significant changes seen in crepitus sound. Muscle power was normal before and after *marma chikitsa*. So *Marma chikitsa* is a promising Less time consuming, cost effective, easy to use and non-invasive alternative method for treatment of *Gadhrasi*.

Conflict of Interest
There is no conflict of interest.

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Table 1: Muscle power

Muscle power
0 Active movement against gravity and full resistance (normal power)
1 Active movement against gravity and mild resistance
2 Active movement against gravity without resistance
3 Active movement with gravity eliminated
4 No contraction.

Table 2: Gradation for SLR

Gradation for SLR
0 Equal to or greater than 90^0
1 71^0 - $<90^0$
2 51^0-70^0
3 31^0-50^0 No contraction
4 $<30^0$.

Table 3: Marma Location

MARMA	LOCATION
KSHIPRA MARMA	Paadasyangushthangulyormadhye". In between the big toe and the second toe (web between the first distal phalangeal joint and the second medial phalangeal joints of the foot).
GULPHA MARMA	"Paadjanghayohsandhane". It is situated at the junction of Pada (foot) and jangha (leg).
INDRABASTI MARMA	"paarshnipratijanghamadhye" i.e. in the mid of leg in the line of heel or calcaneum.
KATIKATARUNA MARMA	"Pristhavanshamubhayatah pratisronikandamasthini" i.e. On both sides of Vertebral Column corresponding to each hip bone.
KUKUNDARA MARMA	On both posterior superior iliac spine notches, just above buttocks (inside or spinal area of the hip bone).

Table :4 Observation and Results

SYMPTOMS	BEFORE MARMA THERAPY	Just AFTER MARMA THERAPY	AFTER 7 day of MARMA THERAPY
PAIN (VAS SCALE)	8	5	0
MUSCLE POWER	5	5	5
SLR	4	0	0
CREPITUS	Present	Present	Present
STIFFNESS	Present	Decreased	Absent



Figure:1 xraylumbar



Figure:2 before marma chikitsa



Figure :3 after marma chikitsa

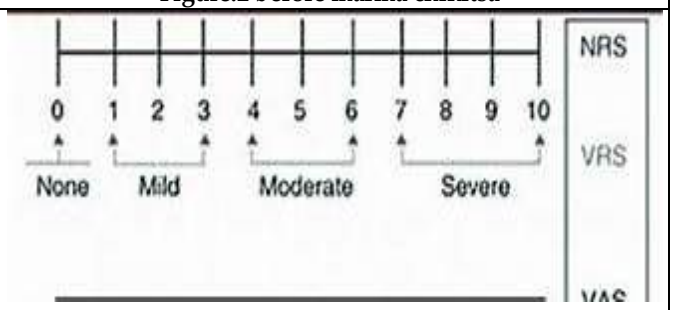


Figure: 4 Pain(VAS SCALE)

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RESEARCH ARTICLE

Assessing Drought Tolerance in *Justicia beddomei* (C.B. Clarke) Bennet under Water Withholding Condition: A Preliminary Morphological Study

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ABSTRACT

Justicia beddomei (C.B. Clarke) Bennet, a medicinal plant endemic to the Western Ghats and belonging to the family Acanthaceae, encounters drought throughout its life cycle. Despite demonstrating remarkable drought tolerance, the mechanisms underlying *Justicia beddomei*'s performance and ability to withstand water scarcity remain unclear. Drought stress significantly impacts plant physiology, consequently restricting growth and development. The present study investigated drought tolerance in *Justicia beddomei* through growth parameters, primarily focusing on leaf morphological traits. A preliminary drought stress experiment was conducted with both control and treated plants, observing morphological parameters such as plant height, number of leaves, number of sprouts, internodal length, number of nodes, leaf length, leaf breadth, leaf shape index, and leaf area. Results revealed that drought stress significantly affected *J. beddomei*'s leaf morphological traits. The leaf area under drought stress decreased due to the smaller size of the leaves. All morphological parameters decreased in stressed plants compared to the control. The plant can withstand drought for 30 days, with a 3.4% reduction in leaf area for stressed plants compared to the control. Leaf morphological traits related to leaf shape index and leaf area significantly correlated with drought stress. The findings suggest that drought stress significantly alters the morphological characteristics of *Justicia beddomei*, revealing a tradeoff between growth potential, drought tolerance, and conservation strategies. Specifically, drought stress reduced plant height, number of leaves, number of sprouts, leaf area, length, leaf breadth, leaf shape index, and number of nodes. These findings highlight the drought tolerance mechanisms employed by *J. beddomei* and provide valuable insights for the sustainable management and planting of this species in water-scarce environments.

Keywords: *Justicia beddomei*, morphological parameters, drought tolerance

INTRODUCTION

Plants are the backbone of our biosphere, performing many ecological and biochemical functions. One of the most notable contributions of the medicinal plant is the synthesis of rich therapeutic bioactive compounds. However, the more significant part of plants used as active ingredients in various medicines are wild-sourced, posing a considerable threat to their sustainability, biodiversity, and ecosystem health. Notably, the cultivation of Medicinal plants is highly sensitive to climate change with fluctuations in temperature, drought, salinity, altered light regimes, and other environmental factors significantly impacting their growth, development, and productivity. *Justicia beddomei* (C. B. Clarke) Bennet; syn: *Adhathoda beddomei* C. B. Clarke), commonly known as chitadalodakkam or cheriyaadalodakam. In Indian Systems of Medicine (ISM) this plant is recognized for its therapeutic potential in treating a variety of ailments, including leprosy, blood disorders, heart issues, fever, cough, bronchitis, inflammation, jaundice, tumors, tuberculosis, and hemorrhage (Srinivasan *et al*., 2014). Quinazoline alkaloids such as vasicine, and vasicinone are the reason for its pharmacological properties (Kharel, 2010). This perennial shrub is found across tropical regions in Asia, Africa, and America, with its native habitat in Kerala, India (Haleshi*et al*., 2020), and is known for its drought tolerance. Drought tolerance in plants refers to their ability to survive and maintain growth under drought conditions. Drought, defined by insufficient water supply is a primary stressor that significantly affects plant survival, development, and productivity. Drought stress induces structural changes in plant morphology because of turgor pressure loss through transpiration (Hund *et al*., 2009). One of the most crystal clear hallmarks of drought is the obstruction of plant morphological growth(An and Liang, 2012). To thrive in drought environments, plants have evolved various adaptative strategies at the morphological, physiological, biochemical, and molecular levels (Chen *et al*., 2021) and also functional features. Among the functional characteristics of plant parts, the physiological and biochemical cycle of the plant is mostly determined by the functional characteristics of the leaves (Roa-Fuentes *et al*., 2015). As the most sensitive and vulnerable plant organ, leaves exhibit remarkable phenotypic plasticity, displaying striking changes in response to shifting environmental conditions. Through their dynamic adjustments, leaves reveal the intricate mechanisms by which plants adapt to their surroundings, making them an ideal indicator of environmental responsiveness. The three categories of leaf functional traits are physiological, biochemical, and morphological (Avalos *et al*., 2023). *Justicia beddomei*, a tropical wild plant, has demonstrated adaptability to drought conditions, making it a valuable species for sustainable planting and management. Understanding its performance under drought stress is crucial for optimizing its cultivation. This study aimed to investigate how *J. beddomei* adapts to drought stress, addressing the knowledge gap surrounding the mechanisms underlying its drought tolerance. To achieve this, a preliminary drought experiment was designed to explore the morphological adaptations of *J. beddomei* in response to varying levels of drought stress.

MATERIALS AND METHODS

The experiment was conducted in the greenhouse of the Department of Botany, University of Kerala, India (8°34'02"N latitude, 76°54'16"E longitude) during July- November 2022 for 5 months. From a trial experiment, the ideal environmental conditions such as water required, average temperature, relative humidity, etc. for *Justicia beddomei* were found. Relative humidity: 60 ± 5% and Average temperature: 28 ± 2°C were consistently monitored and maintained inside the canopy using a portable meteorological meter, ensuring optimal growth and experimental accuracy. The study focused on *Justicia beddomei* (C.B. Clarke) Bennet. Stem cuttings with relatively uniform growth and strong stalks were collected from the Siddha Regional Research Institute, Thiruvananthapuram (TVM). The stem cuttings were sectioned into 10-15 cm lengths, each containing at least two nodes. These sections were inserted 3 cm deep into polybags filled with a potting mixture comprising cow dung, coir pith, and soil (2:1:1, v/v). Plants were grown in a greenhouse conditions for 3 months. After three months, the plants were well-established, and those with similar height and leaf number were transplanted into new grow bags (15 cm height × 15 cm top diameter × 10 cm bottom diameter) containing potting mixture. Before being transplanted to the soil, the physio-chemical properties of the experimental soil were analyzed. The polybags were watered daily before the experiment began. Drought stress was applied by water withholding from one month after transplantation. For the stress experiments, Plants were

divided into test and control groups. Control plants received 200 ml of water at an interval of 2 days, while stressed plants were grown without water for 5 days (T1), 10 days (T2), 15 days (T3), 20 days (T4), 25 days (T5), 30 days (T6), 35 days (T7), and 40 days (T8). Three replicates were carried out for each treatment. No fertilizer was used during the experiment. Morphological parameters were recorded at an interval of 5 days until the experiment ended.

Soil Sampling and Analysis

Soil samples were collected from the experimental site following the standard procedure. The samples were subsequently analyzed to determine various physicochemical properties, including pH, Electrical conductivity (EC), and Organic carbon (OC). The macronutrients such as Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca), Magnesium (Mg), and Sulphur (S), and the micronutrients like Zinc (Zn), Iron (Fe), Copper (Cu), cadmium (cd)and Manganese (Mn) were analysed.

Morphological analysis

Morphological parameters, such as Plant height, No. of leaves, sprouts, nodes, leaf length, leaf breadth, leaf shape index Leaf area, and Internodal length were analyzed at 5-day intervals. 5 days (T1), 10 days (T2), 15 days (T3), 20 days (T4), 25 days (T5), 30 days (T6), 35 days (T7), and 40 days (T8) in both control and drought-stressed plants.

Statistical analysis

All experimental data were analyzed by Excel 2019 and ANOVA through SPSS 22.0 software (SPSS Inc., Chicago, IL, USA) and expressed as mean ± standard error (SE). Two-way ANOVA was used to analyze themain effects and test duration on the morphological traits ofplants and Duncan's multiple comparison test was used to make multiple comparisons at the $p < 0.05$ level. The significance of differences among groups was expressed with different letters.

RESULTS AND DISCUSSIONS

Plant growth, survival, and water status are the three most important factors to be considered when studying drought stress in plants (Verslues *et al.,* 2006). In the present study, physicochemical properties of the experimental soil and plant growth parameters such as plant height, number of leaves, nodes, sprouts, leaf length, leaf breadth, leaf shape index, leaf area, and internodal length were recorded to screen for overall drought tolerance. The plant can survive drought conditions for up to 30 days (T6) which shows the plant is a drought tolerant one. The plants of T7 and T8 treatments show wilting, and coloration in the leaves, and overall can't survive the drought condition. So the morphological parameters of T6 were compared with control. Effects of drought treatments and treatment durations were observed for plant morphological parameters, leaf morphological traits, and, which were significant ($p < 0.01$).

Physicochemical properties of the soil

The physicochemical properties of the experimental soil used for growing *Justicia beddomei*were thoroughly analyzed to ensure its suitability for the study, particularly under drought-stress conditions. These properties include pH, electrical conductivity (EC), organic matter content, and nutrient availability. The experimental soil used was ideal for plant growth. Soil is slightly acidic (pH-5.9), non-saline, electrical conductivity was 0.83 (dS/m), and rich in organic content. The present experiment successfully demonstrated the effects of drought stress on *J. beddomei*, supported by the careful analysis of the physicochemical properties of the soil used. These properties were crucial in determining the ability of plants to cope with stress, and the study provides valuable insights into how environmental factors influence plant stress physiology. The experimental soil used in this study was found to be ideal for the growth of*J. beddomei*, as indicated by its slightly acidic pH of 5.9. While slightly acidic, this pH level does not hinder nutrient uptake, ensuring that essential nutrients remain available to the plants. The amount of macro and micro nutrients present in the analyzed soil were depicted in Fig. 1. The non-saline nature of the soil further contributed to the optimal growing conditions, as salinity can often inhibit plant growth by disrupting water and nutrient absorption. Additionally, the richness in organic content, verified by the Central Soil Analytical Laboratory in Thiruvananthapuram, likely enhanced soil structure and fertility, promoting healthy root development and

microbial activity. These factors collectively created a favorable environment for the plant to establish and grow, particularly before the application of stress treatments.

Morphological parameters

Water is a very important limiting factor for plant growth and establishment. Morphological changes are the first effect we can observe with the naked eye (Safaei Chaeikara *et al*., 2020). In our research a significant reduction in growth parameters of *Justicia beddomei* was observed. Even though they reduce their growth, they can grow with reduced soil moisture upto certain level (T6). Water deficit conditions may cause a reduction in soil water potential as a result plant turgor pressure decreases (Singh *et al.,* 2018) so that the water flow from the xylem to the surrounding elongating cell gets interrupted thus resulting in reduced growth.

Plant height

The effects of various levels and days of drought on *J. beddomei* are shown in Table 1. The growth patterns of *J. beddomei* exhibited a consistent trend across various drought levels, with all groups demonstrating increased growth over time. However, when soil moisture was limited, the groups displayed differing degrees of growth deceleration, indicating varying levels of drought tolerance. A significant decrease in plant height was observed in *J. beddomei* under drought stress conditions compared to control plants ($p<0.001$). The plants in treatments T7 and T8 exhibited slower growth rates, with mean plant heights of 55.90 ± 0.06 cm. In contrast, the control plants reached a mean height of 58.80 ± 0.06 cm. Notably, the T7 and T8 plants showed a 4.93% reduction in height compared to the control. The period between day 10 and day 30 was identified as the phase of maximum plant growth increment, highlighting the importance of this stage in the plant's development. However, the plants in drought stress reduced plant height. The reduction in plant height was associated with a decline in cell enlargement and leaf senescence (Bhatt & Rao, 2005). Our results are consistent with the results in *Dracocephalummoldavica* (Hassani *et al*., 2006) in which decreased water availability significantly decreases the plant height. The reduction in plant height can be attributed to inhibition of the efficiency of the translocation and assimilation of photosynthetic products (Xiong & Zhu, 2002).Similar results were seen on *Helianthus annuus* (Manivannan *et al*., 2007), *Melissa officinalis* (Abbaszadeh *et al*., 2009), *Tages minuta* (Babaei *et al*., 2021), *Catharanthusroseus* (Amirjani, 2013). *Petroselinum crispum* (Borges *et al*., 2016).

Number of nodes and internodal length

The total number of nodes in *Justicia beddomei* was decreased and the effect intensified with an increase in drought stress intensity. The number of nodes is increasing in control plants as the days of treatment increase. Compared to the control plants no. of nodes in the treated plants decreased which was significant at $p<0.001$. The total number of nodes remains the same after the 30^{th} day further, no change is seen. The number of nodes in the T6 condition was 20.40 ± 0.15 and that of the control was 22.37 ± 0.13. The percentage of decrease was 8.80% with that of control. The number of sprouts and internodal length also follow the same trend. The maximum internodal length was observed for control plants and the minimum for stressed plants (Table 1). The percentage of reduction is 7.23% compared to the control on the 30^{th} day. A significant difference was recorded between the treated and control groups. The emergence of new sprouts in plants indicates the growth of the plant. The highest number of sprouts was observed in control plants. As stress intensity increases, the number of sprouts decreases. Compared to the control the reduction in the number of sprouts is 100% for T6-treated plants. The number of nodes and internodal length decreased with an increase in drought stress in *Justicia beddomei*. The reduction is due to stress is responsible for reduction in plant growth. Our results were similar to those of Babaei *et al*., (2021) in *Tages minuta*, Lahijanian *et al*., (2023) in *Stevia rebaudiana*, Sadeghi *et al*., (2021) in *Glycine max*.

Leaf parameters

The leaf morphological parameters in *J. beddomei* are shown in the Table 2. Leaf morphological traits were significantly affected by drought. As the intensity and duration of drought treatment increases the leaf length, leaf breadth, leaf area, leaf shape index and number of leaves were decreased significantly at $p<0.001$. In drought-stressed plants, the number of leaves per plant decreased remarkably compared to the control. The percentage of decrease was 3.8 % for T6-stressed plants compared to the control groups. The reduction in the number of leaves per plant in

treated groups was significant compared to control groups. Drought stress produces a negative impact on the *Justicia beddomei* leaf area which is a stress marker. Leaf area decreases as stress progresses and the decrease was notable. The percentage of reduction was 3.4% compared to the control in the T6 condition. Maximum reduction was for stressed plants and the highest leaf area was for control plants. As the primary production organ of plants, leaves exhibit remarkable plasticity, closely tied to resource acquisition and utilization. Leaves serve as a crucial interface for studying plant-environment interactions (Xu *et al.*, 2022). Under drought stress, leaves undergo changes in functional traits, balancing rapid growth with stress tolerance (Stahl *et al.*,2013). In response to drought stress, *J. beddomei* leaves become smaller but denser. These changes reflect the plant's adoption of conservative strategies to adapt to drought stress, involving tradeoffs in resource allocation. Our study revealed significant changes in leaf morphological traits related to shape and size in response to drought stress. These findings highlight the importance of leaf adaptations in enabling *J. beddomei* to cope with water scarcity. Leaf area is the most important biological parameter involved in carbon dioxide fixation, water usage efficiency, photosynthesis, and biomass production in plants. Decreasing soil water potential reduces the number of leaves per plant and leaf area in *J. beddomei*. The results show that leaf area was more sensitive to soil moisture regimes than other growth parameters. Shoot growth, particularly growth of leaves is generally more sensitive to soil water deficit than root growth (Hopkins & Huner, 2004). The uptake of water and availability of nutrients for plants becomes less under drought conditions correspondingly number of leaves, specific leaf area, and total leaf area are decreased. The reduction in leaf number under extreme water deficit may be due to a reduction in leaf formation (Luvaha *et al.*,2008). The growth of the leaf area is influenced by leaf pressure, temperature, and assimilated supply for growth (Reddy *et al.*,2004). Drought stress causes a reduction of water in the soil thus soil water potential decreases accordingly leaf turgor pressure decreases, which results in the leaf area reduction as a consequence photosynthesis is affected (Rucker *et al.*,1995). Our results are consistent with *Amaranthus* spp (Jomo *et al.*,2015), *Populus* (Wullschleger *et al.*,2005), and *Glycine max* (Zhang *et al.*,2004). With increasing stress intensity leaves showed curling and older leaves tend to wither and fall off due to accelerated leaf senescence. The ability of leaf curling is an adaptive morphological trait restricting transpiration and promoting water retention in leaf tissues.

Correlation between leaf and plant morphological traits

A correlation analysis revealed significant relationships between various plant morphological parameters. A negative correlation was observed between Plant height and leaf length and also between plant height and leaf shape index. Positive correlations were found between Plant height, number of nodes, number of sprouts, and internodal length with leaf area ($p < 0.01$) and leaf length and leaf shape index. Notably, plant morphological parameters such as plant height, number of nodes, number of sprouts, and internodal length were negatively correlated with drought stress, indicating their sensitivity to water scarcity. Most correlations were significant at $p < 0.01$ (Fig. 2).

CONCLUSION

This study highlights the drought tolerance of *Justicia beddomei*. Our results show that the plant growth parameters and leaf morphological traits changed under drought conditions. During drought exposure, it showed adaptive changes to water limitation. Drought inhibited the plant height, leaf area, leaf shape index, number of nodes, leaves, sprouts, and internodal length compared to control. From the study, it is clear that there are no considerable changes in morphological parameters between control and stressed plants. It suggests that the plant may have inherent drought tolerance mechanisms that allow it to maintain its morphological characteristics under drought stress. Further studies are needed to investigate the physiological and biochemical adaptations contributing to *J. beddomei's* drought tolerance. Furthermore, as it is a medicinal plant rich in phytochemicals, future investigations should also focus on the phytochemical basis of its drought tolerance mechanisms. Elucidating the molecular responses of *J. beddomei* to drought stress will provide valuable insights into the underlying mechanisms of its drought tolerance.

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Table 1: Effect of drought stress on the growth parameters of *Justicia beddomdei*; values are mean ± S.E.

Days of treatment	Treatment	Plant height (PH) (cm ± SE)	Number of nodes (NN)	Number of sprouts (NS)	Internodal length (IL) (cm ± SE)
5	Control	54.73±0.09^{g}	20.03±0.03^{fg}	1.13±0.03^{de}	4.70±0.36^{f}
	T1	54.23±0.15^{g}	19.67±0.17^{g}	1.03±0.03^{de}	4.60±0.31^{f}
10	Control	54.80±0.15^{fg}	20.20±0.06^{ef}	1.00±0.00^{e}	5.00±0.00^{e}
	T2	54.20±0.36^{g}	20.00±0.00^{fg}	1.00±0.00^{e}	5.00±0.00^{e}
15	Control	56.13±0.09^{e}	20.63±0.07^{de}	1.17±0.17^{d}	5.27±0.32^{de}
	T3	54.27±0.35^{g}	20.30±0.06^{de}	0.00±0.00^{f}	5.23±0.23^{de}
20	Control	57.17±0.09^{d}	21.00±0.06^{d}	2.07±0.03^{bc}	5.70±0.17^{cde}
	T4	54.73±0.37^{g}	20.40±0.15^{ef}	0.00±0.00^{f}	5.40±0.00^{def}
25	Control	57.47±0.20^{cd}	21.67±0.17^{c}	2.00±0.00^{c}	6.07±0.09^{bcd}
	T5	55.33±0.12^{f}	20.53±0.09^{e}	0.00±0.00^{f}	5.87±0.09^{cd}
30	Control	57.80±0.15^{bc}	22.37±0.13^{b}	2.17±0.09^{b}	6.50±0.29^{bc}
	T6	55.93±0.07^{e}	20.40±0.15^{ef}	0.00±0.00^{f}	6.03±0.41^{bcd}
35	Control	58.07±0.07^{b}	22.67±0.24^{b}	2.33±0.03^{a}	6.73±0.27^{ab}
	T7	55.90±0.06^{e}	20.40±0.15^{ef}	0.00±0.00^{f}	6.07±0.38^{bcd}
40	Control	58.80±0.06^{a}	23.17±0.17^{a}	2.43±0.03^{a}	7.33±0.17^{a}
	T8	55.90±0.06^{e}	20.40±0.15^{ef}	0.00±0.00^{f}	6.07±0.38^{bcd}

Main effect; Df (n-1)= 15F value	64.15***	62.42***	346.92***	8.70***
Days of treatment; Df (n-1)=7F Value	73.25***	56.66***	28.90***	16.04***
Treatment; Df (n-1)=1F Value	374.47***	336.78***	3660.11***	8.74***
Days of treatment * Treatment Df (n-1)=15F Value	10.30***	28.99***	191.63	1.36***

Mean values within column followed by same alphabets are not significantly different as determined by Duncan's multiple range test. *- significant F Value at p<0.001.**

Table 2: Effect of drought stress on the leaf morphological traits of *Justicia beddomdei*; values are mean ± S.E.

Days of treatment	Treatment	Number of leaves(NL)	Leaf length (LL) (cm ± SE)	Leaf breath (LB) (cm ± SE)	Leaf shape index (LI)	Leaf area (LA) (cm^2 ± SE)
5	Control	$52.06±0.53^{i}$	$12.10±0.06^{c}$	$3.97±0.03^{bcd}$	$3.02±0.01^{f}$	$48.50±0.12^{hi}$
	T1	$51.93±0.46^{i}$	$12.00±0.00^{c}$	$3.97±0.03^{bcd}$	$3.00±0.06^{f}$	$48.03±0.09^{i}$
10	Control	$52.66±0.16^{ghi}$	$12.85±0.01^{a}$	$3.78±0.02^{d}$	$3.42±0.01^{a}$	$48.83±0.17^{gh}$
	T2	$52.16±0.16^{efg}$	$12.78±0.01^{a}$	$3.80±0.06^{d}$	$3.36±0.01^{ab}$	$48.60±0.21^{hi}$
15	Control	$53.16±0.16^{efg}$	$12.20±0.06^{c}$	$4.10±0.12^{abc}$	$3.00±0.06^{f}$	$50.00±0.58^{de}$
	T3	$53.03±0.03^{fgh}$	$12.60±0.12^{ab}$	$3.77±0.07^{d}$	$3.36±0.01^{ab}$	$48.63±0.19^{hi}$
20	Control	$53.66±0.16^{def}$	$12.83±0.03^{a}$	$3.80±0.06^{d}$	$3.30±0.01^{bc}$	$50.53±0.26^{de}$
	T4	$52.83±0.16^{ghi}$	$12.64±0.00^{ab}$	$3.80±0.06^{d}$	$3.23±0.01^{d}$	$49.27±0.03^{fg}$
25	Control	$55.06±0.52^{c}$	$12.50±0.12^{b}$	$4.00±0.06^{bcd}$	$3.04±0.01^{f}$	$51.23±0.15^{c}$
	T5	$54.00±0.00^{de}$	$12.78±0.01^{a}$	$3.73±0.09^{d}$	$3.27±0.01^{cd}$	$49.90±0.10^{de}$
30	Control	$56.30±0.30^{b}$	$12.10±0.00^{c}$	$4.23±0.12^{ab}$	$2.81±0.01^{h}$	$52.00±0.00^{b}$
	T6	$54.16±0.16^{d}$	$12.80±0.06^{a}$	$3.87±0.09^{cd}$	$3.30±0.01^{bc}$	$50.23±0.23^{de}$
35	Control	$56.83±0.16^{b}$	$12.80±0.06^{a}$	$4.20±0.15^{ab}$	$3.14±0.01^{e}$	$52.67±0.17^{a}$
	T7	$52.33±0.33^{ghi}$	$12.47±0.15^{b}$	$4.00±0.12^{bcd}$	$3.12±0.01^{e}$	$50.00±0.00^{de}$
40	Control	$57.80±0.15^{a}$	$12.23±0.09^{c}$	$4.30±0.12^{a}$	$2.80±0.00^{h}$	$53.00±0.00^{a}$
	T8	$50.33±0.33^{j}$	$12.00±0.15^{c}$	$4.14±0.08^{abc}$	$2.91±0.01^{g}$	$49.67±0.17^{ef}$
Main effect; Df (n-1)= 15F value		48.58***	17.94***	4.55***	80.85***	53.91***
Days of treatment; Df (n-1)=7F Value		31.67***	26.88***	6.09***	108.19***	69.69***
Treatment; Df (n-1)=1F Value		215.51***	2.20***	14.21***	133.38***	230.73***
Days of treatment * Treatment Df (n-1)=15F Value		41.64***	11.25***	1.62***	46.00***	12.86***

Mean values within column followed by same alphabets are not significantly different as determined by Duncan's multiple range test. *- significant F Value at p<0.001.**

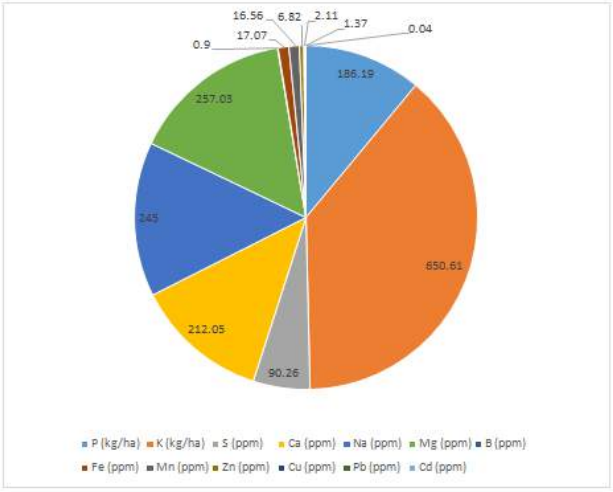


Figure 1 : Macro and microelements in the analyzed soil
P- phosphorous, Na- sodium, K- potassium, S- sulphur, Ca-calcium-Fe- iron, Mn- manganese, Zn- zinc, Cu- copper, Mg- magnesium, Cd cadmium, Pb-lead.

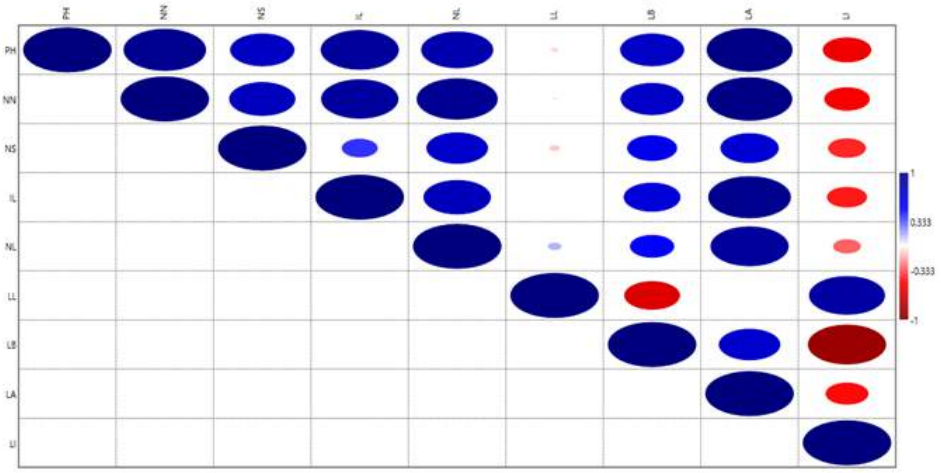


Figure 2. The correlations between plant growth traits and leaf morphological traits.
The indicators are same in table 1-2, biomass and biomass allocation ratio. The PH-plant height, NN- no. of nodes, NS- no. of sprouts, IL- intermodal length, LL- leaf length, LB- leaf breadth, LA- leaf area, LI- leaf shape index

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REVIEW ARTICLE

A Review of Management Strategies for Tomato *Fusarium* wilt. Caused by *Fusarium oxysporum* F.sp. *Lycopersici* (Sacc.)

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ABSTRACT

The tomato is a highly valued source of nutrition that contributes to the global nutrition of both rural and urban populations. Low tomato yields are caused by a variety of causes, including weed competition and fungal, bacterial, nematode, or viral infections. One of the most significant and pervasive diseases of the cultivated tomato is *Fusarium* wilt disease, which is brought on by *Fusarium oxysporum f. sp. lycopersici.* The only target of this soil-borne disease, which belongs to the class Hyphomycetes, is the tomato, which wilts when it is exposed to it. Vein-let clearing and petiole drooping on young plants are the first indications. The oldest lower leaves start to yellow as the first sign of *Fusarium* wilt. Lower leaves turn yellow and eventually perish. This review documented many methods used to combat the disease, which is extremely harmful in tomatoes grown in nurseries and fields. The most economical and environmentally responsible method is Integrated Disease Management (IDM), which has been promoted as being safe and non - toxic, priceless organisms, plants, animals, and human beings. However, instead of focusing only on the greenhouse, measures should be taken to examine and increase their effectiveness, efficiency, and stability on the fields.

Keywords: Tomato, *Fusarium oxysporum* f. sp. *Lycopersici*, Integrated Disease Management

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is belongs to Solanaceae family includes tomato which are grown total area of 4.5 million hactare and a yield of 115.5 million metric tonnes, it is one of the most important vegetables in the world (Kaiser and Erns,2011). Because it is a crop with a short growing season and a high yield, it is commercially

appealing, and the cost of cultivation is growing every day. In terms of both area and output, it comes in third place globally behind potatoes and sweet potatoes (Naika *et al*, 2005). From a total cultivated areas of 27.56 million hectares, India produced roughly 333.25 metric tons of tomatoes in 2020–21.The average tomato yield per hectare in the world was 34.85 tones, whereas the yield per hectare in India was 21.18tones. India is the world's second-largest tomato growing country. Primarily in highly populated urban regions, there is an internal market for local fresh tomato fruit. There is also a growing opportunity for processing companies for the foreign and Indian markets as tomato sauce, ketchup, squeeze, and tomato glue (puree) etc.(AVRDC,2003). The climate and soil in India are ideal for growing a variety of fruits and vegetables, including tomatoes. The best temperature range for tomato growth is between 15^0C and 25 °C, despite the fact that it is actually adaptable. High temperatures reduce the productivity. While temperatures above 30° C hinder the lycopene formation and flavor of tomato fruit, exceptionally low temperatures can have an impact on production. Tomatoes grow best in areas with low to moderate precipitation and an effective watering system during the off-season. Disease attacks increase under wet conditions, which also affect fruit ripening. Tomatoes thrive in a variety of soil types with a pH range of 5.5-7.5, high organic matter content, and good drainage. (Hanaa et a**l**, 2011, Waiganjo *et al,* 2006). The best soil for tomato plants is one that has been thoroughly amended with organic matter and is well drained. It is important for the soil to be capable of holding moisture (Robert, 2005). Tomato yield is restricted by a variety of factors. . These include: a dearth of enhanced, high-performing cultivars; poor fruit setting brought on by severe rainfall and extremely high temperatures; and pests and illnesses. A common occurrence is yield losses of 100 percent, especially when tomatoes are affected at an initial phase of development (Cohen and antignus, 1994). The world average crop loss due to all illnesses put together was around 12.8% of the crop productivity, whereas the tomato alone saw a loss of 21.8 percent.

The main biotic restrictions in India are caused by disease and insect pest damage. Much research has been done on the country's pathological and entomological concerns in order to reduce harm caused by illness and insect pests. As a result, roughly 13 illnesses brought on by various fungal, bacterial, and viral pathogens have been found and documented (Jones et al, 2014)and commercially significant insect and mite pests targeting tomatoes have also been reported (Elsafie et al, 2017). Previous research has identified early blight (*Alternaria solani*), late blight (*Phytopthora infestans*), septorialeaf spot (*Septorialycopersici*), and viruses as the four most commercially significant tomato diseases (Winad and Willium, 1999). A major financial loss is brought on by the illness *Fusarium* wilt of tomato, which is brought on *by Fusariumoxysporum* f. sp. *lycopersici.* On an astonishing variety of host plants, *Fusarium*species produce a wide variety of illnesses. The fungus can be retrieved from any part of the plant, from the deepest root to the topmost flower, and it can be conveyed in the soil, the air, or in plant residue (Singha *et al,* 2011). Wilted plants, yellowed leaves, and root rot are the hallmarks of the fungus's sickness, which also causes a low or nonexistent agricultural output. This disease is particularly destructive to tomato types that are sensitive to it during the summer season when soil and air temperatures are typically high (Akrami and Yousefi 2015).

PATHOGEN

The *Fusarium* genus is among the most versatile and diverse species in the Eumycota, and the *Fusariumoxysporum* species complex has a wide variety of non-diseases in addition to plant, animal, and human pathogens (Gorden, 2017). Numerous soil-borne infections of a variety of horticultural and food crops, including members of the *Fusarium* genus, are responsible for the deadly vascular wilts, rots, and damping-off diseases (Bodah, 2017). More than 150 hosts are affected by wilt disease caused by the *Fusariumoxysporum* species, which has a variety of distinct formae speciales (Bertoldo *et al*, 2015). *Fusariumoxysporum* Schlectend was mentioned in reports (Asha *et al,* 2011, Nirmala Devi and Srinivas, 2012). The most severe reduction in yield was caused by F. sp. lycopersici (Sacc.) W.C. Snyder and H.N. Hansen (FOL), which causes vascular, wilt of tomato disease(Asha *et al,* 2011). *F. oxysporum* can survive for a long time in soil as dormant propagules, which is a feature of soil-borne pathogens (chlamydospores). Chlamydospore germination is triggered by the presence of host roots. The infected hyphae stick to the root surface before penetrating it. The mycelium enters the vascular system through the xylem pits and interpenetrates the root cortical cells. The fungus then exhibits a distinct mode of infection in which it prefers to grow just within the xylem vessels before quickly invading the host(Srinivas *et al,* 2019). The fungus begins to develop microconidia inside the vessels, and as they separate, they are carried upward through the sap stream. Furthermore, the top vessels are

penetrated by mycelial growth as a result of microconidia germination. The typical wilt symptoms manifest as vascular blockage brought on by the accumulation of fungal hypae and a mixture of host-pathogen interactions, including the production of toxins, the creation of gums, gels, and tyloses (Khan, *et al*, 2017, Cha *et al*,2016) The appearance of typical disease symptoms such leaf epinasty, vein clearing, wilting, and defoliation inevitably precedes the death of the host plant (Fig. 1). During this phase the vascular wilt fungus, which stays limited to the xylem vessels, propagates through parenchymatous tissue and begins to sporulate abundantly on surface of the plant such as, leaf, steam etc. Dissemination of the pathogen can occur via seeds, transplants, soil or other means (Mc Govern, 2015, Joshi, 2018).

SYMPTOMS OF *FUSARIUM* WILT DISEASE ON TOMATO

Inoue *et al.* (2002) found that the fungus directly invades roots and colonizes vascular tissue. *Fusarium* wilt symptoms can include growth retardation, chlorosis and drooping of the leaves, reddish deep gouges of the xylem vessels (perceptible inside the stem as strands or dots in transverse section), and on the infected parts of the plant whitish pink fungal growth was seen (particularly in wet conditions). They can also affected root or stem decay.

Attack signs initially manifest as modest vein clearing on the young leaves' outer surface, proceeded by epinasty of the mature leaves (Sally *et al,* 2006). This condition frequently only affects one side of the plant or one stalk. Before the plant reaches maturity, successive leaves normally turn yellow, wilt, and fall. Growth is sometimes stunted and almost no fruit typically begins as the condition worsens. Dark brown stripes that run vertically through the main stem can be noticed if the stem is sliced. The disease's characteristic tanning of the vascular system can typically be utilised to identify it (Mui Yun, 2003). The symptoms frequently appear on mature plants following blooming and during the start of fruit 21 setting, as demonstrated by Walker (1971). A small amount of wilting on a portion of the plant may be the first sign. Chlorotic symptoms first occur on one side of the leaf before turning that side of the foliage yellow. Wilting is frequently related to one side of the plant as conditions worsen.

ETIOLOGY OF PATHOGEN

Mycelia of *Fusariumoxysporum* range from sparse to profuse and are delicate whitish pink, frequently with a purple tinge. The fungus creates three different types of spores: chlamydospores, macroconidia, and microconidia. Microconidia are plentiful, oval-ellipsoid, straight to curved, 5-12 x 2.2-3.5 mm, nonseptate, and borne on simple phialides emerging laterally. Macroconidia are thin-walled, three- to five-septate, fusoid-subulate, pointy at both ends, and have a pedicellate base. They are borne on branched conidiophores or on the surface of sporodochia and can range in number from sparse to profuse. Conidia with three septa are 27–46 x 3-5 mm in size, whereas those with five septa are 35–60 x 3-5 mm. The three-septate spore is more prevalent. The three-septate spore is more prevalent. There are many chlamydospores, both smooth and rough walled, and they can form terminally or intercalarily. Although they sometimes form pairs or chains, they are typically single. The perfect stage is unknown(Gerlach,1982).

ECOLOGY AND SPREAD OF THE INFECTION

A soil-borne pathogen that may survive for many years in the soil without a host is the cause of *Fusarium* wilt. The community surrounding infected tomato detritus is where the majority of infections start. Healthy plants may contract *F. oxysporum* infection if the soil they are growing in harbours the pathogen (Walker, 1971) In all kinds of soil, *Fusarium oxysporum* can be found, it can survive there, and it can grow there, but sandy soil offers the best condition for this to happen. Since it is soil-borne, the pathogen can survive in infected soil for many years. Pathogen thrives in environments with soil and air temperatures are 28 °C. The pathogen will spread to the lower regions of the stem if air temperatures are below 25^0C but at optimal soil temperatures the plants won't show any visual signs. Nitrate nitrogen reduces pathogen virulence while micronutrients, phosphorus, and ammonium nitrogen increase it.(Mui, 2003). The disease can spread over long distances via infected soil or transplants (Agrios, 1988), but it is more commonly short distance transmission by irrigation water and contaminated farmtools(Stephen, 2003).Furthermore, the disease can spread through contaminated soil and infected plant debris. Other ways of disease transmission include direct contact between a human and an infected field, the use of irrigation water or equipment that has formerly been used on a diseased crop, and direct contact between a human and an affected crop (Ajigbola, 2013).

EPIDEMIOLOGY OF DISEASE

According to Sally *et al.* (2006), the pathogen enters the plant by the root hairs and can survive in the soil for many years (Thangavelu *et al*, 2003). Mycelium develops in xylem channels where it blocks water flow, causing wilting (Stephen and Andre, 2003). *Fusarium* wilt frequently coexists with nematode colonization, with the worms serving as the fungus' entry point. Additionally, enzymes may make it easier for *Fusarium* to enter the plant host (Babalola, 2010). Warm temperature as well as low soil moisture increase infection and disease development in *Fusarium* wilt (Lewis, 2003).

TREATMENT OF *FUSARIUM* WILT DISEASE

Fusarium wilt in tomato plants needs to be managed if plant health, fruit quality, and yield are to be preserved. Management of *Fusarium* wilt is challenging [38, 39, and 40]. Several strategies have been put out to control this fungus pathogen. However, due to the introduction of new pathogenic strains, efforts to end the pandemic have mostly failed. The control of this pathogen is documented using a variety of techniques, including cultural, biological, resistance-based, chemical, and the use of natural materials (Pottorf, 2006).

Control by Culture Practices

Agriculture procedures and tactics that boost productivity and production while minimizing the consequences of illness are referred to as cultural control. To prevent plant diseases, it includes non-mechanical ecosystem manipulation. It requires altering agricultural methods to create a hostile environment for the growth of disease pathogen (Islam, 2001).It might also refer to the deliberate control of plant development, planting, and culture in a farm or yard to decrease plant disease. It has been found that treating soil-borne pathogens with cultural methods enhances soil composition, which minimizes the incidence of disease (Neshav, 2008). These techniques are mostly preventative, because controlling the spread of disease necessitates thorough understanding of the concept, habit, and environmental factors that the disease agent prefers. For a while, it was difficult to control soil- and seed-borne pathogens like *Fusarium* wilt, which is caused by a *Fusarium* species. To reduce fungus infestations and prevent disease issues unique to this type of vegetable, crop rotation with non-Solanaceous plants for 4-6 seasons is typically advised. Cereal crops should rotate with the grain whenever possible (Sally, 2006). Weed management, soil moisture management, and soil heating are all benefits of mulching, or topping the soil surface with a thick layer of mulch.

As the tomato receives shadow from the maize and is grown out of season, intercropping of tomato and corn should be promoted in order to increase the farmer's productivity and profitability. This technique enhanced production in Cuba by 5–6 tones/ha per year. By creating unfavorable conditions for soil-borne microorganisms, it aids in disease control. The hydrated tomato leaves are kept free of soil-borne germs by mulching. The farmer's advantage and yield would improve as a result (Maurya *et al,* 2019). Diseases like *Fusarium* spp. can be avoided through weed control. The virus can infect plants when sick weeds are destroyed. The *Fusarium* wilt pathogen can more easily infect plants when they are subjected to excessive plant care techniques such tying, trimming, and pruning (Ajigbola and Babalola, 2013).

Biological treatment

The use of hostile microorganisms is a different disease prevention technique for having a *Fusarium* disease control system that is eco - friendly alternative (Lutenberg, 2009). Biological control agents can accomplish their objectives directly, indirectly, or through a combination of both (Pal and Gardner,2006]. There have been reports of great success using bio agents to control the *Fusarium* wilt disease on tomatoes (Freeman *et al,* 2002). Non-pathogenic *F. oxysporum* and *F. solani* were successfully identified and prevented *Fusarium* wilt in greenhouse testing (Momol, 2003). When applied quickly, CS-20, CS-1, CS-24, and Fo-47 were among the consistently effective isolates. Since being sprinkled with *Phytophthora cryptogea* zoospores and then injected with the disease's pathogen, tomato plants don't exhibit symptoms of wilt disease (Attitala *et al*, 2001). According to Kapoor and Kar (1988), *Arthobacter, Bacillus*, and *Pseudonomas* species are among the bacterial antagonists. 30 biological control agents, including bacteria and non-pathogenic strains of *Fusariumoxysporum*, have been identified by Lemanceae and Alabouvett (1991) and Fuchs *et al*. (1997) as having potential for controlling *Fusarium* wilt of tomato. In comparison to field circumstances, controlled greenhouse conditions have shown biological control agents to be more effective at decreasing *Fusarium* wilt in

tomato plants. *Fusariumoxysporum* f. sp. *lycopersici* incidence on tomato was found to be reduced by 6–15 percent by coating seeds with *Trichoderma viridae* culture(Panteleev 1973).An innovative disease management technique is the employment of antagonistic microorganisms, which can provide an eco-sustainable *Fusarium* disease control system (Lutenberg and Kamilova, 2009). According to Pal and Gardener (2006), the biological control agents' mechanisms may be direct, indirect, or a combination of both. According to Freeman *et al*. (2002) the application of biological agents was quite successful in preventing *Fusarium* wilt disease in tomato plants. Researchers have observed the inhibition of plant pathogens by halophilic and green manure, especially *Rhizoctonia,Phytopthora, Plasmidiophora brassicae*, *Gaeumannomyces graminis,* and *Fusarium*(Pitt et al, 1998,,Kannangowa *et al*, 2000,Cotxarrera,2002). It was discovered that *G. intraradices* and a few gram-negative and fluorescent RB (rhizobacteria), *P. fluorescens*, *P. putida*, and *Enterobacter cloaceae*, were efficient against *Fusariumoxysporum* f. sp. Lycopersici in the rhizoplane of solanaceous plants (Akkopru and Dermir, 2005). The bacterial biocontrol agents *B. subtilis*, *Streptomyces corchorusii*, *S. pulcher*, and *S. mutabilis* have been shown to exhibit promising biocontrol actions against wilt (Monda,2002)]. By generating phytohormones including Indole acetic acid, Ethylene, Cytokinin, Gibberelin, and mineral elements, rhizobacteria can operate as biofertilizers and biostimulants. They can also provide as a passive barrier to harmful microorganisms by generating antibiotics and siderofore (McMillan, 2007 and Smith, 2007). According to Widnyana *et al.,* (20130, three isolates of rhizobacteria known as *Pseudomonas alcaligenes,* KtS1, TrN2, and TmA1, were taken from the rhizobia of plants belonging to the families Solanaceae and Leguminoseae and demonstrated inhibitory action against *Fusariumoxysporum* f. sp. lycopersici by significantly lowering the wilt disease. Numerous crops are said to be induced to grow by biological agents. These responses could be brought on by (i) suppressing harmful root microflora, including those that aren't directly causing disease, and (ii) producing growth-stimulating substances. (iii) Improved root development and/or solubilization of nutrients, which resulted in an increase in nutrient intake. *Trichoderma* is one of the most well-known and frequently utilised organisms for promoting plant development and biologically controlling plant diseases (Shirzad *et al*, 2016, Vipin Kumar *et al*, 2017, Kloepper, 1993).

Mechanisms of bio control by PGPB

The fight for resources and space at the infection site, the creation of metabolites, and the modification of bacterial signalling molecules are frequently used as disease controls by BCA (biocontrols) (Raaijmakers *et al* 2002). All of these situations involve pathogens being agitated by the existence and actions of other species (Fig. 1). The release of substances like siderophores, which effectively sequester iron and deny the pathogen of this crucial element, is the key process of pathogen suppression via nutritional competition (Whipps, 2001).Some bacteria secrete metabolites, such as antibiotics, toxins, surface active substances (biosurfactants), and cell wall-degrading enzymes, which suppress the growth of pathogens (Compant *et al*, 2005, Haas and Defago, 2005, Kumar *et al,* 2015). However, their particular byproducts also cause the induction of systemic resistance (Van Loon *et al*, 1998). Some *Bacillus* and *Pseudomonas* species produce several antibiotic substances that fight pathogenic bacteria, nematodes, helminths, fungus, and more (Thomashow and Weller, 1995,Raaijmakers *et al* 2002, Almaghrabi, 2013). Different bacterial strains, including *Pseudomonas* (Ligon *et al,* 2000), *Serratia* sp. (Kalbe et al, 1996), and *B. cepecia* (Burkhead, 1994), create secondary metabolites, such as pyrrolnitrin (3-chloro-4- (20-nitro-30-chlorophenyl) pyrrole, which is efficient against various infections. The primary tactics applied by BCA to suppress soil-borne pathogens are the production and release of cell wall-degrading enzymes (Kobayashi *et al,* 2003). The structural rigidity of the target pathogen's cell wall is impacted by these enzymes. B-1, 3-glucanase, chitinase, cellulase, and protease were the cell wall-degrading enzymes that biocontrol strains released(Budi *et al*, 2000).

Use of Botanicals

The use of medicinal herbs for the control of *Fusarium* wilt in crops is limited, despite the fact that numerous research activities have been made to identify alternative and environmentally acceptable strategies for controlling plant diseases(Agbenin, *et al*, 2004, Agbenin *et al*, 2006)). When compared to synthetic pesticides, plant metabolites and plant-based pesticides are recognised to have less of an adverse effect on the environment and pose fewer risks to consumers. Therefore, they seem to be one of the better alternatives. As natural products that are freely accessible and have no negative effects, the demand for plant-based therapies is rising in developing nations. The goal of the current study was to assess the effectiveness of certain plant extracts in preventing the tomato wilt disease caused by

Fusarium oxysporum f. sp. *lycopersici.* When compared to synthetic pesticides, plant metabolites and plant-based pesticides are recognised to have less of an adverse effect on the environment and pose less risk to consumers. Therefore, they seem to be among the better options. As natural products that are freely accessible and have no negative effects, the demand for plant-based therapies is rising in developing nations. The goal of the current study was to assess the effectiveness of certain plant extracts in preventing the tomato wilt disease caused by *Fusarium oxysporum* f. sp. *lycopersici.* Daradka *et al*(2021) were investigating the antifungal activity of ten plant extracts against A. *alternata* and F.*oxysporum*, the causative agents of tomato early blight and wilt diseases. The tested plants belonged to several families. Plant extracts had an inhibitory impact on *A. alternata* and *F. oxysporum* that ranged from 10-29 and 12-31 mm zone of inhibition, respectively. *Citrullus colocynthis*, *Psiadia arabica*, and *Olea chrysophylla* extracts were the most potent antifungals, followed by extracts of *Pulicaria crispa*. Using 50 plant extracts, Ramaiah and Garampalii (2015) assessed *in vitro* antifungal activity against *Fusarium oxysporum* f. sp. *lycopersici* (FOL) using the food poison approach. Three plants out of fifteen were shown to have the potential to slow the growth of the FOL: *Solanum indicum* (78.33%), *Azadirachta indica* (75.00%), and *Oxalis latifolia* (70.33 percent). Three chemical fungicides, namely (Mancozeb with 82.66 percent, Copper oxychloride with 79.33 percent, and Copper sulphate with 82.33 percent) at various concentrations, were compared for their antifungal effectiveness. The antifungal crude extract at varying concentrations (ten percent, twenty percent, forty percent, and sixty percent) on the mycelial development of FOL was assessed using the poison food method.As a result of this work, it is possible to develop effective plant-based fungicides that can be utilised in organic farming to treat *Fusarium oxysporum* f. sp. *lycopersici* using botanical extracts as a better option.

Application of Resistance Crop species

The use of disease resistance, when available, is the most economical and environmentally secure way of control. The greatest method for disease control is the use of resistant cultivars, which is also one of the finest alternative methods for wilt disease management (Sheu *et al.,* 2006). But the utility of several resistant cultivars is limited to just a few years because of the loss of resistance in the face of significant pathogenic diversity in the pathogen population .For some plants, such as peas and China asters, cultivars that are resistant to or tolerant of *Fusarium* wilt are available. The other races of the same forma specialise may not be resistant to a cultivar that is resistant to a specific forma specialise Burgess *et al,* (2008). Identification and usage of tomato plant types that are disease-resistant constitute a viable alternative to the use of chemicals (Pritesh and Subramanian, 2011).When there is no known dominant gene, breeding for resistance might be extremely challenging. The development of novel pathogen races that are able to overcome host resistance has also been reported by Momol and Pernenzy (2003). This approach has the benefits of reducing the cost of disease-controlling chemicals and maximising the cultivation of previously diseased fields.

Chemical Control

Chemicals are frequently used in agriculture to control diseases and pests. The incidence of tomato wilt is significantly decreased in seeds treated with synthetic fungicides. However, using them is expensive and environmentally harmful (Song and Goodman, 2001). The primary technique for managing plant diseases is fungicides, however biological agents, particularly *Trichoderma* species, are also effective at limiting the pathogenic activities of phytopathogenic fungus (Taran,2000). It is therefore crucial to implement a good management approach to combat tomato *Fusarium* wilt. Prochloraz, propiconazole, thiabendazole, carbendazim, benomyl, thiophante, fuberidazole, and all of the benzimidazoles are a few of these substances. Using the root dip treatment approach, benomyl was found to be only moderately effective against F. *oxysporum* f. sp. cubense (Nel *et al.* 2007). When this technique was used to treat *Fusarium* wilt-infected tomato seedlings, it increased yield by roughly 24 percent (Khan and Khan, 2002). The introduction of alternative approaches to disease management has been prompted by factors such as the high frequency of chemical usage, non-target effects, and the development of chemical resistance, the persistence of pathogens for long periods of time, and hazards to human health and the environment. Additionally, compared to their soil-borne competitors, insecticides are typically more effective against aerial plant diseases. The range of approved chemicals is dwindling as bioactive molecules are withdrawn for toxic effects and environmental reasons; for example, methyl bromide has already been carried out due to its extremely high potential to deplete the ozone layer. It is also technically challenging to treat large amounts of soil. Chemical control techniques lead to

microbial population imbalances that may be detrimental to the activities of beneficial soil microorganisms and may also encourage the emergence of infections with heightened resistance. Overuse of chemicals in the soil has polluted the environment and harmed humanity (Asaka And Soda, 1996). Chemical control techniques lead to microbial population imbalances that may be detrimental to the activities of beneficial soil microorganisms and may also encourage the emergence of infections with heightened resistance. Overuse of chemicals in the soil has polluted the environment and harmed humanity (Asaka And Soda, 1996).Some chemicals like Topsin-M, Nativo, Curzate, Carbendazim, Cabriotop, Prevail, and Antracol showed fungicidal activity against *Fusarium oxysporum f*.sp. *lycopersici.* Blosch *et al*. 2021investigated the effectiveness of fungicides, such as etalaxyl+mancozeb, copper oxychloride, benalaxyl+mancozeb, carbendazim, and mancozeb, at increasing doses (2, 2.5, 3, 3.5, and 4 g/litre water), against the *Fusarium* wilt of tomato affected by *Fusarium oxysporum* f. sp.The outcome showed that copper oxychloride was efficient in all of its doses to control the *Fusarium* wilt of tomato; the most effective dose was 3 g/l at which disease incidence was only recorded 6.2 percent.

CONCLUSION

In summary, efforts should be focused on evaluating and improving these technologies' utility, productivity, and stability on the fields rather than merely in the greenhouse, aside from considering the fact that they are working in various ways. In biological control, it is also crucial to consider the specific microbial product compositions that would produce the best results. Therefore, a focus should be placed on training farmers on how to employ cultural traditions appropriately and how to incorporate them into other tactics for a healthier and cheaper outcome.

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Fig. 1 [A] Showing only affects one side of the plant; leaf turned yellowing, wilt and fall. [B] Dark brown stripes that run vertically through the main stem

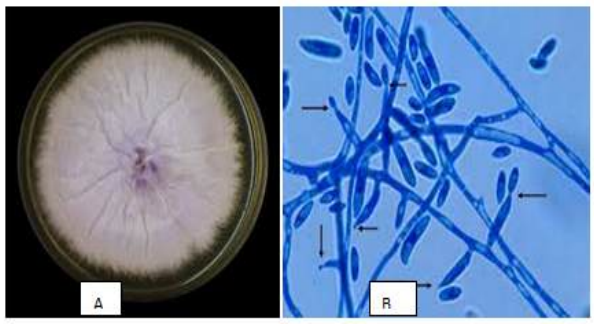


Fig. 2. [A] Profuse whitish purple mycelium growth of *F. oxysporum* [B] Microscopic observation of *F. oxysporum* including ; macroconidia, microconidia and chlamydospore

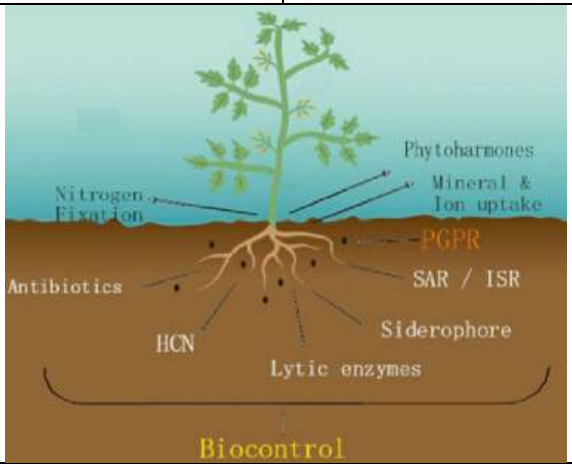


Fig. 3 Plant Growth Promoting Bacteria shows Antagonistic Activity

RESEARCH ARTICLE

Biological Activity of Metallic Nanoparticles against Multi-Drug Resistant Organisms: A Nanomedical Approach

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ABSTRACT

Over the past few years, antimicrobial and antibacterial resistance has been scary and represents a major risk to public health worldwide. The onset of multidrug-resistant (MDR) organisms has been blamed for the rise in mortality and morbidity caused by microbial and bacterial diseases. Antibiotic choices for MDR organisms are often constrained. This has contributed to massive researches to explore novel and efficient antimicrobial and antibacterial strategies to overcome clinical challenges. Nanotechnology is progressively being used for medical applications, particularly as a new approach for treating microbial and bacterial infections.Chemically produced metallic nanoparticles (MNPs) or metal oxide nanoparticles (MONPs) are harmful to a variety of living cells and generate unfriendly byproducts that can seriously damage cell membranes. There is a lot of interest in new biological techniques that don't result in hazardous materials as byproducts because of the increasing need for non-toxic and ecologically friendly methods for creating nanoparticles. The increasing demand for environmentally friendly and health-protective nanoparticles has led to the use of green methodologies in the synthesis of various MNPs. The green synthesized or biogenic MNPs or MONPS are recognized as eco-friendly, environmentally sustainable, cost-effective biocompatible nanostructures with biological activities and possible therapeutic implementations. Furthermore, new strategies like the combination of MNPs and MONPs with conventional antibiotics have a good synergistic effect as they enhanced the potency of the antibiotics against bacteria and microbes. The synergetic effect of MNPs/ MONPs when combined with ideal antibiotics may assist to combat the global challenge of emerging MDR organisms. In this review, we summarized the recent research on green synthesized AgNPs, AuNPs, CuNPs and, ZnONPsas well as their synergetic effect in combination with different antibiotics against MDR organisms. It provides a comprehensive summary of the latest discoveries in the application of these biosynthesized nanoparticles (NPs) as anti-MDR pathogenic bacteria agents.

Keywords: Multi-drug resistant organism, Metallic nanoparticles, biogenic and, synergetic effect.

INTRODUCTION

Antibacterial/antimicrobial agents are biologically active substances that kill or delay the development of germs without being hazardous to the healthy tissue. Though antibiotics can cure the majority of bacterial illnesses, the emergence of microbial resistance limits the effectiveness of the antibacterial drug in managing infectious diseases. This is a significant difficulty that poses a huge hazard, spurring the quest for alternate treatment techniques for bacterial infections. The prevalence of microbiological infections has risen considerably in recent decades. The widespread use of antimicrobial medications to treat infections has resulted in the establishment of resistance among many microbial strains. MDR (multidrug-resistant) is characterized as a microorganism's reduced sensitivity or tolerance to antimicrobial medications notwithstanding previous sensitivity to them [1-3]. According to the WHO, these resistant microbes can withstand antimicrobial drug attacks, resulting in inefficient treatment, infection persistence, and dissemination. Antibiotic resistance patterns raise concerns regarding the establishment and revival of multidrug-resistant organisms or parasites [4]. The most difficult MDR microbes are Mycobacterium tuberculosis, Acinetobacter baumannii, Pseudomonas aeruginosa, methicillin-resistant Staphylococcus aureus, Escherichia coli, and Klebsiella pneumoniae bearing NDM-1 (New Delhi metallo-beta-lac)[5]. Nanotechnology is recognized as a new subject with several applications that have a substantial impact on human existence in different ways [6]. Recent breakthroughs in nanotechnology have focused great interest on the new possibilities of nanoscience implementation in the disciplines of healthcare science, pharmaceutical industries, and immunotherapy. The role of nanochemistry in the development of suitable nano antibacterial/antimicrobial formulations to fight MDR is hereby gaining more and more importance in the modern scientific era, where, bacteriological applications of nanoparticles are one of the research topics of key interest. However, because regular drug use has resulted in antibiotic/multidrug resistance in microbes, and metal nanoparticle delivery is affecting the food chain, it has become critical to create interdisciplinary approaches incorporating Microbiology and Nanotech to overcome secondary health of individuals, as well as worldwide environmental damage. The combination of these professions provides reasonable, inventive, and long-term solutions. NPs could be a feasible solution to MDR because they can both fight bacteria and act as transporters for antibiotics and natural antibacterial molecules [7].

Considerable research has been done to assess the antibacterial prospective of Nanoparticles. The antibacterial properties of NPs highlight their innovativeness in upcoming generations of antimicrobial agents [8]. Nanoparticles can direct antimicrobial drugs to the infection site, allowing greater dosages of medicine to be administered at the diseased location and thus overcoming resistance [9]. Antibacterial NPs can target several macromolecules and also have the ability to inhibit or abolish MDRO evolution [10]. It has been found that NPs coupled with antibiotics have synergistic antibacterial effects [11,12]. Because NPs exhibit several antibacterial pathways, bacteria are rare to acquire resistance to these nanomaterials. The most promising seems to be metallic nanoparticles. They demonstrate a wide range of anti-drug actions against pathogens that are resistant [13,14,15]. The silver nanoparticles (AgNps) and gold nanoparticles (AuNPs) are the most researched metal nanoparticles. Other than these the copper nanoparticles (CuNps),and, zinc oxide nanoparticles (ZnONps), have also been shown to have biologically active properties. Nanoparticles provide an alternative in the treatment of most infectious diseases, particularly those that included MDR organisms Nanoparticles could be used alone or in combination with antibiotics to provide outstanding synergistic impacts [16]. Because of the unique features of MNPs, the field of nanotechnology appeared to be a promising option to control the MDR organism lethal activity. TheAntibacterial/ Antimicrobial mechanism of MNPs is shown graphically in figure-1

Nanoparticles as Nanoantibiotics

The reengineering of antibiotics at the nanoscale or the physicochemical conjugation of nanoparticles with antibiotics is an emerging application of nanotechnology to overcome the worldwide problem of MDR, leading to the evolution of nanoantibiotics [17]. Nanoparticles operate through several mechanisms to combat antibacterial/antimicrobial activities. Antibiotic-tagged nanomaterials help to boost antibiotic concentrations in the infected area and also improve antibiotic adherence to bacteria.

Green synthesizedmetallic nanoantibiotics and their synergetic effect in combination with conventional antibiotics

Green synthesis of metallic nanoparticles utilizing microorganisms and plants is biologically secured, cost-effective, and environmentally sustainable. Plants and microbes have developed the ability to consume and acquire inorganic metallic ions from their surroundings. It is known that biological entities can produce nanoparticles in both extracellular and intracellular processes. Algae, photosynthetic bacteria, actinomycetes, microbes, viruses, yeasts, fungi, and plants are examples of living organisms of both prokaryotic and eukaryotic origin that are involved in nanobiotechnology. The ability of each biological system to provide metallic nanoparticles differs. As a result, living organisms or their extracts are being used for green synthesis of metallic nanoparticles via bio-reduction of metallic particles resulting in nanoparticle synthesis. These green synthesized metallic nanoparticles offer a plethora of medicinal uses, including drug or gene delivery, pathogen or protein detection, and tissue engineering. The proper implementation of medications and tissue engineering by nanotechnology has contributed a great deal to therapeutic research relating to medical products and their uses [18]. Biological synthesis is preferable to conventional chemical synthesis because it is less expensive, produces fewer pollutants, and boosts human and environmental health security [19]. Biogenic synthesis of metallic nanoparticles can be accomplished through the use of organisms including plants, algae, fungi, and bacteria as well as their metabolites, which act as reducing and stabilizing agents [20-23] Green synthesis offers several benefits over chemical and physical approaches, including the fact that it would be non-toxic, pollution-free, eco-responsible, economic and much more sustainable [24-27]. Plant-based NPs synthesis is a simple technique in which a metal salt is synthesized with plant extract and the reaction is finished in minutes to a few hours at standard room temperature. This technique has gotten a lot of attention in the last decade, especially for AgNPs and AuNPs, which are far safer than other metallic NPs. Greenways for generating NPs may be easily scaled up and are also cost-effective. Greenly coordinated NPs are presently preferred over conventionally supplied NPs due to their excellent qualities [28]. Because of their unique qualities, such as overcoming bacterial resistance, lowering acute toxicity compared to their sizes, and allowing dose reduction of active medicinal substances, metal-based nanoparticles have piqued the interest of researchers.

Integrating MBNPs and antibiotics not only improve antibacterial efficacy but also allows for biofilm suppression [29]. Antibiotics are being released into the environment through bio waste, livestock feed, and agribusiness products. Metallic nanoparticles are also accumulated in the environment as a result of their widespread usage as a biocidal agent in everyday items. The biological activity of green synthesized AgNPs, AuNPs, CuNPs and, ZnONPs against different MDR organism is shown in table.1 The combination of antibiotics and MNPs/ MONPs has the potential to develop resistance against MDR bacteria to enhance human health. Synergistic action is now often used to define the interaction of two antimicrobial medicines, or even more than two in which the impact caused by the medications in combination is better than the total of their individual effects against the MDR bacteria when the antibiotics are administered alone [30,31]. In this review, the current research on the green synthesis of different MNPs such as Gold (AuNPs), Silver (AgNPs), Copper (CuNPs), and, Zinc oxide (ZnONPs) nanoparticles and their synergetic effect in combination with the antibiotic were examined. The synergetic effects of these MNPs/MONPs in combination with different antibiotics against different MDR organism is shown in table-2 This review provides a comprehensive biological activity of above mentioned MNPs/MONPs from plant extract, which has the potential to promote green research in the field of nano-medicine shortly and also focused on the nano-technology role for improving antibiotic bactericidal efficiency through the synergetic use of MNPs/MNOPs, antibiotics to address bacterial/microbial resistance.

MNPs/MONPs as Nanoantibiotics

The antimicrobial/antibacterial activity of green synthesized MNPs/MONPs and their synergetic effects in combination with the traditional antibiotic against MDR organism is described in detail here-

AgNPs as nanoantibiotic:

For centuries burns and wounds have been treated with silver to prevent infection. The cause of this specific behavior of silver is unknown, however, it has been suggested that silver and silver ions can permeate bacterial cell walls and

membranes by interacting with thiol moieties in proteins due to their smaller size (10 nm) [32]. Thereby resulting in an interplay of actions with intrabacterial environment [33]. Once inside the cell, Ag/Ag^{+} can also attack and destroy bacterial genetic material and respiratory enzymes, causing the cell to lose its ability to replicate and eventually die [34]. Another evident benefit of using AgNPs is the well-known fact that these particles remain for a much longer duration in the body (even years) in comparison to the small molecules commonly used in antibacterial therapy. This boosts the long-term release of active chemicals, resulting in longer-lasting therapeutic effects [35,36]. Several researchers worked on the antibacterial effect of AgNPs against pathogenic, MDR, and multidrug-susceptible strains of bacteria, and it was proven that AgNPs are potent weapons against MDR bacteria such as Pseudomonas aeruginosa, Escherichia coli, Streptococcus pyogenes, Staphylococcus aureus [37]. AgNPs have been found in studies to be very stable and poisonous to bacteria, fungi, and viruses. The AgNPs were chemically produced and tested for antibacterial efficacy against MDR *klebsiella pneumoniae* strains using agar diffusion and broth microdilution assay. AgNPs are antibacterial and antibiofilm chemicals that are safe against MDR K. pneumonia [38]. Antibacterial investigations with multifunctional peptide (MFP)-coated AgNPs (MFP@AgNPs) against Gramme-positive and Gramme-negative bacteria were conducted. MDR-AB (multidrug-resistant *Acinetobacter baumannii*) afflicted mice were used to test the antibacterial activity in vivo. In vivo tests verified the increased antibacterial efficacy against MDR-AB infections by using MFP@AgNPs [39]. AgNPs were also effective against MDR P. aeruginosa. It had an effective minimum inhibitory concentrations (MIC) range of 1.406–5.625 g/mL and an MBC range of 2.813–5.625 g/Ml against multidrug-resistant P. *aeruginosa* which showed its antibacterial activity[13]. The antibacterial effect of AgNPs against clinical strains of MRSA and MDR P. aeruginosa was determined using the broth microdilution technique. At all investigated doses, silver nanoparticles showed strong antibiofilm action against MRSA and MDR P. *aeruginosa,* with maximum inhibition values of (82%) and (91%), respectively [40].

The biosynthesis of nanoparticle has minimal or almost non-toxic, and also a variety of plants and herbal extracts have been reported to be used in the biosynthesis of MNPs [41]. Plant extracts include secondary metabolites that function as reducing or capping agents during nanoparticle synthesis [42]. A biosynthesized non-toxic lignin-based biocompatible AgNPs found to have antibacterial efficacy against MDR bacteria such as S.aureus, S.epidermidis, P. *aeruginosa*, K. *pneumoniae*, and A. *baumannii* [43]. Ag NPs produced from Ocimumgratissimum leaf extract reduced biofilm development by both E. coli and S. *aureus.* The AgNPs suppressed bacterial cell development by causing damage to the cell surface of E. coli and S. *aureus* as well as reducing reactive oxygen species (ROS) production [44]. Catharanthusroseus and Azadirachta indica extracts were used to produce green-synthesized AgNps. MDR bacteria isolated from individuals with septic wound infections were successfully suppressed by Ag NPs [45]. AgNPs were biosynthesized utilizing Galaxaurarugosa crude methanol extract and raw powder aqueous solution. Antibacterial and antibiofilm activity of AgNPs was demonstrated against eighteen therapeutically relevant microorganisms, including MDR bacteria. The most impacted strains were sensitive and resistant to A.*baumannii* and S.*aureus.* MDR strains' biofilms were generally disrupted, showing that resistant strains had lower bacterial viability.

These results may aid antibacterial agent development by investing in natural resources available abundantly in our environment [46]. The AgNPs from Curcuma caesia aqueous rhizome extract was discovered as an effective source of nanomedicine against MDR strains of K. pneumonia, E. coli, and P. *aeruginosa*. The biosynthesized AgNPs from Curcuma caesia aqueous rhizome extract were discovered to be an invaluable nanomedicine against MDR bacterial strains of K. pneumonia, E. coli, and P. aeruginosa [47]. Because of the long-term usage of antibiotics in an unselective manner, MDR bacteria and extensively drug-resistant organisms have emerged, offering a new threat to the healthcare world. The researchers tested the synergistic impact of various antibiotics with silver nanoparticles (AgNPs) to cure infections caused by MDR bacteria. Many kinds of research have been conducted to analyze the synergetic effects of AgNPs with antibiotics. The combination of biosynthesized AgNPs using cloves seed extract and Tetracycline in sublethal concentrations proved successful to cure Gramme-positive bacteria such as S. aureus. Antibiotic use in conjunction with AgNPs has resulted in a significant increase in antibiotic resistance [48]. AgNPs are a viable option for combating drug resistance since they have synergistic effects against ESBL[extended spectrum beta-lactamases] generating bacterial when mixed with other ineffective antibiotics [49]. A nanoformulation was synthesized by utilizing AgNPs in combination with ampicillin (Amp-AgNps) having dual properties of antibiotic as

well as Ag metal. The nano formulation of Amp-AgNps had great antibacterial potential against MDR bacteria as these bacterial strains showed non-resistivity towards the Amp-AgNps even after exposure up to 15 successive cycles [50]. AgNPs were tested alone or in combination with vancomycin for antibacterial and antibiofilm action against the pathogens S. *aureus*, P. *aeruginosa*, and S. pneumonia. There is up to a fourfold decrease in AgNP inhibitory dosage when it is used with vancomycin.[51]Biosynthesized AgNPs from Cinnamomumzylinicum bark extracts in combination with Gentamycin showed that combining antibiotics with AgNPs has tremendous antibacterial advantages. Gentamycin was most effective against S.*aureas*, K. pneumonia, P. *aeruginosa,* and A. *baumanni*. This implies that AgNPs might be used to improve the efficiency of current antibiotics against MDR bacteria [52].

AuNPs as Nanoantibiotics

The antibacterial action of AuNPs has been attributed to a variety of mechanisms, viz. degradation of cell metabolism by AuNPs due to a decrease in membrane potential, which inhibits ATPase activity; preventing the ribosome's binding component from attaching to t-RNA; by targeting nicotinamide, AuNPs may harm the bacterial respiratory chain [53,54]. AuNPs have been identified as a highly beneficial framework for efficient drug delivery/carrier systems due to their simple and well-studied production, easy surface functionalization and biocompatibility, and low toxicity [55]. Furthermore, AuNPs have been demonstrated to boost medication concentration in infected sites while reducing drug toxicity [56]. This allows gold nanoparticles to be utilized as therapeutic agents or vaccine carriers in particular cells, increasing the efficacy of antibiotic therapy for the treatment of serious bacterial infections while using a lower antibiotic dosage with minimum side effects [57]. Physical and chemical methods are commonly used to make AuNPs, which are both expensive and dangerous to the environment. As a result, the biosynthesis of nanoparticles has recently gotten a lot of attention because the nanoparticles produced are non-toxic and can be employed in biomedical applications [58]. were successfully synthesized using aqueous leaf extract of Artemisiaherba-alba and Morusalba as bioreducing agents. The biosynthesized AuNPs showed profound antibacterial activity against MDR E. coli and Salmonella species [59]. The antibacterial activity of AuNPs obtained from Jatrophaintegerrima floral extract against E. coli and Bacillus subtilis was maximum and minimum, respectively. AuNPs had MICs (minimum inhibitory concentration) of 5.0, 10, 2.5, and 2.5 g/mL against B. subtilis, S. *aureus*, E. coli, and K. *pneumoniae*, respectively. As a result, synthesized nanoparticles may be a viable option for developing an antibacterial agent against identified human diseases [60]. The chitosan grafted pyromelliticdianhydride– cysteine (CS-g-PMDA-CYS) was conjugated with AuNPs via the –SH group of CYS, and antibiotics RF (rifampicin) and INH (isoniazid) were inserted in the AuNPs-fused CS-g-PMDA-CYS system. The AuNPs system developed in combination with Rifampicin antibiotic is a potential medication carrier and delivery method for the suppression of MDR bacteria such as S. *marcescens* [61].

CuNPsas nanoantibiotics

Since ancient times, this metal has been employed as a possible antibacterial agent. Traditional inorganic antibacterial agents are copper-containing compounds such as $CuSO_4$ and $Cu(OH)_2$ [62]. The American Environmental Protection Agency (EPA) has now registered copper as the first and only metal with antibacterial characteristics [63]. Within 2 hours of contact, this substance eliminates 99.9% of most infections caused by pathogens [64]. CuNPs inhibited efflux in both wild-type strains of S.*aureus* and P.*aeruginosa* and had a lesser but substantial inhibitory impact against MRSA and drug-resistant mutant strains of S. *aureus*. According to the findings, CuNPs might be used as bacterial adjuvants to combat MDR microorganisms [65]. CuONPs and copper ions (Cu^{2+}) both have the potential to enhance the conjugative transfer of multiple-drug resistance genes. The excessive generation of reactive oxygen species (ROS) was critical in boosting conjugative transfer [66]. CuNPs were shown to generate reactive oxygen species (ROS) within the bacterial cells of MDR pathogens Klebsiellaquasipneumoniae and Enterobactersp, therefore reducing bacterial growth and division [67]. Varshney et al. have suggested a fast green synthesis method for the preparation of spherical CuNPs (8-15 nm in diameter) by utilizing non-pathogenic P. *stutzer* [68]. The biosynthesized CuNPs utilizing Tilia extract were studied for their antimicrobial activity. The investigations revealed reasonably strong activity against Gramme-positive and Gramme-negative bacteria [69]. The green synthesized CuNPs from Hageniaabyssinica leaf extract was also investigated for its antibacterial activity against E. coli, P. *aeruginosa,* S.aureus, and B.*subtilis*. The findings revealed a good zone of inhibitions of 12.7, 12.7, 14.7, and 14.2 mm,

demonstrating the potentiality of CuNPs as a treatment for infectious disorders caused by tested pathogens.[70] The biogenic CuNPs produced from Ficussycomorus aqueous fruit extracts showed promising antibacterial activity against MDR clinical isolates of bacteria [71]. By agar well diffusion, CuNPs derived from *Garcinia*mangostana (GM-CuNPs) showed the most substantial bactericidal action against MDR grammeme negative bacterial strains such as Aeromonassorbia, Edwardsiellatarda, Enterobacter spp., K.pneumoniae, and Pseudomonas spp. It is possible to infer that GM-CuNPs have the best antibacterial capabilities for MDR therapy and should be considered for future bullfrog MDR therapeutic applications [72]. The biosynthesized CuNPS from Sennadidymobotrya roots exhibited significant antimicrobial activity on E. coli and S. aureus [73]. A green biosynthesis has indeed been widely researched by several researchers recently, and it was adopted as an alternate way to generate safe and environmentally acceptable Cu-NPs. Synthesis of CuNPs employing green substrates such as plant-based extract, microbe, biopolymer, and carbohydrate is much more desirable nowadays to preserve the environment by minimizing the use of deadly chemicals. It is hoped that by improving the synthesis method for Cu-NPs, additional information about these metal nanoparticles would be discovered.The disc diffusion technique was also used to assess the synergistic action of CuNPs with erythromycin, azithromycin, and norfloxacin. The antimicrobial activities of these antibiotics were shown to be enhanced in combination with the CuNPs. The results showed that combining medicines with nanoparticles had strong antibacterial benefits, particularly against Klebsiella and Pseudomonas. Cu-NPs have the potential to increase the antibacterial activity of antibiotics against resistant pathogenic microorganisms, although their intended impact depends on their concentration [74]. The antibacterial activity of CuNPs was examined by the agar well diffusion method. The synergistic effect of CuNPs was determined in combination with different broad-spectrum antibiotics such as Tetracycline Rifampicin Chloramphenicol Vancomycin Gentamycin Streptomycin Kanamycin Tobramycin Penicillin Ampicillin against E. coli, P.*aeruginosa,* Bacillus cereus and S.*aureus*. In the presence of CuNPs, all antibiotics' antibacterial activity against tested microorganisms was boosted. Streptomycin (9.332.05 mm), Vancomycin (7.331.18 mm), and Tetracycline (10.660.24 mm and 7.331.89 mm) showed the greatest fold increase in the area against E.*coli*, P.*aeruginosa*, B. cereus, and S. *aureus*, respectively. Tobramycin showed the smallest fold increase in area (0.670.47 mm) against S. *aureus*. Among the studied microorganisms, E. coli had the highest synergistic bactericidal activity (54.70%), followed by B. *cereus* (51.68%), P.*aeruginosa* (36.77%), and S. *aureus*(10.91 %) [75]. The synergistic action of CuNPs with antibiotics may be due to the development of a specific complex that has become more efficient in the suppression of a certain type of bacteria, either by blocking cell wall production or by inducing lysis or death.[76]

ZnONPs as nanoantibiotics

Interestingly, multiple investigations have found ZnO-NPs to be non-toxic to human tissues.[77]This compelled their use as antibacterial drugs, toxic to microorganisms, yet biocompatible with human tissues. The effect of ZnO-NPs on a carbapenem-resistant strain of A. baumannii was studied. The formation of ROS by ZnO-NPs increases membrane lipid peroxidation, which triggers leakage of reducing sugars membrane, DNA, and proteins and lowers cell viability. These findings suggest that ZnO-NP might be developed as an alternate therapy for A. baumannii [78] Nowadays, eco-friendly NP synthesis has gained popularity among researchers relatively low cost, biosynthesis in an ambient environment, non-toxicity, environmental friendliness, and simplicity of application since the resultant nanoparticles are highly hydrophilic, biocompatible, and free of harmful stabilizers. Plant extracts have great promise for the simple production of NPs through green approaches. Plant-based nanoparticle development offers several benefits over traditional physicochemical approaches and has numerous applications in biomedical. The production of ZnONPs utilizing Buteamonsoperma seed extract and their influence on the quorum-mediated virulence factors of MDR clinical isolates of P.aeruginosa at sub-MIC were investigated. The results revealed that increasing the concentration of ZnONPs at sub-MIC levels resulted in increased aggregation of nanoparticles within the cells finally causing the death of bacterial cells [79]. The green synthesized ZnO NPs produced from Aristolochia indica were tested for bactericidal activity against MDR Organisms MDR collected from pus samples of Diabetic foot ulcer patients. ZnONPs had exceptional bactericidal action, with a substantial drop in viable count beginning at 2 h. Protein leakage and flow cytometric analyses indicated that ZnONPs caused bacterial cell death. [80] The potential of Caryophyllusaromaticus leaf extract-derived ZnONPs to prevent MDR A.baumannii infection was investigated. The biosynthesized ZnONPs suppressed nearly 90% of MDR A. baumannii infection without causing cytotoxicity. As a

result, biosynthesized ZnONPs were regarded as a robust anti-MDR A. baumannii agent for effective therapy, leading to the growth of numerous practical medical applications in-hospital care [81]. ZnONPs were made using a simple and effective biogenic synthesis method that took use of the reducing and capping capability of Aloe barbadensis Miller leaf extract (ALE). The biosynthesized ALE-ZnONPs from Aloe barbadensis Miller leaf extract showed significant antibacterial efficacy against ESBL positive E. coli, P.aeruginosa, and methicillin resistant S. aureusclinical isolates. ALE-ZnONPs inhibited the bacterial growth kinetics, extracellular polysaccharides, and biofilm formation indicating antibiotic and anti-biofilm potential. The findings revealed that ALE-ZnONPs, might be used as nanoantibiotics or controlled drug delivery [82]. P. *aeruginosa* biomass filtrate obtained from mangrove rhizosphere sediment was employed for the production of ZnONPs. Green-synthesised ZnO-NPs were highly effective against Gramme-positive bacteria (S.*aureus* and B.subtilis), Gramme-negative bacteria (E.coli and P.aeruginosa), and unicellular fungus (Candida albicans).[83] ZnONPs derived from Acacia arabica aqueous leaf extract. The results demonstrated the width of zones of inhibition against food-borne pathogens such as E. coli, S. aureus, and S. enterica. After treatment with sub-inhibitory nanoparticle concentrations, EPS generation was reduced by almost 50.6–65.1 % (wet weight) and 44.6–57.8 % (dry weight) [84]. The green synthesis of ZnONPs utilizing **Origanum vulgare** extract was tested for antibacterial, anti-quorum sensing, and antibiofilm properties against the bioreporter strain of Chromo bacterium violaceum. The finding highlighted the potential uses of ZnO NPs against bacterial interaction, quorum sensing, and biofilm development [85].

The antibacterial activity of produced ZnONPs from Menthapulegium (L.) aqueous extracts against E. coli and S.aureus has been investigated. These findings suggest that ZnONPs have high antibacterial activity.[86]The biological synthesis of NPs utilizing microorganisms appears to be a more ecologically sustainable NPs manufacturing method and has sparked considerable attention since microorganisms are readily cultivated and do not have seasonal or geographical limitations. Furthermore, employing bacteria for the biosynthesis of ZnONPs has considerable benefits since the supernatant contains functional biomolecules that may convert metal ions into metal NPs [87,88]. Furthermore, due to the existence of a functional group on the bacterial cell membrane that converts M^+ into MNPs, the cell biomass of bacteria might work as a nanofactory in the creation of ZnONPs [89,90]. The ZnONPs produced from microalga Arthrospira platens is were tested for their antimicrobial activity against B. subtilis, S.aureus, P.*aeruginosa*, Escherichia coli, and C. *albicans*[91]. A low-cost, unreported, and simple procedure for the biosynthesis of ZnONPs using reproducible bacteria Aeromonashydrophila to examine its antimicrobial activity was investigated. Bacteria-mediated ZnONPs were proved to be a good novel antimicrobial material [92]. Bacterial synthesis of ZnONPs is an eco-friendly, simple, and inexpensive way. The antimicrobial assay by well diffusion method showed a direct relationship of antibacterial activity with the concentration of nanoparticles against E. coli, S.aureus, and Salmonella typhi. Conclusively, bio-transformed ZnONPs have great potential as an alternative to conventional antibiotics and as a drug delivery tool [93]. ZnONPs were effectively produced by Lactobacillus plantarum TA4, and tested for antibacterial activity against major avian pathogens such as Salmonella spp., E. coli, and S.aureus.

According to the findings, ROS-induced oxidative stress produced membrane destruction and bacterial cell demise. ZnONPs have the potential for development as an effective antibiotic in poultry production and have shown new avenues for battling harmful pathogens [94]. When compared to the action of antibiotics in medical care, the combination of antibiotics with nanoparticles is more beneficial for boosting antibiotic effectiveness. The combination results in less bacterial resistance development, shorter treatment duration, and lower antibiotic dosage required [95]. A ZnONPs produced by the E. coli bacteria in combination with the antibiotics showed antibiofilm action against MDR isolates (Ciprofloxacin for Gramme-negative and Tetracycline for Gramme-positive bacteria). These results of biosynthesized ZnONPs combined with antibiotics demonstrated antibacterial and antibiofilm properties against MDR bacteria [96]. Incomparision to their individual effects, the synergistic effects of ZnONPs and streptomycin demonstrated improved effectiveness which is proved by an increased zone of clearance (either ZnONPs or streptomycin). ZnONPs in combination with streptomycin employed as a potential antibacterial agent against MDR pathogens [97]. ZnONPs were synthesized and conjugated with Quercetin, Ceftriaxone, Ampicillin, Naringin, and Amphotericin B antibiotics to test their antibacterial activity against Gramme-positive (Methicillin-resistant S.aureus, Streptococcus pneumoniae, and Streptococcus pyogenes) and Gramme-negative (E. coli K1, Serratiamarcescens and

P.aeruginosa) bacteria. Drug effectiveness against MDR bacteria was dramatically increased when coupled with ZnONPs. Ceftriaxone- and ampicillin-conjugated ZnONPs, in particular, demonstrated strong antibacterial activity. The antibiotic-loaded on ZnONPs provide a viable way to combat increasingly MDR bacterial disease [98]. The ZN-CIP antibiotic-loaded NPs, which were generated by coupling ZnONPs with ciprofloxacin (CIP) under microwave-assisted conditions, demonstrated strong antibacterial activity against clinically derived multidrug-resistant bacterial strains of E. coli, S.aureus, and Klebsiella sp. similar concentrations of antibiotic were incapable of establishing antibacterial activity throughout the examination of MIC values [99]. The synergetic effects of ZnONPs and ciprofloxacin and ceftazidime antibiotics, as well as their modes of action, were studied against MDR A. baumannii strains. The results demonstrated that in the presence of a sub-inhibitory concentration of ZnONPs, the bactericidal activity of both antibiotics was enhanced. The combination of ZnONPs with antibiotics boosted antibiotic absorption and transformed the bacterial cells from rod to cocci forms. Bacterial filamentation was also seen, but no DNA fragmentation was found. The findings proposed that ZnONPs enhance the antibacterial activity of ciprofloxacin and ceftazidime [100]. However, research on antibiotic-metallic NP interactions has been focused primarily on conventional antibiotics. Metallic NP-based platforms have the potential to overcome drug resistance whether used alone or in conjunction with antimicrobial drugs. Understanding the mechanisms of action responsible for NPs' bactericidal characteristics is critical given their tremendous therapeutic potential [101]. Against carbapenem-resistant P. aeruginosa infections, Mohamed El-Telbany et al. demonstrated a dual enhancement of antibacterial and antibiofilm activity via the use of meropenem–ZnONPs combination [102]. Almaary KS, et al. evaluated the biopreparedZnONPs' synergism with fosfomycin and their antibacterial efficacy against the target pathogens using the disk diffusion assay. The possible usage of biogenic ZnONPs in food packaging applications is suggested by their potential antibacterial activity against food pathogens such as Salmonella typhimurium and Escherichia coli [103]. ObaidHasson S. et al.'s production of the ithmid kohl/ZnONPs formulation and its in vivo trial in albino rabbits for the cure of bacterial endophthalmitis was a novel strategy that has shown promise and might work as a workable substitute. The formulation with the largest zone of inhibition, ithmid kohl/ZnONPs, was found to have potential as confirmed by an in vitro antibacterial assay [104]. ZnONPs have also been explored as drug nanocarriers and bioactive agents for targeted drug delivery with reduced side effects and synergistic effects [105]. ZnONPs use is growing and has many beneficial biomedical applications, but long-term toxic effects must be investigated. With the potential for clinical translation, ZnONPs design for biomedical applications has a promising future.

CONCLUSION

As highlighted in this review, the green synthesized AgNPs, AuNPs, CuNPs, and ZnONPs from plant extract and algae showed profound antimicrobial/antibacterial properties. These biologically produced MNPs/MONPs inhibited several pathogenic microorganisms therefore serve as a powerful nanoantibiotic weapon to control infectious diseases. These MNPs/MONPs killed a variety of microbial/bacterial species that had developed high resistance to available drugs. Furthermore, when combined with antibiotics, these MNPs/MONPs demonstrated potent antibacterial/antimicrobial activity against MDR organisms. It is expected that these biogenic NPs will successfully replace the available drugs against which the bacteria have developed resistance. The MNPs/MONPs discussed in this review have the potential to transform clinical care by improving existing therapies or incorporating new therapeutic agents.

Conflict of Interest

There is no conflict of Interest.

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Table.1- Biological activity of green synthesized MNPs/MNOPs against different MDR organism

Types of MNPs/MONPs	Source	Targeted MDR organism	Biological activity	References
AgNPs	lignin-based	S. aureus, S. epidermidis, P. aeruginosa, K. pneumoniae, and A. baumannii.	Antimicrobial and anti-inflammatory activity	[43]
	Ocimumgratissimum leaf extract	E. coli and S. aureus	antimicrobial activity	[44]
	Catharanthusroseus and Azadirachta indica extracts	(MDR) bacteria isolated from septic wound infections	antibacterial activity	[45]
	Galaxaurarugosa crude methanol extract	A. baumannii and S. aureus	Antibacterial activity	[46]
	Curcuma caesia aqueous rhizome extract	K. pneumonia, E.coli, and P. aeruginosa	antibacterial activity	[47]
	Cloves seed extract	S. aureus	antibacterial activity	[48]
AuNPs	aqueous leaf extract of A. herba-alba and M. alba	E. coli and Salmonella spp	antimicrobial activities	[59]
	Jatrophaintegerrima floral extract	E. coli and B. subtilis	antibacterial	[60]
CuNPs	AquousTilia extract	Gram-positive and Gram-negative bacteria.	antimicrobial	[69]
	Hageniaabyssinica leaf extract	E. coli, P. aeruginosa, S. aureus, and B. subtilis	antibacterial	[70]
	Ficussycomorus aqueous fruit extracts	MDR clinical isolates of bacteria.	antibacterial activity	[71]
	Sennadidymobotrya Roots	E. coli and S. aureus	antibacterial activity	[73]
ZnONPs	Calotropisprocera leaf extract	A. baumannii	antibacterial	[78]
	Buteamonsoperma seed extract	P. aeruginosa	antibacterial activity	[79]
	Aristolochia indica leaf aqueous extract	MDR collected from pus samples of Diabetic foot ulcers patients	antibacterial activity	[80]
	Caryophyllusaromaticus leaf extract	A. baumannii	antimicrobial activity	[81]

	Aloe barbadensis Miller leaf extract	E. coli, P. aeruginosa, and S. aureus	antibacterial activity	[82]
	Pseudomonas aeruginosa biomass filtrate obtained from mangrove rhizosphere sediment	S. aureus, B, subtilis, E.coli and P.aeruginosa .	antibacterial, anti-candida, and larvicidal activity	[83]
	Acacia arabica aqueous leaf extract	E. coli, S. aureus, and S. enteric	Antibiofilm activity	[84]
	Origanumvulgareleaf extract	C.violaceum	antibacterial, antiquorum sensing, and antibiofilm activity	[85]
	Menthapulegium aqueous extracts	E. coli and S. aureus	antibacterial activity	[86]
	microalga Arthrospiraplatensis	B. subtilis, S. aureus, P. aeruginosa,E coli.	Antimicrobial Activity	[91]
	reproducible bacteria Aeromonashydrophila	P. aeruginosa and Aspergillusflavus	antimicrobial activity	[92]
	Lactobacillus plantarum TA4	Salmonella spp., E. coli, and S. aureus.	Antibacterial activity	[94]

Table.2- Synergetic effect of MNPs/MONPs in combination with different antibiotics against different MDR organism.

Types of MNPs	Antibiotics Used	Targeted MDR organism	Biological Activity	Reference
AgNPs	Tetracycline	S. aureus	antibacterial activity	[48]
	Ampicillin	E. coli and S. aureus cells	antibacterial activity	[50]
	Vancomycin	S. aureus, P.aeruginosa, and S.pneumonia	antibacterial and antibiofilm activity	[51]
	Gentamycin	S.aureas, K. pneumonia, P.aeruginosa, and A.baumanni	Antibacterial activity	[52]
AuNPs	ciprofloxacin, gentamycin, rifampicin, and vancomycin,	S. epidermidis and S.haemolyticus	antibacterial and antibiofilm activity	[57]
	Rifampicin	S. marcescens	antibiofilm activity	[61]
CuNPs	erythromycin, azithromycin, and norfloxacin.	Klebsiella and Pseudomonas.	antibacterial activity	[74]
	Tetracycline Rifampicin Chloramphenicol Vancomycin Gentamycin Streptomycin Kanamycin Tobramycin Penicillin Ampicillin	E. coli, P. aeruginosa, Bacillus cereus, S. aureus.	antibacterial activity	[75]
ZnONPs	Ciprofloxacin and Tetracycline	P.aeroginosa, E.coli, K.pneumoniae and A.baumannii	antibacterial and	[96]

			antibiofilm activity	
	Streptomycin	S. aureus, S.pyogenes, B. cereus, P. aeruginosa, Proteus mirabilis ,E. coli	antibacterial activity	[97]
	Quercetin, Ceftriaxone, Ampicillin, Naringin, and Amphotericin B	Gram-positive (S. aureus, S. pneumoniae, and S. pyogenes) and Gram-negative (E. coli , Serratiamarcescens and P. aeruginosa) bacteria	antibacterial activity	[98]
	ciprofloxacin	E. coli, S. aureus, and Klebsiella sp.	antibacterial activity	[99]
	ciprofloxacin and ceftazidime	A. baumannii strains.	antibacterial activity	[100]

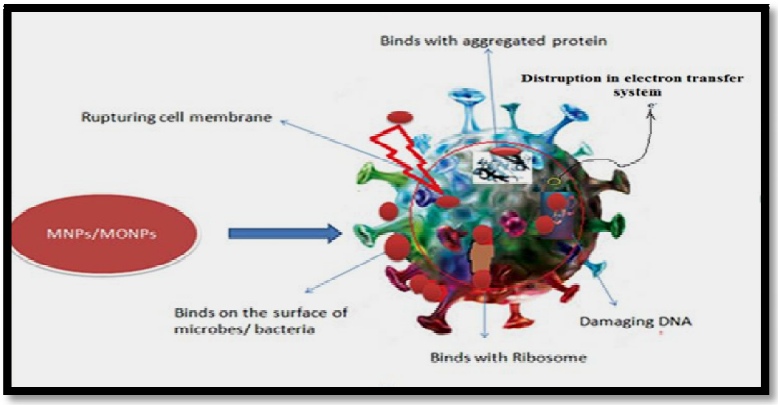


Figure-1: Antibacterial/ Antimicrobial mechanism of MNPs

REVIEW ARTICLE

The Role of Sweet Basil (*Ocimum basilicum*) in Management of Type II Diabetes Mellitus : A Review from Animal Studies and Clinical Trials

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ABSTRACT

Sweet Basil has therapeutic potential in treating Type II Diabetes, a condition marked by poor glucose metabolism and insulin resistance. Its abundance of bioactive components like flavonoids and phenolic acids has contributed to its health-promoting qualities. Interest in how it affects glucose regulation and metabolic health has resulted in this review. This review examines animal studies and clinical trials from the past 20 years referring to about fifty articles from Google Scholar, Scopus and PubMed. The subjects were divided into control and intervention groups, with primary and secondary outcomes focusing on insulin sensitivity, fasting blood glucose levels, lipid profiles, weight and metabolic markers. The studies evaluated the effects of sweet basil extract on glycemic control with trials obtained ethical approval. Sweet Basil shows hypoglycemic properties by reducing and enhancing insulin sensitivity, likely by improving glucose absorption and insulin signaling. Though there are only a few clinical trials, animal studies suggest that sweet basil supplements can be a safe option for diabetic treatment with minimal side effects. This review emphasizes sweet basil's potential as a strategy for managing Type II Diabetes and brings out the need for larger clinical trials and optimal dosage to completely understand and optimize its therapeutic benefits.

Keywords: Insulin Resistance, Sweet Basil Supplement, Therapeutic Potential, Glucose Regulation Hypoglycemic Properties, Insulin Sensitivity, Glycaemic Control, Diabetic Treatment, Type II Diabetes Management.

INTRODUCTION

Type II Diabetes, a chronic metabolic disease is characterized by elevated blood glucose levels because of insulin resistance or inadequate insulin synthesis. Millions of people worldwide are impacted by this illness, which has emerged as a global health concern [1]. There has been a rise in interest in finding natural treatments for Type II Diabetes as the condition becomes more common. Sweet basil (Ocimum basilicum), which is used in many different cuisines, has gained attention as a possible option due to its many pharmacological qualities, which include hypoglycemic, anti-inflammatory, and antioxidant benefits [2]. This article explores the possible therapeutic benefits of sweet basil in the treatment of Type II Diabetes, combining data from clinical trials and animal research. This review examines the effects of Ocimum basilicum on lipid profiles, insulin sensitivity, and blood glucose levels besides discussing the processes underlying these effects. The article will also evaluate the available data from clinical studies and emphasise the need for more studies to validate sweet basil as a complementary medicine for diabetes.

METHODOLOGY

This review examines the effects of sweet basil on glycemic control, analyzing animal studies and clinical trials published within the past 20 years. The review will adhere to a systematic approach to ensure comprehensive and unbiased results. The selection of the articles for this review is systematically shown in figure 1.

LITERATURE SEARCH

Databases

A comprehensive literature search will be conducted using electronic databases including Google Scholar, Scopus, and PubMed.

Search Terms

The search strategy will employ a combination of related to sweet basil and glycemic control. Examples include: "sweet basil," "*Ocimum basilicum*," "basil extract," "glycemic control," "insulin sensitivity," "fasting blood glucose," "lipid profile," "diabetes mellitus," "metabolic syndrome," "blood glucose," "HbA1c." The search will also include terms related to animal studies (e.g., "animal model," "rat," "mouse") and clinical trials (e.g., "randomized controlled trial," "clinical study," "human").

Inclusion Criteria

Publication date within the last 20 years (2004 - Present),Studies investigating the effects of sweet basil extract (any form) on glycemic control, Studies involving animal models (in vivo) or human participants (clinical trials), Studies reporting relevant outcomes, including insulin sensitivity, fasting blood glucose levels, lipid profiles (e.g., cholesterol, triglycerides, HDL, LDL), weight, and other metabolic markers (e.g., HbA1c, HOMA-IR), Studies published in peer-reviewed journals or reputable conference proceedings. Grey literature (e.g., unpublished reports, dissertations) may be considered if deemed relevant and rigorously conducted, Studies published in English (with translation considered if resources allow for key non-English language studies).

Exclusion Criteria

Studies not directly related to sweet basil extract and glycemic control, In vitro studies (unless they provide essential context for in vivo findings), Studies using basil in combination with other herbs or interventions where the specific effect of basil cannot be isolated. Studies lacking clear methodology or reporting of results, Duplicate publications.

Data Extraction

A standardized data extraction form will be used to collect relevant information from included studies. Extracted data will include:

1. Study characteristics (author, year, study design, sample size, animal model or participant characteristics).
2. Intervention details (type of basil extract, dosage, duration, administration method).
3. Control group details (type of control, interventions).
4. Outcome measures (insulin sensitivity, fasting blood glucose, lipid profile, weight, metabolic markers).
5. Key findings and statistical significance.
6. Ethical approval information (where applicable).

Ethical Considerations

This review will only utilize publicly available data from published studies. Therefore, no new primary data will be collected, and ethical approval for this review is not required. However, the review will acknowledge the importance of ethical conduct in the original studies included.

REVIEW AND DISCUSSION

Sweet Basil *(Ocimum basilicum)*: A Medicinal Herb

Sweet Basil *(Ocimum basilicum)*is a member of the Lamiaceae family and is widely used in all cuisines all around the world owing to its distinct flavor and aromaticleaves. Sweet basil has long been used in traditional medicine to treat a range of illnesses, such as respiratory problems, inflammatory conditions, and digestive disorders [3]. Several bioactive chemicals that contribute to sweet basil's therapeutic benefits have been identified by modern scientific research. These consist of essential oils, phenolic acids, and flavonoids, each of which contributes to the medicinal properties of the plant [4]. For instance, phenolic acids like rosmarinic acid and flavonoids like luteolin and apigenin have shown strong anti-inflammatory and antioxidant properties [5]. There is also evidence for antibacterial and anti-inflammatory properties of essential oils, such as linalool and eugenol [6][7]. The ability of sweet basil to regulate blood glucose levels is particularly intriguing, as it has gained attention for its possible implications in the management of Type II Diabetes. Compounds in sweet basil have been demonstrated in preclinical research to have a favourable impact on glucose metabolism and insulin sensitivity. For example, research investigations have shown that sweet basil extract can enhance glucose tolerance in diabetic animal models and lower fasting blood glucose levels [8]. Furthermore, research has shown that the active ingredients in sweet basil can improve insulin production and reduce insulin resistance [9]. In the context of these results, sweet basil has begun to exhibit potential as a subject for more study in the treatment of diabetes. However, more clinical trials are necessary to validate these benefits in human populations and provide actionable suggestions for their application in diabetes management, even though preclinical research offers insightful information [10].

Action of Bioactive compounds in Sweet Basil *(Ocimum basilicum)*

Sweet Basil *(Ocimum basilicum)* is a good source of numerous bioactive compounds with medicinal properties. Many of these compounds have antidiabetic, antioxidant, and anti-inflammatory properties. These compounds include essential oils, flavonoids, polyphenols, terpenoids, and other phytochemicals. Some significant bioactive compounds in sweet basil and its potential mechanism of action for controlling Type II Diabetes are explained below.

Eugenol

One of the most prevalent essential oils in sweet basil is eugenol, which gives the plant its distinct flavour and fragrance. It exhibits significant biological properties, including as antibacterial, anti-inflammatory, and antioxidant properties [11][12]. It is a strong free radical scavenger that aids in neutralising reactive oxygen species (ROS), which cause oxidative damage to pancreatic β-cells, a major factor in the pathogenesis of diabetes [13]. Eugenol can help maintain insulin-producing β-cells and enhance glucose homeostasis by reducing oxidative stress [14]. Insulin resistance in Type II Diabetes is mostly driven by persistent low-grade inflammation. Insulin signalling is known to

be hampered by pro-inflammatory cytokines such as TNF-α, IL-6, and IL-1β, which eugenol has been demonstrated to suppress. This reduction in inflammatory markers facilitates improvement in insulin sensitivity and glucose uptake in the tissues [15].

Flavonoids (Orientin and Vicenin)

Sweet basil leaves are rich in flavonoids, particularly orientin and vicenin. Strong antioxidant qualities are exhibited by these components, which help sweet basil in lowering oxidative stress [3]. Flavonoids scavenge free radicals, protecting cells from oxidative damage. This function is particularly crucial in the case of Type II Diabetes since high levels of oxidative stress can result in insulin resistance and β-cell malfunction [16]. Basil contains flavonoids that support improved insulin secretion by preserving the integrity and functionality of β-cells. It has been shown that flavonoids increase peripheral tissue glucose absorption, thereby increasing insulin sensitivity. They could impact insulin receptor signalling pathways, enhancing insulin's effectiveness in tissues such as muscle and adipose [17]. The flavonoids included in basil extract have the potential to block the α-glucosidase enzyme through hydroxylation bonds, and they also contain powerful inhibitory chemicals that work against the α-amylase enzyme, which breaks down carbs. Because of this enzyme's inhibitory action, the breakdown and absorption of carbs are hampered, potentially lowering blood sugar levels [18].

Polyphenols (Rosmarinic Acid and Caffeic Acid)

Another group of bioactive compounds found in *Ocimum basilicum* are polyphenols, among which rosmarinic and caffeic acids are particularly important. Strong antioxidant and anti-inflammatory properties of the plant are facilitated by these polyphenols [19]. With its potent antioxidant qualities, rosmarinic acid scavenges free radicals and shields cells from oxidative damage. When it comes to diabetes, this substance aids in preventing the degeneration of the β-cells of the pancreas, which produce insulin. Additionally, rosmarinic acid reduces inflammation by preventing the expression of pro-inflammatory enzymessuch as cyclooxygenase (COX) [20]. It has been shown to improve insulin sensitivity and aid in the reduction of oxidative damage. Moreover, caffeine has been associated with enhanced lipid metabolism, indicating that people with Type II Diabetes can benefit from its use in controlling both their blood sugar and lipid profiles [21]. The pancreatic α-amylase and intestinal α-glucosidase inhibitory effects were evaluated to explore the in vitro antidiabetic actions of O. basilicum methanol extract and caffeic acid. In a dose-dependent way, α-amylase and α-glucosidase were inhibited by O. basilicum methanol extract and one of the main constituents, caffeic acid [22].

Linalool

Linalool is another important essential oil present in sweet basil. It is widely recognized for having relaxing and anti-inflammatory properties that can reduce the systemic inflammation that is frequently experienced by the diabetic population [23]. Like eugenol, it has been discovered that linalool inhibits the expression of pro-inflammatory cytokines. Linalool helps control insulin resistance because it reduces inflammation, which enhances insulin signalling and glucose utilization [24]. In addition to its anti-inflammatory characteristics, linalool also has antioxidant qualities, which reduce oxidative stress on pancreatic cells and tissues associated with glucose metabolism [25].

Tannins

Sweet basil contains a class of polyphenolic chemicals called tannins, which give the herb its astringent and anti-oxidant properties. Research has shown that tannins have anti-diabetic properties, especially through regulating the digestion and absorption of carbohydrates [26]. Enzymes involved in the digestion of carbohydrates, such α-glucosidase, may be inhibited by the tannins found in sweet basil which slows the conversion of complex carbs to glucose and reduces blood glucose spikes that occur after meals (postprandial) [27]. Additionally, tannins increase glucose tolerance by modifying the absorption of glucose in the gastrointestinal tract, which can assist diabetics in controlling their blood sugar levels [28].

Terpenoids

Sweet basil contains terpenoids, recognised for their diverse pharmacological properties and include cineole and camphor [29]. The metabolism of glucose may be impacted by these substances both directly and indirectly. According to research, terpenoids reduce blood sugar levels by increasing insulin sensitivity in peripheral tissues and enhanceglucose absorption in muscles and adipocytes by stimulating glucose transporter proteins like GLUT4 [30][31]. Like other bioactive components of basil, terpenoids also help to lower inflammation, which may contribute to improved glucose and insulin sensitivity [32].

Animal Studies Supporting Sweet Bail in Treatment of Type II Diabetes Mellitus

Understanding the hypoglycemic effects of sweet basil has been greatly aided by research conducted on animals. Studies carried out on animal models of diabetes have indicated that *Ocimum basilicum* extracts can notably lower blood glucose levels, increase insulin production, and promote lipid metabolism.

Antihyperglycemic Effects

The anti-diabetic properties of O. basilicum aerial component extract are possibly due to the inhibition of enzymes that metabolize carbohydrates, which limits the absorption of glucose, and increased hepatic glucose mobilisation [33]. It was demonstrated that administering basil leaf extract to hyperglycaemic diabetic rats lowered blood glucose levels in every group that received the extract.[34]. When streptozotocin was used to develop gestational diabetes mellitus in female rats, the average blood glucose levels in the basil extract group decreased [35]. With little adverse effects, an extract from *Ocimum basilicum* may block the α-glucosidase and α-amylase enzymes. α-glucosidase and α-amylase dietary inhibitors have been shown to regulate reduced glucose absorption in hyperglycemia [18]. The components of O. basilicum leaves could possess antihyperglycemic effects in alloxan-diabetic mice, lowering blood glucose levels only in diabetic conditions—not in normoglycemic ones. The synergistic actions of the leaf components may be largely responsible for the antihyperglycemic action [36].This meta-analysis showed that basil leaf extract effectively lowered blood glucose in diabetes-induced animal models. Further exploration of its active constituents and efficacy in human subjects is needed to confirm its potency as a promising antidiabetic phytotherapy.

Improvement in insulin sensitivity

Every component of the sweet basil plant shows an improvement in insulin sensitivity. Dietary fibre found in basil seeds helps to regulate blood sugar levels. Due to their ability to regulate blood sugar levels, they are thought to be beneficial for those with type II diabetes. They regulate the body's metabolism, which lowers the pace at which glucose is produced from carbs. Insulin sensitivity can be enhanced throughout the day by drinking a glass of water infused with basil seeds in the morning [37][38]. By decreasing insulin resistance and enhancing the performance of pancreatic β-cells, *Ocimum basilicum* extract increased insulin sensitivity. Insulin sensitivity and glucose levels were significantly improved in streptozotocin-induced diabetic mice by the antidiabetic action of *Ocimum basilicum* extracts [39].

Antioxidant and Anti-inflammatory Effects

The basil aqueous extract provided advantageous effects in managing diabetes through its antioxidant properties and potential to inhibit α-glucosidase and α-amylase, [18].Basil essential oil and basil aqueous extract were found to have antioxidant activity that shielded pancreatic b-cells from damage, lowering blood sugar in diabetic rats to a certain extent and exhibiting some antidiabetic properties [39]. The antioxidant effects of basil extracts were demonstrated in diabetic rats by their ability to reverse increased glucose and insulin levels, restore redox status, and prevent oxidative damage to the liver and kidney. Additionally, it reduces tissue apoptosis and inflammation -[40] [41].When diabetic rats were provided with basil extracts, there was a reduction in pro-inflammatory cytokines (TNF-α and IL-6), which was linked to improved insulin sensitivity and reduced inflammation [42].

Lipid Profile and Cardiovascular Benefits

In diabetic rats, *Ocimum basilicum* extracts increased high-density lipoprotein (HDL) cholesterol and decreased serum triglycerides, total cholesterol, and low-density lipoprotein (LDL) cholesterol, suggesting a potential benefit in

managing diabetes-associated dyslipidemia. [43]. A component of sweet basil powder was found to improve lipid metabolism, particularly the action of SREBP1-c, which in turn reduced liver enlargement. This resulted in a suppression of body-weight gain caused by the consumption of a high-fat and high-sucrose diet for 12 weeks.
Additionally, it was proposed that consuming sweet basil powder reduced inflammation in mice's perirenal fat by reducing MCP-1 mRNA expression in that fat [44]. *Ocimum basilicum* showed promise for comprehensive diabetes treatment by lowering cardiovascular risk factors and improving lipid profiles in diabetic mice [45]. In conclusion, the aqueous extract of *Ocimum basilicum* demonstrates strong anti-hyperglycaemic and long term cholesterol and triglycerides-reducing effect in streptozotocin diabetic rats irrespective of insulin secretion. These outcomes validate its traditional application in the management of cardiovascular disease and diabetes [46].

Evidence from Clinical Trials Supporting Sweet Bail in Treatment of Type II Diabetes Mellitus

Clinical trials are necessary to confirm the efficacy of sweet basil *(Ocimum basilicum)* in human populations, even though animal studies have given important insights into the plant's potential health benefits. The effects of sweet basil on lipid profiles, insulin sensitivity, and blood glucose management in people with Type II Diabetes have been the subject of several small-scale clinical investigations. However, no strong evidence is supporting clinical trials including sweet basil (Ocimum basilicum) as a comphrehensive treatment in Type II Diabetes. Therefore more clinical trials are required to study the effects of sweet basil in glucose metabolism, insulin sensitivity, blood glucose control and diabetes management.

CONCLUSION

While there is promising evidence from animal studies, more investigation is required to completely understand the potential of sweet basil in the management of Type II Diabetes. To ensure that it is safe and effective enough for general usage, extensive, long-term clinical trials are required. In the near run, chronic oral dosing might not increase the risk of hepatotoxicity. To assess the effects of long-term extract administration in diabetes, more research is necessary [33]. Furthermore, more research should be done to determine the optimal supplementation dosage, formulation of sweet basil and duration for the treatment of diabetes. To sum up, sweet basil *(Ocimum basilicum)*can be a significant natural therapeutic agent for Type II Diabetes management. With its potential to improve lipid profiles, increase insulin sensitivity, and control blood glucose levels, it can be a promising subject for further research. However, Sweet basil should be considered as a supplemental rather than a stand-alone medication for the management of diabetes until more solid clinical data is available.

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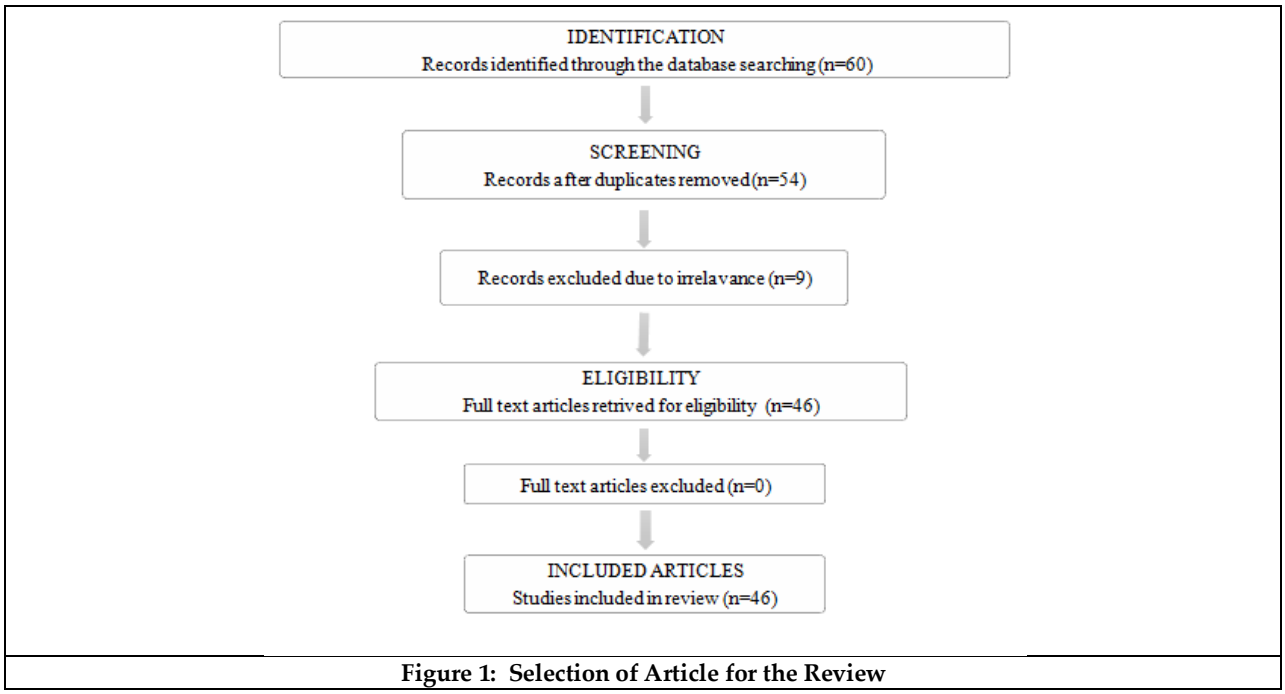


Figure 1: Selection of Article for the Review

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RESEARCH ARTICLE

The Impact of Mathematics - Enhanced Van Hiele Model (VHM) Learning Activities based on Experience – Language – Pictorial – Symbolic - Application [ELPSA] Framework on Spatial Reasoning of Students Engagement in Mathematics at Elementary Level

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ABSTRACT

Spatial reasoning plays a crucial role in understanding geometry and measurement in math education. The ELPSA framework builds upon the Van Hiele model and incorporates different learning modes: experience, language, pictorial, symbolic, and application-based. Mathematics-Enhanced Van Hiele Model (VHM) Learning Activities Based on the ELPSA framework, these activities provide students various opportunities to develop their spatial reasoning skills. These activities may involve hands-on exploration of geometric concepts, using language to describe shapes and their properties, creating and interpreting pictorial representations of geometric objects, using symbols to represent geometric concepts, and applying geometric ideas to real-world problems. The research, conducted with the thirty-two elementary level students of class-VIIIth of Rameshwar Middle School, Salempur, Tekari, Gaya, was sampled for the study using a One group Pretest-Posttest experimental design. The research results, backed by robust data and analysis, can have significant implications for mathematics education at the elementary level. The study found that the Mathematics-Enhanced Van Hiele Model (VHM) learning activities, based on the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework, had a remarkably positive impact on enhancing the spatial reasoning ability of elementary-level learners in mathematics. The study observed significant differences in the pretest scores between low and high-achieving learners. Still, non-significant differences were found in both groups after the intervention, i.e., after the posttest. Similarly, the study found a significant difference in the pretest scores between boys and girls. The study found that non-significant differences were observed in both groups after the

intervention, i.e., after the posttest. Overall, the ELPSA framework offers a promising approach to teaching spatial reasoning and geometry in mathematics. By merging the Van Hiele Model with learning principles, educators can design practical learning activities that engage students and foster their geometric thinking skills. The comprehensive nature of the ELPSA framework instills confidence in its potential to impact mathematics education significantly. If integrated into the curriculum as a standard teaching method, it could provide a more engaging and effective way for students of all backgrounds and abilities to learn mathematics. This prospect should excite policymakers in the field.

Keywords: Spatial reasoning, Mathematics-Enhanced Van Hiele Model (VHM) Learning Activities, Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework

INTRODUCTION

Spatial reasoning skills are closely associated with success in Science, Technology, Engineering and Mathematics (STEM) fields, both in terms of educational outcomes and career achievements. (Kell, Lubinski, Benbow, & Steiger, 2013; & Nath & Szucs, 2014). Throughout history, schools have consistently prioritized the teaching of core subjects, including social science, mathematics, english and science. According to Uttal et al. (2013), the development of spatial thinking is highly significant, and it is necessary for students to receive spatial skill intervention at an early stage to improve their spatial abilities. This will prevent them from feeling overwhelmed by STEM content knowledge in their later years of education. The study of spatial reasoning is gaining significant attention these days, which is unsurprising given its close relationship with Science, Technology, Engineering, and Mathematics (STEM). Spatial thinking involves understanding three important properties that are related to space. The first is an awareness of space, which includes factors like distance and dimensions. The second is the representation of spatial information, whether it is mentally or graphically in diagrams and maps. And finally, there is the reasoning involved in interpreting this spatial information and making decisions. Effective teaching of spatial reasoning in an instructional environment necessitates addressing and fostering all three elements, with a focus on the cognitive processes themselves (DeSutter & Stieff's, 2017).

Components of Spatial Reasoning Skill

According to Ramful, Lowrie, and Logan (2017) spatial reasoning have three major components namely mental rotation, spatial orientation, and spatial visualization based on the national school curriculum standards to determine the effectiveness and its potential benefits for those who participate in it.

Mental Rotation

Mental rotation is a vital component of spatial cognition. It entails the capacity to mentally visualize an object spinning, as (Shepard & Metzler, 1971) described, and is categorised as an intrinsic-dynamic spatial ability in Uttal et al.'s (2013) taxonomy. The phenomenon of mental rotation has been thoroughly researched, mainly because of its importance in practical areas like mathematics performance (Mix et al., 2016).

Spatial Orientation

Spatial orientation is a crucial skill that humans have from birth. It involves understanding and operating on relationships between different positions in space, including our position and movement through it. Over time, this skill develops to include using maps and coordinates at various scales. Gelman and Williams (1997) consider spatial orientation a core skill that includes seeking out and interpreting relevant information actively, even when it is ambiguous. This ability is essential for navigating from one location to another, identifying objects in motion, estimating quantities, comprehending drawings and charts, and creating various items (Patkin & Dayan, 2013).Interestingly, spatial orientation has been recognized as an essential skill for students to improve their

performance in mathematics, geography, and other science subjects. Different countries have varying approaches to teaching spatial orientation, as seen in their curricular documents (Diezmann and Lowrie, 2009).

Spatial Visualization

Spatial visualization is defined as the ability to mentally manipulate the visuospatial properties of an object, separate from the rotation of the object or varying one's perspective. For example, visualizing a cube from its net or predicting a pattern on a piece of paper that has been unfolded. Mix et al. (2016) found that traditional tests of spatial visualization were strong predictors of mathematics performance across three grade levels. Spatial visualization involves mentally manipulating internal components of spatial arrangements, often involving intricate, multi-step actions (Ramful et al., 2017). One example of this is converting two-dimensional (2D) shape depictions into three-dimensional (3D) object depictions, also known as mental folding or 3D mental folding (Chen & Yang, 2023; Harris et al., 2013). Spatial skill measures in the literature include the Differential Aptitude Test (DAT), the Space Relations Subset (Bennett et al., 1947), and the Surface Development Test (Ekstrom et al., 1976). These tests require test takers to visualize a 2D shape on a flat surface that can be transformed into a 3D solid figure through folding. Decisions on the relationships between the corners and edges of the folded object are frequently necessary.

Conceptual underpinnings of the Study

According to various studies, including those conducted by Van Hiele, Abdullah & Zakaria (2013) it has been observed that students often face difficulties in learning geometry shapes that need spatial reasoning abilities to understand. However, some Western countries and a few African nations have successfully implemented the Van Hiele's Model of learning in geometry to improve the performance of their students in this subject. This model has not only helped students but has also provided valuable insights to curriculum developers and teachers about the significance of geometric tests. As a matter of fact, the model was able to provide valuable insights to curriculum developers and educators about the significance of incorporating geometric tests into their teaching. According to the theory, there are five sequential levels that students must go through in order to truly grasp the intricate systems of relationships between various geometric concepts. These five levels have been used to create the Van Hiele Instructional Procedure (VHIP), which serves as a framework for guiding students towards a deeper understanding of geometry. According to Vojkuvkova (2012), the Van Hieles initially designated numbers 0 through 4 for their levels of geometric thought. However, the USA later introduced a numbering system ranging from 1 to 5. It is important to note that the labeling of levels has evolved over time, even though Pierre Van Hiele's work only comprised of 3 levels.

These five levels are as follows

- Level 0 (visualization). Learners are able to recognize geometric shapes based on appearance rather than their properties.
- Level 1 (descriptive/analytical). Learners are able to recognize characteristics of shapes and learn to use appropriate vocabulary related to these characteristics.
- Level 2 (abstract/rational). Learners can identify relationships between and among properties of shapes or classes of shapes. Also, they are able to follow logical arguments using such properties.
- Level 3 (deduction). Learners are able to construct geometric proofs using postulates or axioms and definitions. A student can take a high school geometry course at this level
- Level 4 (rigor). This is the highest level in the model. Students are able to work in distinct geometric systems.

The items for the current study will be develope based on Van Hiele's by keeping the mind of ELPSA framework. The ELPSA framework is based on ideas about learning that emphasize the active role of students in constructing their own knowledge. Learning is seen as a social process, where students engage with their peers and use their individual differences to develop their understanding. The framework prioritizes the components of Experience, Language, Pictorial representations, Symbolic manipulation, and Application (Lowrie & Patahuddin, 2015). These components, when implemented effectively by teachers, can help students develop the necessary skills for success in the real world. The mathematics-enhanced Van Hiele model learning activities on based on experience-Language-Pictorial-Symbolic-Application [ELPSA] framework will be developed based on well-established sociological and

psychological theories of learning. We will relied on the Experience-Language-Pictorial-Symbolic-Application (ELPSA) learning framework outlined by Lowrie and Patahuddin (2015) to design spatial reasoning lessons. Our goal is to explain how students develop an understanding of concepts related to spatial reasoning. The ELPSA framework emphasizes that learning is an active process where individuals construct knowledge through scaffolded activities and social interactions. According to Lowrie and Patahuddin, (2015) each step of the framework is essential to establish sense-making, and the sequence of activities provides a logical structure for reinforcing and applying knowledge and concepts. Effective learning requires teachers to prioritize five key components. Firstly, assessing students' current knowledge and identifying areas for improvement is crucial. Secondly, it is important to teach students the appropriate language to communicate their understanding of new concepts and encourage them to use this language in their own work to solidify their understanding. Thirdly, using visual representations to convey ideas and concepts is a powerful tool that can be created by either the teacher or the students themselves. Fourthly, formalizing ideas and concepts through symbolic manipulation helps students analyze and understand information more effectively(Burte, Gardony, Hutton, & Taylor, 2017). Lastly, it is essential to help students apply their knowledge to new situations for real-world application. By focusing on these five components, teachers can ensure their students are fully equipped with the skills needed for success(DeSutter&Stieff,2017).

Need and Significance of the Study

Spatial reasoning skills are strongly linked to success in Science, Technology, Engineering, and Mathematics (STEM) fields, both in terms of educational outcomes and career achievements (Kell et al., 2013; Nath & Szucs, 2014). Therefore, students must develop their spatial abilities early through proper training, as it will prevent them from feeling overwhelmed by STEM content in their later years of education (Uttal et al., 2013).Spatial thinking involves understanding three essential properties related to space: an awareness of space, representation of spatial information, and cognitive processes (DeSutter & Stieff, 2017). Visualization and representation are vital skills that should be developed separately from the mathematics curriculum. Yi et al. (2020) revealed that van Hiele's theory-based instruction effectively improved participants' geometry knowledge, including knowledge of geometry instructional activities, geometry content knowledge, and students' van Hiele levels. Yalley et al. (2021) also found that the Van Hiele instructional model improved students' performance in Circle Geometry at Daffiama Senior High School in Ghana. Dahlan and Suryadi (2017) found that students' mathematical spatial visualization ability increased significantly when they received proper training, highlighting the potential of students to excel in STEM fields when their spatial reasoning skills are effectively developed. Spatial sense is a crucial skill that students can develop through various teaching methods and experiences. When children manipulate, rotate, visualize, and transform objects in space, they acquire a deeper understanding of shapes and their properties, which enhances their spatial sense (NCTM, 1989). Therefore, engaging in mathematical activities, games, and puzzles can help children make connections and enhance their understanding. Pointey et al. (2017) state that spatial reasoning has always been crucial for human actions and thoughts but needs to be adequately supported in formal education. Therefore, this paper explores methods for improving mathematics students' spatial reasoning ability, emphasizing the importance of abstraction in mathematics and the progression from concrete to abstract in the primary mathematics curriculum.

OBJECTIVES OF THE STUDY

1. To study the impact of mathematics-enhanced Van Hiele Model (VHM) learning activities based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] framework on spatial reasoning of students' engagement in mathematics at elementary Level.
2. To compare impact of mathematics-enhanced Van Hiele Model (VHM) learning activities based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] framework through on spatial reasoning of students' engagement in mathematics at elementary level with respect to (i) learners (among high and low achievers) (ii) Gender (boys and girls).

Hypotheses of the Study

1. Impact of Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on experience-Language-Pictorial-Symbolic-Application [ELPSA] framework significantly enhances the spatial reasoning ability of elementary level learners in mathematics.
2. There is no significant difference in spatial reasoning ability of students concerning level with respect to (i) learners (among high and low achievers) (ii) Gender (boys and girls) teaching through Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] framework.

RESEARCH METHODOLOGY

The study, titled "Mathematics-Enhanced Van Hiele Model (VHM) Learning Activities Based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] Framework affects students' spatial reasoning ability," is experimental research with a "one-group pretest-posttest design." In this study, students are assigned to equivalent groups, where the independent variable is the 'activity-based learning strategy,' and the dependent variable is the 'spatial reasoning ability in mathematics.' The pretest-posttest group design determines the change in spatial reasoning ability in mathematics by computing the difference between pretest and post-test scores. The first group of students was given a spatial reasoning test to assess their understanding of geometrical objects and figures (pretest). After the pretest, this group received 30 days of treatment in a regular class setting. The activities were based on the Mathematics-Enhanced Van Hiele Model (VHM), which focused on experience, language, pictorial, symbolic, and application-based learning. Students and teachers engaged in various activities to help them better understand the shape, size, and implications of geometrical objects in the real world. After 30 days of treatment, the same spatial reasoning test was given to the students (posttest) to evaluate the effectiveness of the treatment.

Population of the Study

The population of study was elementary school students of Gaya district of the south region of Bihar state.

Sample of the Study

The sample consists of students of Rameshwar Middle School, Salempur, Tekari, in the Gaya, district of the south region of Bihar state. The school was chosen because students from different kinds of cultures and backgrounds made up the sample of the school. The thirty-twoelementary level students of class-VIIIth of Rameshwar Middle School, Salempur, Tekari, Gayawas sampled for thestudy because students at this level are assumed to have acquired the requisite knowledge to deal with spatial reasoning items of the test.

Tool used

Self-developed spatial reasoning tool based on Van Hiele Model (VHM) learning activities on Experience-Language-Pictorial-Symbolic-Application [ELPSA] framework was used to conduct the study. The tool has two sections: A and B. Section A collects demographic information, while Section B includes 15 items with four options to collect participants' responses. This tool was developed and verified using an appropriate validation approach. In the initial stage, the researcher developed 35 items Ten experts in the field of mathematics subject, two in education and two in language experts, thoroughly reviewed and evaluated all the items. Following analysis and evaluation, 20 items with multicollinearity and singularity were disregarded, and 15 items were taken into consideration for the final tool items. Before administration, a bilingual (Hindi and English) version of the tool was prepared. The tool didn't have a set time limit for how long it could be used. However, it would typically take a respondent 25 to 35 minutes to complete it. Each item has four possible responses, as per the nature of questions. Cronbach's alpha is used to evaluate the reliability of a spatial reasoning tool. In this study, the tool's internal consistency was analyzed, and its reliability coefficient of 0.89 indicated high reliability.

Procedure Used for Data Collection

Both pretest and posttest were conducted at Rameshwar Middle School in Salempur, Tekari, Gaya, Bihar. The study was carried out over three months, with a thirty-day intervention for the group of sample students. The researcher maintained a friendly and positive atmosphere during the intervention, pretest, and posttest. The data were analyzed after both the pretest and posttest, leading to a conclusion.

Procedure forAnalysing and Interpreting Data

The researcher utilized the quantitative method for data analysis and employed various statistical techniques, including graphical representation, 't' test, and ANCOVA (Analysis of CO-Variance).

Descriptive Statistics of Pretest

Descriptive statistics for the pre-test are provided in table 2, containing the detailed results. The descriptive data of the students' scores of pretest is shown in table 2. The Statistical Package for Social Science (SPSS-20) was used to analyze the variables used in this research study. The sample's minimum (Min), maximum (Max), of students scores were 6.30, 12.32 respectively. The mean of pre-test of group is 9.3.049, The median of pre-test of group is 9.055, and variance is 2.040. The Standard Deviation of pre-test of group is 1.428. So, it indicates that the scores have low variability. The skewness of pre-test of group is -038 which means the pre-test scores group is negatively skewed. The kurtosis of pre-test of group is found to -0.487, so it indicates that group vary slightly from the normality. Can (2017) asserted that if the skewness and kurtosis values are between +1.96 and -1.96, this indicates a normal distribution. Therefore, the obtained data suggests that it is normally distributed. As data does show the Gaussian distribution, the best alternatives for parametric statistic are t-test and ANCOVA.

Normality and Homogeneity Test of Students' Score on Pretest

The researcher tested the normality and homogeneity of the student's scores on the pretest. The normality of the sample scores was tested using the Kolmogorov-Smirnov test, and homogeneity was tested using Levene's test, as mentioned in Table 3. Based on the data presented in Table 3, the p-value exceeds 0.05, indicating that the scores of the samples are assumed to follow a normal distribution. This conclusion is further supported by the histogram and Quantile-Quantile (Q-Q) plot shown in Figures 4.1 and 4.2, respectively.

Descriptive Statistics of Posttest

Descriptive statistics for the post-test are provided in table 4, containing the detailed results. The pretest scores of the students are shown in Table 4. The Statistical Package for Social Science (SPSS-20) was used to analyze the variables in this research study. The minimum and maximum scores of the students were 10.27 and 13.96, respectively. The mean and median of the group's post-test scores are 12.1062, and the variance is 1.132. The standard deviation of the group's post-test is 1.06390, indicating low variability. The skewness of the group's post-test is 0.125, showing a positive skew. The kurtosis of the group's pre-test is -0.528, indicating a slight deviation from normality. According to Can (2017), if the skewness and kurtosis values are between +1.96 and -1.96, it indicates a normal distribution. Therefore, the obtained data suggests that it is usually distributed. Since the data shows a Gaussian distribution, the best choices for parametric statistics are the t-test and ANCOVA. The pretest scores of the students are shown in Table 4.1. The Statistical Package for Social Science (SPSS-20) was used to analyze the variables in this research study. The minimum and maximum scores of the students were 10.27 and 13.96, respectively. The mean and median of the group's post-test scores are 12.1062, and the variance is 1.132. The standard deviation of the group's post-test is 1.06390, indicating low variability. The skewness of the group's post-test is 0.125, showing a positive skew. The kurtosis of the group's pre-test is -0.528, indicating a slight deviation from normality. According to Can (2017), if the skewness and kurtosis values are between +1.96 and -1.96, it indicates a normal distribution. Therefore, the obtained data suggests that it is usually distributed. Since the data shows a Gaussian distribution, the best choices for parametric statistics are the t-test and ANCOVA.

Normality and Homogeneity Test of Students' Score on Posttest

The researcher tested the normality and homogeneity of the student's scores on the posttest. The normality of the sample scores was tested using the Kolmogorov-Smirnov test, and homogeneity was tested using Levene's test, as mentioned in Table 5. Based on the data presented in Table 5, the p-value exceeds 0.05, indicating that the scores of the samples are assumed to follow a normal distribution. This conclusion is further supported by the histogram and Quantile-Quantile (Q-Q) plot shown in Figures 4.3 and 4.4, respectively.

Testing of the Hypotheses objective wise

Objective 2. To compare impact of mathematics-enhanced Van Hiele Model (VHM) learning activities based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] framework through on spatial reasoning of students' engagement in mathematics at elementary level with respect to learners (among high and low achievers)

H1. Impact of Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on experience-Language-Pictorial-Symbolic-Application [ELPSA] framework significantly enhances the spatial reasoning ability of elementary level learners in mathematics.

Comparison of mean scores of Pretests and Posttest of Students

The difference between the student's pretest and post-test scores shows that the intervention positively impacted their spatial reasoning abilities. The pretest and post-testing scores of the students' group were calculated, and their means and standard deviations were compared. Table 6 presents the calculated 't' values and their corresponding significance tests. Table 6 indicates that the mean and standard deviation (SD) of the pretest scores for the students are 9.0150 and 12.1103, respectively. Similarly, the mean and SD of the post-test scores for the student group after the intervention are 12.1103 and 1.06393, respectively. There is a significant increase in their mean scores after the intervention. The 't' value is 6.675, and the p-value is 0.00, which is less than 0.05, indicating a significant difference in the pretest and posttest scores of the students. This suggests a positive impact of Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework to enhance the spatial reasoning ability of elementary-level learners in mathematics.

ANCOVA of Students Group score illustrating the effect of Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on experience-Language-Pictorial-Symbolic-Application [ELPSA] framework

Table 7 displays the results of an analysis of covariance that utilized pretest scores as covariates to adjust the pretest scores of the experimental groups to their post-test scores. This adjustment helps in understanding the true impact of the treatment or intervention received by the experimental group. Upon adjusting the post-test scores of the control and experimental groups with their pretest scores, it was discovered that the obtained F value was 263.746 with a p-value of less than 0.01 and df (1,30). The calculated F value was more significant than the table value of F at df (1,30) at a 0.01 significance level. This suggests that there is a substantial difference between the mean scores of the experimental group at the post-test level, and this difference is attributed to the impact of Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework. The covariate has a negligible impact on the dependent variable. The calculated F ratio for the effect of the pretest is 1.700 at df (1,30). The table value of the F ratio at df (1,30) at a 0.01 significance level is 0.202. Therefore, the obtained F ratio in the covariate (pretest) case is significantly greater than the table value. The covariate does not significantly impact the dependent variable. Based on the analysis of covariance, it was observed that after the intervention with Van Hiele Model (VHM) learning activities, particularly within the context of the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework, students' spatial reasoning abilities greatly improved. Objective 2. To compare impact of mathematics-enhanced Van Hiele Model (VHM) learning activities based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] framework through on spatial reasoning of students' engagement in mathematics at elementary level with respect to learners (among high and low achievers). H2. There is no significant difference in spatial reasoning ability of students concerning level with respect to learners (among high and low achievers) through Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] framework.

Comparison of mean scores of Pretests of low achiever learners and Posttest of low achiever learners

Table 8 presents the pretest and posttest scores of low-achiever learners. The pretest means and standard deviation (SD) for low achievers are 8.13 and 1.025, respectively. The posttest scores for low achievers have a mean of 11.88 and an SD of 1.147. The results indicate a significant difference between the two groups, with a t-value of 9.073, significant at df 17, and a p-value of 0.00 at the 0.01 level. It's important to note that there was an increase in the mean score of low achievers, suggesting an improvement in their spatial reasoning abilities after participating in the intervention-based activities.

Comparison of mean scores of Pretests of high achiever learners and Posttest of high achiever learners

Table 9 displays the pretest and posttest scores of high-achieving learners. The pretest mean and standard deviation (SD) for low-achievers are 10.75 and 0.965, respectively. The posttest scores for low-achievers show a mean of 12.25 and an SD of 1.215. The results demonstrate a significant difference between the both groups, with a t-value of 3.447, significant at df 13, and a p-value of 0.07 at the 0.01 level. It's important to note that there was an increase in the mean score of high-achievers, suggesting an improvement in their spatial reasoning abilities after participating in the intervention-based activities.

Comparison of mean scores of Posttest of low achiever learners and Posttest of high achiever learners

Table 10 presents a comparison of the posttest results of low-achiever learners and high-achiever learners after interventions. The posttest mean and standard deviation (SD) for low-achiever learners are 12.00 and 1.128, respectively, while high-achiever learners have a mean of 12.25 and an SD of 1.215. The results indicate no significant difference between the both groups, with a t-value of 0.585, insignificant at df 30, and a p-value of 0.570, which exceeds the 0.01 level. However, it is worth noting that there was a slight increase in the mean score of girls, suggesting that they performed better after participating in the intervention-based activities. Objective 2.1. To compare impact of mathematics-enhanced Van Hiele Model (VHM) learning activities based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] framework through on spatial reasoning of students' engagement in mathematics at elementary level with respect to Gender (boys and girls). H3. To compare impact of mathematics-enhanced Van Hiele Model (VHM) learning activities based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] framework through on spatial reasoning of students' engagement in mathematics at elementary level with respect to Gender (boys and girls).

Comparison of mean scores of Pretests and Posttest respect to Gender (Boys)

In Table 11, it's shown that before the intervention, the student's average pretest scores were 9.54, with a standard deviation of 1.330. After the intervention, their average posttest scores were 11.92, with a standard deviation of 0.954. There's a significant increase in their scores after the intervention. The 't' value is 6.819, and the p-value is 0.00, which is less than 0.05, indicating a significant difference in the pretest and posttest scores. This suggests that the mathematics-Enhanced Van Hiele Model (VHM) learning activities based on the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework have a positive impact on enhancing the spatial reasoning ability of boys.

Comparison of mean scores of Pretests and Posttest respect to Gender (Girls)

In Table 12 of the research findings, it is presented that before the intervention, the student's average pretest scores stood at 9.16, with a standard deviation of 1.803. Following the intervention, their average posttest scores notably increased to 12.11, with a standard deviation 1.286. This substantial rise in scores post-intervention is evidenced by a 't' value of 5.985 and a p-value of 0.00, indicating a statistically significant difference in the pretest and posttest scores. Furthermore, it was observed that girls exhibited improved performance after the intervention in the Van Hiele Model (VHM) learning activities, particularly within the context of the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework. Notably, the ELPSA framework positively enhanced girls' spatial reasoning abilities.

Comparison of mean scores of Posttest of Boys and Posttest of Girls

Table 13 compares boys' and girls' scores following interventions, revealing exciting findings. The boys' post-test mean and standard deviation (SD) are 11.92 and 0.954, respectively, while the post-test scores for girls have a mean of 12.15 and an SD of 0.954. The results clearly show no significant difference between the two groups, with a t-value of 0.585, insignificant at df 30, and a p-value of 0.570, exceeding the 0.01 level. However, it is worth noting that there was a slight increase in the mean score of girls, suggesting that they performed better after participating in the intervention-based activities.

DISCUSSION & CONCLUSION

This study focused on the impact of mathematics-enhanced Van Hiele Model (VHM) learning activities, which are based on the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework, in improving students' spatial reasoning abilities in mathematics. Students are believed to grasp abstract mathematical concepts better and retain more when they actively participate in learning. The primary objective in teaching mathematics should be to encourage students to think independently and recognize mathematics's fundamental order and patterns. Mathematics education should present mathematical concepts through less procedural and more open-ended tasks and activities. The study found that mathematics-Enhanced Van Hiele Model (VHM) learning activities based on the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework have a positive impact on the spatial reasoning ability of elementary-level learners in mathematics. The study revealed a significant difference in the pretest and posttest scores of students after implementing Mathematics-Enhanced Van Hiele Model (VHM) learning activities. Further, the study revealed that there was an improvement in the scores of low-achieving learners after receiving intervention, indicating an enhancement in their spatial reasoning ability. The obtained result may be supported by that of Khan et al. (2012). Additionally, there was an increase in the scores of low-achieving and high-achieving learners following the intervention, suggesting that the spatial reasoning ability of high achievers was also improved. Furthermore, when the posttest results of low-achieving and high-achieving learners were compared, the non-significant outcome indicated no discernible differences between the two groups. This suggests that after the intervention, the level of reasoning ability for both groups was at a similar level. With respect to high and low achievers, the study found a significant difference in the mean scores of low achiever learners' pretest and posttest. The study also found a significant difference in the mean scores of high achiever learners' pretest and posttest. Interestingly, the study found no significant difference in mean scores of the posttest of low achiever learners and the posttest of high achiever learners, indicating after the intervention, the reasoning ability levels of both were at the same level. The study found that Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework have a positive impact on boys' spatial reasoning ability. The study also found that Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on the Experience-Language-Pictorial-Symbolic-Application (ELPSA) framework positively impact girls' spatial reasoning ability. The study found a significant difference in the mean scores of the pretest and posttest with respect to gender (boys and girls). Hence, the study found a non-significant difference in the mean scores of the posttests for boys and girls, indicating that after the intervention, the reasoning ability level of both was at the same level. However, Yarmohammadian (2014) and Lowrie, Logan, and Ramful (2017) support the idea that there is no significant difference in achievement with respect to gender.

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Table 1: One group Pretest-Posttest design

Group	Pretest	Process	Posttest
G	O_1	X	O_2
	Spatial Reasoning Test	Performing Mathematics-Enhanced Van Hiele Model (VHM) Learning Activities Based on Experience-Language-Pictorial-Symbolic-Application [ELPSA] Framework for 30 days	Spatial Reasoning Test

Table 2: Descriptive Statistics for the Pretest

	N	Min	Max	Variance	Mean	Median	SD	Skewness	Kurtosis
Pretest	32	6.30	12.32	2.040	9.304	9.0559	1.428	Statistic	Statistic
								-.038	-.487

Table 3: Normality and Homogeneity Test of Students' Scores on Pretest

Normality and Homogeneity Test	Kolmogorov-Smirnov[a]			Levene's Test	
	Statistic	df	Sig.	F	Sig
Total	.150	31	.074	.954	.195

Table 4: Descriptive Statistics for the Posttest

	N	Min	Max	Variance	Mean	Median	SD	Skewness	Kurtosis
Posttest	32	10.27	13.96	1.132	12.1062	12.0751	1.06390	Statistic	Statistic
								.125	-.528

Table 5: Normality and Homogeneity Test of Students' Scores on Posttest

Normality and Homogeneity Test	Kolmogorov-Smirnov[a]			Levene's Test	
	Statistic	df	Sig.	F	Sig
Total	.199	31	.012	.001	.981

Table 6: Result of Pretest- Post test Scores on students

Testing	N	Mean	S.D.	't' value	df	p-value	Remarks
Pretest	32	9.0150	2.16397	6.675	31	.000	0.01 (S)
Posttest	32	12.1103	1.06393				

Table 7: ANCOVA Summary Table Students score

Analysis of Co-variate Result by Taking Pre-Test Scores as Co-variate							
Dependent variable	**Source**	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Remarks**
Mathematics-Enhanced Van Hiele Model (VHM) learning activities based on experience-Language-Pictorial-Symbolic-	Pretest	1.882	1	1.882	1.700	.202	p>0.01 (NS)
	Method of teaching	291.955	1	291.955	263.746	.000	

Application [ELPSA] framework	(between groups)						p<0.01 (S)
	Error (within groups)	33.209	30	1.107			
	Total	4728.200	32				
	Corrected Total	35.090	31				

Table 8: Result of Pretests of low achiever learners and Posttest of low achiever learners.

Testing	N	Mean	S.D.	't' value	df	p-value	Remarks
Pretest of high achiever learners	18	8.13	1.025	9.073	15	.000	0.01 (S)
Posttest of high achiever learners	18	11.88	1.147				

Table 9: Result of Pretests of high achiever learner and Posttest of high achiever learner.

Testing	N	Mean	S.D.	't' value	df	p-value	Remarks
Pretest of high achiever learners	14	10.75	.965	3.447	13	.007	0.01 (S)
Posttest of high achiever learners	14	12.25	1.215				

Table 10: Result of Posttest of low achiever learners and Posttest of high achiever learners

Testing	N	Mean	S.D.	't' value	df	p-value	Remarks
Pretest of high achiever learners	18	12.00	1.128	-.821	30	.429	0.01 (NS)
Posttest of high achiever learners	14	12.25	1.215				

Table 11: Result of Pretest- Post test Scores of Boys

Testing	N	Mean	S.D.	't' value	df	p-value	Remarks
Pretest	13	9.54	1.330	6.819	12	.000	0.01 (S)
Posttest	13	11.92	.954				

Table 12: Result of Pretest- Post test Scores of Girls

Testing	N	Mean	S.D.	't' value	df	p-value	Remarks
Pretest	19	9.16	1.803	5.985	18	.000	0.01 (S)
Posttest	19	12.11	1.286				

Table 13: Result of Posttest of Boys and Posttest of Girls

Testing	N	Mean	S.D.	't' value	df	p-value	Remarks
Posttest Boys	13	11.92	.954	.585	30	.570	0.01 (NS)
Posttest Girls	19	12.15	1.281				

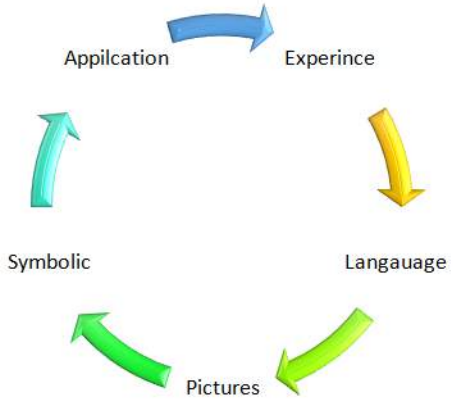


Figure 1. The five components of the ELPSA cycle, illustrating the recursive-progressive nature of the framework.

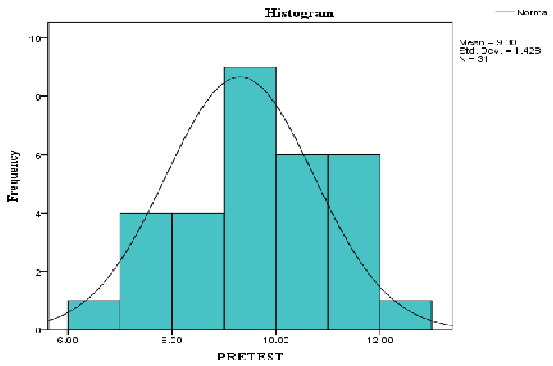


Figure 2: Graphical Representation of Normality Test by Histogram

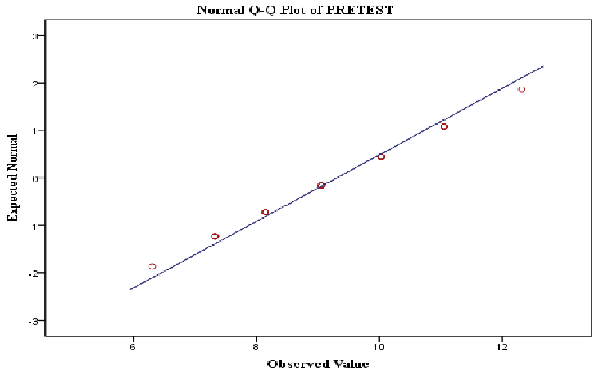


Figure 3: Graphical Representation of Normality Test Quantile-Quantile (Q-Q) plot

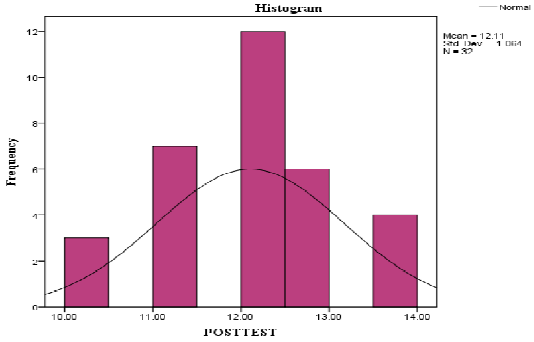


Figure 4: Graphical Representation of Normality Test by Histogram

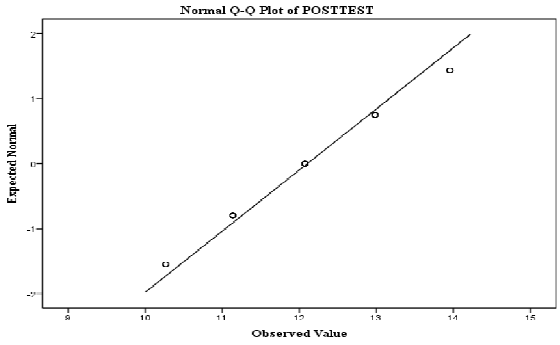


Figure 5:Graphical Representation of Normality Test Quantile-Quantile (Q-Q) plot

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RESEARCH ARTICLE

Recent Advances in Drug Design and Synthesis: Emerging Trends and Techniques

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ABSTRACT

This review delves into the major advancements shaping modern drug design and synthesis, with a particular focus on the transformative role of computational tools, sustainable practices, and innovative synthetic methods in overcoming contemporary pharmaceutical challenges. A detailed exploration of rational drug design (RDD) demonstrates how this targeted approach, supported by insights into structure-activity relationships, has revolutionized the development of drugs with enhanced specificity and minimized side effects. In tandem, structure-based and fragment-based approaches are examined for their contributions to the discovery of effective drug leads through detailed molecular insights and the selection of fragments with favorable pharmacokinetic profiles. The integration of computer-aided drug design (CADD) and artificial intelligence (AI) has streamlined drug discovery further, allowing for virtual screening, rapid data analysis, and predictive modeling that reduce the time and cost associated with traditional drug development workflows. Beyond computational advances, the review also addresses cutting-edge synthetic techniques that prioritize efficiency and environmental sustainability, reflecting the growing emphasis on green chemistry within the pharmaceutical industry. Techniques such as high-throughput synthesis, microwave-assisted organic synthesis (MAOS), flow chemistry, and biocatalysts are highlighted for their ability to produce compounds more rapidly and with lower environmental impact than conventional methods. These approaches not only support the scalable

production of pharmaceuticals but also align with global sustainability goals by minimizing hazardous waste and reducing energy consumption. The review culminates with a discussion on emerging trends in drug target identification, featuring case studies of successful drug designs that demonstrate the practical applications and impact of these methods. Looking ahead, the review outlines future directions for drug design and synthesis, emphasizing continued innovation in computational tools, synthetic methodologies, and sustainable practices to address evolving healthcare needs.

Keywords: Rational drug design, structure-based drug design, fragment-based drug design, computer-aided drug design, artificial intelligence, green chemistry, high-throughput synthesis, microwave-assisted organic synthesis, flow chemistry, biocatalysts, drug target identification, sustainability in pharmaceuticals.

INTRODUCTION

Medicinal chemistry in a broad meaning represents two basic aspects of pharmaceutical development, namely the drug design and synthesis of the new chemical compounds to be tested as potential drugs. Traditionally, drug discovery was a blind and more or less random process with some occasional discoveries made by accident and much groping in the dark. While it sometimes proved useful in developing inventive ideas, there was no planned way of implementing such a method; the development span almost always turned out to be unreasonably long. Over the years however the field grew with the introduction of concepts such as rational and computational approaches to drug discovery taking the process from a rather lucky find scenario to more systematic and scientific (Hughes et al., 2011; Schneider & Baringhaus, 2008). The quagmire has led to the development of structures in elements of desire thus improving precision and efficiency of therapeutic outcomes in the molecule. Among the various achievements in the recent advancements in the drug design, the use of high through- put screening or HTS can be regarded as one of the most important breakthroughs made. The speed enabled by the HTS technology lets researchers screen large numbers of compounds in a relatively short period of time and find out which of those compounds may interact with a specific target of interest. By this capability, the rigorous phase of drug discovery in the first instance has become much faster to enable the assessment of hundreds of thousands of compounds within the shortest time possible (Macarron *et al.,* 2011). These changes notwithstanding though, the cost of developing a drug remains high.

It has been postulated that investment in research and development of each molecule that makes it to the market is above $2 billion (DiMasi *et al.,* 2016). Due to these high costs, there are growing expectations of the industry to look for even better ways of discovering drugs. To overcome these challenges, inputs like computational modeling and machine learning have gained significance in drug development process. Computer-aided technologies make it possible to filter through increasingly large compounds libraries, estimating their interactions in the context of a biological system before they are synthesized in the lab, thus helping save the costly time and energy of the scientists and directing them to the best of the available compounds to work on. Machine learning helps in this process by being able to decipher certain physiological data d to establish certain trends as well as prognoses that would else wise would be hard to determine (Swinney & Anthony, 2011). Combined, these approaches are contributing to the rationalization of discovery efforts and the costs incurred, which could afford drug development. Besides technology trends, new trends have been recognized in chemin formatics for data analysis and compound selection. Cheminformatics enables researchers to process big data more stream linedly since it helps in the selection of drug prospects that are more likely to be successful in clinical trials (Brown & Superti-Furga, 2003). In tandem with these innovations, improved understanding of molecular biology disease processes has further strengthened patient treatments toward more specific and selective ones. Specialized scientists are already able to develop drugs and their specific molecular goals more concisely, which may in turn; make them more effective while causing fewer side effects (Paul *et al.,* 2010).The evolving landscape of molecular biology has further enriched the drug discovery field,

especially in terms of understanding the precise mechanisms underlying diseases. With a deeper comprehension of molecular pathways and genetic markers, scientists can develop targeted therapies that are designed to interact with specific proteins or cellular processes, leading to increased efficacy and reduced side effects. These targeted therapies represent a shift away from broad-spectrum drugs, focusing instead on precision medicine that tailors treatments to individual patient profiles and specific disease markers (Paul *et al*., 2010). This focus on precision is part of a broader trend in healthcare, driven by the goal of personalizing treatment for maximum therapeutic benefit. The scope of drug discovery has expanded to address a more diverse range of health needs, particularly neglected diseases that have historically received limited attention due to low profitability. With increased awareness and global health initiatives, pharmaceutical research is now exploring diseases that disproportionately impact underserved populations, a development that signifies a shift toward more equitable health outcomes. This trend reflects a growing understanding within the pharmaceutical industry of the need to balance profitability with social responsibility (Lazo & Sharlow, 2016). By prioritizing neglected diseases, researchers are contributing to broader health equity, ensuring that medical advances benefit a wider demographic rather than remaining confined to high-revenue markets.

Emerging Trends in Drug Design

Emerging methods, enabling greater understanding of biological targets, have powered dramatic progress in drug design. These methods also enhance the ability to create drug which has more precise and could have less side effect and tailored efficacy to a particular illness. However, within these approaches, rational drug design (RDD), the integration of structural biology and molecular pharmacology to design drugs selective for intended biological targets, has over time become the cornerstone approach.

Rational drug design (RDD)

Rational drug design (RDD) is a means of intentional design of therapeutic molecules (i.e. drug molecules) made exiting on extensive knowledge of biological target(s) especially at molecular level. This is an approach based on structure activity (SAR), that is, how a compound's molecular structure relates to its biological activity. Learning these relationships allows scientists to design drugs which bind to one specific site on a target protein with great selectivity, increasing therapeutic efficacy and decreasing off target effects and side effects. *Morphy, and Rankovic, in their research (2007)* describe RDD application as successful when multiple ligands are used targeting specific disease pathways. HIV-1 protease inhibitors is a noticeable example of the application of this. In these inhibitors the active site of the HIV-1 protease enzyme was targeted with specific binding, a protein that is essential for viral replication. Because of this, HIV-1 protease inhibitors usefully block this enzyme in order to prevent the virus from multiplying and manage HIV/AIDS *(Morphy & Rankovic, 2007). Ghosh et al. (2017)* show how this approach illustrates how RDD took the treatment of viral diseases to a new more targeted approach, where therapies interrupt the disease generating mechanism at a specific target. *Congreve et al. (2003)* also describe another significant development within RDD, that of fragment based drug discovery (FBDD) techniques. An application of FBDD positively involves the identification of small chemical fragments with favourable binding characteristics and pharmacokinetic properties that can then begin drug development. Such fragments conform to a 'rule of three,' that they should have a molecular weight less than 300 daltons and usually three or fewer hydrogen bond donors and three or fewer hydrogen bond acceptors. Once fragments have been optimized and combined to make more complex and better lead compounds (Congreve et al. 2003), they are available for further optimization. This provides a useful method for the generation of promising drug leads which conform to preferred pharmacokinetic parameters and which can be developed as full therapeutic agents. However, recent advances in structure-activity relationship (SAR) studies have further expanded the use of RDD by improving hit compounds into potent and highly selective lead candidates. SAR can be used to modify compounds to give them desirable pharmacological properties, such as potency, selectivity, and bioavailability. These refinements are emphasized by Bleicher *et al.* (2003) as SAR driven modifications can change initial hits (basic activity with a target) to leads with better therapeutic profiles. This optimization process is of particular importance in oncology and infectious disease where high specificity for diseased cells (or pathogens) is vital to limit damage to healthy cells (Bleicher *et al.,* 2003).

Its implementations in oncology for example, have birthed drugs that can annihilate the pathways of rancid cells without affecting the normal tissue of the patient. In the same way, in infectious diseases, the RDD driven compounds are planned to target the specific portion of the pathogen life cycle, or its pathogenicity factors, thus offering better attenuation of infections with less toxicity. In general, the possibility to design drugs with very high target selectivity has been one of the greatest achievements of RDD, especially when molecule understanding is progressing constantly, and new SAR approaches are being established. Rational drug design can be only considered as an effective strategy for modern medicinal chemistry where the detailed molecular and structure interplay between all components of rational drug design is elaborated through state of the art structural techniques to produce highly specific drugs with the improved therapeutic indices. It has made continuous improvement by using SAR, fragment based methods and due to all these RDD has remained an integral part of new drug discovery especially in areas like oncology, virology and infectious diseases.

Structure-Based Drug Design (SBDD)

Structure based drug designing (SBDD) is one of the revolutionary approaches of drug discovery that uses the specific three dimensional structural information of the target biological system to design them. The structural data recovered by sophisticated methods such as X-ray crystallography and nuclear magnetic resonance (NMR) spectroscopy allows the scientists for structural determination of proteins as well other biomolecules at the atomic level. This feature assists the researcher in finding features like binding domains, active sites, and allosteric sites into a protein. Consequently, SBDD enables the identification of the apt regions to design molecules with greatest propensity to accommodate the target protein while avoiding unwanted interactions that may lead to adverse effects *(Blundell et al., 2006).* SBDD uses several methods of which molecular docking is a key computational strategy that predicts the possible binding modes of small molecules, including drugs, with a selected protein. As mentioned earlier, molecular docking imitates the binding of a compound to the target and estimates the аденtification number and its position in relation to the target compound. This approach along with the Virtual screening helps the identification of large sets of compounds against particular protein targets This along with Vehicle docking make it possible to screen a large compound database within a short span of time. Additional to time and cost saving, virtual screening also improves outcomes by focusing on the molecules most likely to lead to a successful compound, which saves time and resources for further experimental testing *(Jiménez et al., 2018).* Closely related, these approaches have widely been adopted into the pipeline of drug discovery, with highly enhancing impacts in the identification and optimization of lead compounds. Among all therapeutic areas, oncology has reaped considerable benefits from the use of SBDD. Protein structure information obtained from SBDD has assisted in cancer drug design through enabling the design of inhibitors that are specific to cancer targets. For instance, because structural differences have been established between kinases which are significant enzymes in cancer signaling, new kinase inhibitors have been designed with higher selectivity and binding probabilities *(Kuntz, 1992).* These inhibitors are intended to target on such irregular kinase activity to inhibit undesirable cell division while the normal cell functions remain unaffected. These efforts are important because traditional chemotherapy harms healthy cells and has side effects, which such targeted methods do not have. Yet another important contribution to the animated discussion of SBDD is its contribution towards the reduction of drug discovery cycle facilitated by virtual screening. *Jain, 2004* describes the role that virtual screening has played in expediting all aspects of lead compound discovery and optimization. Computational tools of virtual screening together with structural investigation make it possible to analyze thousands of compounds in less time than used in experimental approaches while only the most effective compounds are considered for advanced experiments. This not only cuts the discovery timeline but also brings better cost optimization to the method which makes it one of the most valuable tools in modern pharmacological studies.

Fragment-Based Drug Design (FBDD)

FBDD is a process through which target molecules are fragmented into smaller, easier to handle pieces in a quest to discover desirable drug leads. This approach enables the surveying of chemical space more effectively, and, in many cases, results in identification of novel therapeutics. It has been recognized that FBDD is especially suitable for targeting difficult proteins and it has recently been used in numerous fields such as antiviral and anticancer agents. The following sections expand on critical features of FBDD as described in the included papers.

Fragment Library Design

Fragment libraries and, as such, the core of Fragment Based Drug Design (FBDD) is, indeed, an influential aspect of their efficiency. An effective strategy of building a small library of variously functionalized small molecular weight compounds is critical for picking out several drug like compounds. It has been found that the use of an automated system, using KNIME software, is a successful approach in the creation of such libraries, while maintaining chemical space and 3D properties imperative for drug interaction and selectivity *(Dekker et al., 2023).* This variety of libraries helps the researchers scan a vast chemical space and find fragments that can then be optimized into good drug-like molecules. In addition, by targeting the underrepresented scaffolds, including cyclopropane, the enhanced diversity and physicochemical properties of these libraries can be achieved, giving drug design new opportunities (Dekker *et al.*, 2023).

During the Discovery Process of Antiviral Drugs

FBDD has proved beneficial for Antiviral target identification and has seen usage in the inhibitors of viral proteins. One particular example is related to the design of inhibitors which act against the Hepatitis B virus core protein. Through FBDD, researchers have explained that they are able to dissect and remanufacture new forms of existing antiviral drugs like Ciclopirox with higher binding affinities (Mohebbi *et al.*, 2023). Such an approach caused discovery of compounds with improved antiviral activity, which can be considered as a success factor. Furthermore, FBDD has been used in the generation of new molecules for the treatment of multiple strains of the corona virus. Thus, fragmenting and re-mixing known drugs allow obtaining molecules with higher binding to the target viral proteins and higher stability, which proves helpful in designing drugs for combatting the most complex viral diseases *(Benny et al. 2023).*

Fragment Decomposition Techniques

Disassembly of small molecules into smaller parts is an essential process in FBDD, and several strategies have been invented to facilitate it. One such biological process is MedChemFrag which enables one to dissect a molecule while maintaining its functional moieties. This preservation is important since particular non-covalent interactions should be retained if the drug has to effectively bind to its target *(Palyulin, 2023).* Since FBDD breaks molecules into functional fragments, which are then optimized, this approach enables enhanced identification of lead candidates to be optimized further. Thus, the preservation of functional integration during decomposition assists in preserving the energetic and selective potential of potential drugs.

Integration with Structure-Based Drug Design

FBDD does not only stand on its own but can be combined with other techniques in drug design including the Structure Based Drug design (SBDD). One of the promising integration is with Generative Flow Networks (GFlowNets) which enables us to sample over extremely large combinatorial spaces of drug like molecules. This integration hence makes it possible for researchers to put in place molecules that are a perfect fit in protein pockets hence improving the accuracy and efficiency of the drug designing *(Lee et al., 2024).* This concept of integrated approaches of FBDD with SBDD enhances the process of discovering toxicology agents, by mandating those hits, which have been designed to blend with the targets of structure data, giving the best probable prospects. However, some issues are still associated with fragment screening and optimization steps that significantly affect the overall efficiency of the approach, and, therefore, it is critical to have access to the high-quality fragment libraries as well as reliable computational tools to support this type of work.

Computer-Aided Drug Design (CADD)

Computer-Aided Drug Design (CADD) is a pivotal component in modern drug discovery, leveraging computational tools to enhance the efficiency and precision of developing new therapeutic agents. CADD encompasses a range of methodologies that facilitate the identification, optimization, and validation of potential drug candidates by simulating their interactions at the molecular level. This approach not only accelerates the drug discovery process but also reduces costs and improves the success rate of identifying viable drug candidates.

Applications and Methodologies

Computer Aided Drug Design (CADD) is an essential component of the process at the end of which potential lead compounds are identified. A good example is the study done in targeting Streptococcus pneumoniae through compounds extracted from Carica papaya *(Bhanu et al., 2024).* On this basis, CADD can contribute to the prediction of biologically active compounds that may be further developed into novel therapeutics. Further, it is also used in the design of Targeted Drug Delivery Systems (TDDS) at CADD. The6bjectivee of these systems is to follow drugs specifically to the sites that need treatment thereby increasing the dosage effectiveness and reducing toxicity. CADD plays a central role in the computation of these drug delivery vehicles like polymeric micelles and nanoparticles which is a step that completes the creation of these systems *(Sribhavani et al. 2023).* The technique used in CADD such as the virtual screening, molecular docking, and structure based drug design enables the researcher to take rational approach towards biochemical interactions and mediate chemical entities to enhance their polish by turning them into drug like products *(Bassani & Moro, 2023).*

Tools and Techniques

CADD involved many computational approaches that are crucial for the prediction of the 3D structure of target proteins. Some of the techniques used are; Homology modeling, Threading and ab initio. For instance, in the study on schizophrenia homology modeling was applied in order to predict the 3D structure of the SP4 protein *(Hameed et al. 2023).* These tools allow for visual analysis of the structures, as well as for identification of probable locations of the drug binding. Furthermore, the Program including Anolea, ProCheck, and Errat are used to evaluate the accuracy of predicted structures. These tools precede molecular docking analysis by validating the models used in the subsequent analyses, which increases the reliability of the predictions *(Hameed et al. 2023).* The primary goal of this work is to develop optimal methods for predicting protein structures and their interactions with molecular targets in order to achieve higher efficiency in the design of active substances.

Benefits and Limitation

The incorporation of CADD into drug discovery workflows catapulted the entire process to a Gong because of the enhanced velocity at which potential drug targets are recognized. This has ensured that CADD become an essential tool in research, academic institutions, and industrial setting *(Bassani & Moro, 2023; Ece, 2023).* Since the procedure enables the forecasting of how different chemical entities will interact at a molecular level, CADD can be used to optimise samples in a short span of time which in turn speeds up the drug discovery process. Nevertheless, in implementing CADD, it comes along certain challenges as discussed next. High quality of the structural data turns into one of the primary tasks, based on the fact that the reliability of the predictions is directly proportional to the quality of input information. Additionally, the accurate prediction of the biological activity and toxicity of the drug candidates is still a challenging problem; therefore the application of CADD to its full potential in the drug discovery is prevented *(Bassani & Moro, 2023).* Despite the benefits gained on CADD, further research and development are still needed to address these challenges most especially on the enhancement of the fitness of the computational models and the development of new algorithm to boost the accomplishment of the predictions. The continued evolution of these platforms is required for optimizing the use of CADD in the advancement of new pharmaceuticals.

De Novo Drug Design

The field of new drug design is evolving with innovative approaches that leverage advanced computational techniques and novel biochemical strategies. These methods aim to address the limitations of traditional drug design, such as the finite availability of binding sites and the complexity of multifactorial diseases. The integration of artificial intelligence and pharmaco informatics is paving the way for more efficient and targeted drug discovery processes.

Novel Biochemical Strategies

A new concept regarding antiviral drugs implies changing the local conditions of the exterior of the virion. This approach appears to have great potential to prevent the viruses that cause HLs by relaxing spatial configurations in the viral proteins to the extent that they reduce their capability to bind with host receptors. This means that this

strategy could provide a new effective approach in dealing with viral infections like influenza, and other virus diseases *(Mackenzie-Kludas et al., 2023).*

Applications and Advances in Artificial intelligence and Machine Learning Technique in De Novo Drug Design

Specifically Machine learning also a branch of Artificial Intelligence (AI) is changing the way for drug design at a faster rate with much higher accuracy in predicting molecular interactions. One of them is the Joint Transformer model – an effective tool that unites the generative and predictive features to create the deep molecular drugs design. It can also be observed that this model considerably minimizes prediction errors relative to conventional SMILES-based de novo drug design. This means that the application of the proposed model for the generation of new compounds will be faster and more reliable as the generated compounds are likely to possess enhanced target properties *(Izdebski et al., 2023).* Further, protein- anchored encoding and transfer learning techniques from the deep learning class are used to design ligands with high affinity to target proteins even when there is scarce data available, which in turn augments drug discovery *(Wang et al., 2023).*

Addressing Complex Diseases

Such targets are being used frequently in the pharmacophoric design of therapies for intricate diseases such as Alzheimer's that beset a range of physiological systems. These tools assist in the detection of molecules that can modulate several biological processes at a time hence making them potential polypharmacological agents. This is especially crucial as there are multiple mechanisms that are involved in the development of disease like Alzheimer's. And using pharmacoinformatics, scientists can create drugs that match the complexity of such diseases and, therefore, can be more effective *(Arrue et al., 2022).*

Fragment-Based and De Novo Approaches

A fusion of fragment-based and de novo methods creates an opportunity for the generation of novel molecules in underexplored or hard-to-drug regions. Using energy minima and molecular dynamic simulation this method ensures high binding affinities and pharmacokinetic properties of potential drug candidates. This shows that by combining both of these approaches it is possible to tailor the molecules and the characteristics of these molecules in a way that will the chances of the desired outcome in drug discovery. It advances new ways to selectively modulate other developing and hitherto overlooked drug targets *(Kulczyk & Koszytkowska-Stawińska, 2022).* The advances introduced in this discussion underscore the possibility of extensive progress in the utilization of drug targeting. However, there exists some limitation, for instance the lack of validation of computational models and even the lack of incorporation of these models in the established drug development framework. Furthermore, diseases such as the Alzheimer's do not have any one cure or approach that can be followed in order to develop drugs, that is why drugs of all types, conventional and new generation, are needed.

Artificial Intelligence in Drug Design

Artificial Intelligence (AI) is revolutionizing drug design and optimization by significantly accelerating the drug discovery process. AI techniques, such as deep learning and machine learning, are being integrated into various stages of drug development, from target identification to lead optimization. These advancements promise to reduce the time and cost associated with traditional drug discovery methods. However, challenges such as data quality, model evaluation, and ethical considerations remain.

AI Techniques in Drug Design

AI has been on the frontline in introducing revolutionary approaches into drug design by increasing rate and speed of drug discovery. Perhaps the most well-known example is the application of transformer and many-objective optimization algorithms for creating new molecules that can efficiently bind to a particular protein of interest. These methods enable the search across greatly expanded chemical space, enhancing the probabilities for finding the prospective drug candidates with the required characteristics. Using sophisticated computational approaches as a tool, AI contributes toward designing drugs with high accuracy to those diseases and has become a key element in current drug development *(Aksamit et al., 2024).* Another emerging AI methodology is the combination QSAR and

QSPR, which processing molecular structure data in order to predict the biological activity and properties of chemical compounds. These, together with virtual screening, are effective means for searching large databases to find the lead compounds. Furthermore, new learning strategies, that is, neural network learning that is able to decipher intricate patterns directly from data, has been integrated into the drug discovery process to reduce possible human inaccuracies (Khan et al., 2024). In addition, machine learning algorithms combined with reinforcement learning and graph neural network (GNNs) are employed in de novo drug design, where new drug molecules have to be constructed from basic building blocks. These methods also assist in estimating other properties of the drug including solubility, toxicity, and bioavailability to a very large extent, hence faster the drug discovery process *(Qureshi et al., 2023).*

Challenges in AI-Assisted Drug Discovery

However, there are a number of effective barriers that have to be overcome to enhance these AI augmented drug discovery technologies. One major problem is the accuracy of the data that is used in training of such artificial intelligence systems. Some of the issues which are data-related include; bias, inconsistency, and high dimensions which affects the performance of AI systems. For example, When creating models, an imbalance in the data can cause issues in making generalizations about models and thus potentially impact drug predictions. Similarly, this brings about the improper organization of data and likewise brings about bad results to the organization of AI in drug discovery *(Ghislat et al., 2024).* The fourth key issue is the assessment of AI approaches and models, there are also further challenges to overcome in order to promote and integrate AI approaches. Several models are validated against benchmarks, or other datasets, which may in fact not be a good measure of the capacity of AI models in drug discovery applications. This limitation can lead to mismanagement of its abilities to even researchers and developers and draw wrong conclusions concerning a model real potential. Furthermore, given the dynamism in the field, it might be challenging to evaluate current more intricate nature of modern AI drug discovery tools using prior methods as GHISLAT and al. noted in 2024. Furthermore, issues relating to AI's ethical legitimacy in drug discovery and development – data protection, openness, and responsibility – have to be resolved. The use of AI should involve acceptable norms that check the impact that the technology can cause to society for it to benefit the society fully *(Khan et al., 2024).*

Bioinformatics and AI Integration

The coupling of bioinformatics with AI continues to shape the way in which newly identified drug targets are optimized and discovered. Bioinformatics is the study of 'biological information and includes the fields of genomics, proteomics and metabolomics and offers insights into the pathogenesis of diseases. Bioinformatics tools are fast and efficient when implemented along with AI, such that, there is enabling of the study of disease biology leading to the discovery of potential drug targets. By using technologies like machine learning to sort through genomic and proteomic data, researchers can identify which targets are most likely to respond to treatment much more quickly than drug discovery methods of the past *(Yin, 2024).* Also, the integrated use of AI in bioinformatics is becoming increasingly useful in extrapolating the metabolism and toxicity of drugs, which are major areas of concern in drug discovery. AI can predict how a drug will be metabolised in the body, and therefore assist in the design of molecules with improved pharmacokinetic properties hence less toxicity with improved efficiency of the compound. This integration of the application of AI in conjunction with the field of bioinformatics is therefore enabling researchers to enhance optimal drug candidates at concept stage, thereby enabling timely launch of new therapeutic products in the market *(Yin, 2024).* There are quite a number of compelling opportunities offered by AI and bioinformatics in catapulting the drug discovery process to another higher level but there are number of challenges especially on the aspects of data quality, model evaluation as well as ethical issues that need to be discussed so as to enable AI unlock its full potential in the drug design and optimization. To remove these barriers AI technologies could improve the efficiency, efficacy and cost of new drugs from drug discovery to patient care, thus has a huge potential to change the outlook of the health care industry.

Recent Advances in Synthetic Techniques

The developments in the past few decades have provided synthetic chemists with new ideas incorporating the tactic of green chemistry. These techniques are gradually becoming a fundamental strategy in drug synthesis with specific emphasis placed on environmental stewardship. Moreover, the incorporation of high-speed technologies has improved compound making and production to a high level, which has led to increased drug discovery. A breakdown of these advancements, and their possibilities and limitations is provided in detail below.

Green chemistry in drug synthesis

Green chemistry concerns itself with principles aimed at reduction of waste, use of less hazardous materials and enhanced efficiency of a chemical process. The use of microwave in drug synthesis has brought great improvement in method development and technology.

Sustainable Methodologies

New environment friendly strategies in green chemistry have helped to advance methods of drug synthesis by altering the conditions of the reactions and minimizing resource use. A specific case relates to the role of aqueous micellar conditions in the Sonogashira coupling process to increase the effectiveness of synthesizing the antimalarial drug candidate MMV688533. This method also not only increased the yields but also minimize the use of catalyst which is in complete conformity with the concept of green chemistry. Such progress shows that through experimentation, new reaction conditions can be developed which will provide both high performance and feasibility of environmentally friendly solutions (Tyler *et al*., 2023).

Chiral Drug Synthesis

Green chemistry techniques have been particularly valuable in the synthesis of chiral drugs; these drugs are essential in pharmaceutical applications because each has unique biological activity. The major inputs used in the process have been minimized, through improved catalyst design and the use of less hazardous solvents. For example, Current investigators have designed new chiral catalysts which provide very high enantioselectivity despite using minimal wastes. All these developments are important for the pharmaceutical industry in particular where the need for synthesis of chiral drugs with high enantio selectivity and economy has been on the increase (Zhao *et al*., 2024).

Emerging Technologies

Green chemistry has also adopted recent technologies like microfluidics and electrochemical synthesis in order to enhance green efficiency. Micro reactive systems, in which the conditions of the reactions can be fine-tuned on the microscopic level, have proved to offer a high solvents- saving efficiency and significantly shorter reaction times. Likewise, electrochemical synthesis also shows efficiency over the conventional methods where electricity is used to initiate the process of synthesis. These technologies illustrate the emerging trends being applied in an effort to make the synthesis of drugs friendlier to the environment as well as more efficient (Zhao *et al.,* 2024).

High-Throughput Synthesis

Other methods are also linked to green chemistry because high-throughput synthesis methods allow one to obtain large numbers of compounds. These methods are effective in the overall process of drug discovery because they provide a way for the economical generation of a large number of small molecules.

Combinatorial Chemistry

Combinatorial chemistry now enters the age of automation to produce an astonishing array of compound libraries. Building blocks allow researchers to arrange and rearrange a vast number of concepts or substances to soon create thousands of new chemical compounds. This approach is more advantageous in hit identification, specifically during the initial phases of compound discovery because the majority of the potential bioactive compounds need to be examined for possible therapeutic action. Subsequent improvement of these processes by automation has made combinatorial chemistry an indispensable weapon in the modern pharmacologist arsenal.

Large-Scale Applications

GLS high-throughput methods are also being used on a more extensive level to create chemical libraries containing wide variations in functional groups and structure. Indeed, such large libraries are more useful in the identification of leads in the drug discovery and development processes. Since it is possible to generate such libraries in a relatively economical fashion, the freedom to scan a far greater chemical library makes it more likely to discover successful drugs. These methodologies have also become imperative in pharmaceutical pipelines to supplant the time and costs related to traditional combined synthesis.

Microwave-Assisted Organic Synthesis (MAOS)

MAOS (Microwave Assisted Organic Synthesis) has developed as one of the most innovative approaches to organic synthesis especially in line with the developing pharmaceutical industry. This method improves the efficiency of the reaction by using microwave radiation; thus, it can be utilized to synthesize pharmacologically active molecules. Discovering that MAOS was capable of facilitating a decrease in reaction times by several orders of magnitude, the improvement in selectivity to desired products, and its compatibility with green chemistry, there can be no surprise that MAOS has been preferred in drug development. Overview of MAOS Below is the prospects of the technique, fields of application, and limitations inherent to MAOS.

Benefits of MAOS

The benefits of Microwave-Assisted Organic Synthesis arise from the solution that it offers to some of the challenges typically associated with the conventional synthesis processes – time, efficiency and environmental impacts.

1. **Reduced Reaction Times:** The most important feature of the MAOS process is the reduction of reaction times by orders of magnitude compared to conventional heating. Most of the non-chemical reactions can take hours up to days to complete because the heat transfer in non-chemical platforms is slow and irregular. MAOS on the other hand uses microwave radiation to directly induce the required change through radiation heating the molecules up and thereby increasing the rate at which the reaction takes place. For instance, reactions that can normally take h – several hours can be done in a matter of mn- minutes using this technique (Babu & Prasanthi, 2023). It does so not only to boost the efficiency of the research time but also to make high through-put synthesis a realistic ambition.
2. **Improved Efficiency:** MAOS frequently enables yields which are better than ordinary ways, as well as reactions that are less tainted. Microwaves heat the food uniformly and reduce formation of undesired products during cooking hence most of the input materials transform to the end product. This efficiency is even more desirable in drug synthesis because purity and yield are significant parameters that affect subsequent steps (Shu, 2023). Also, the decreased formation of by-product corresponds with the principle of green chemistry due to the effective use of reagents.
3. **Enhanced Selectivity:** Yet another very significant virtue of MAOS is selectivity improvement in the chemical reactions. It is thus easier for the biologist to fine tune the heating parameters and achieve the wanted reaction while minimizing side reactions that will distort the product. Selectivity is an essential aspect of this particular approach, especially in terms of developing drugs since the desired pharmacological action is generally linked with a specific molecular form (Damera *et al.,* 2023).

Utilization in Drug Synthesis

The pharmaceutical industry has received MAOS as a tool of synthesis of pharmacologically active molecules and heterocyclic compounds, which are the framework of many drugs.

1. **Synthesis of pharmacologically active molecules:** Heterocyclic compounds occupy a broad and important place in pharmaceutical chemistry and act as antibiotics and anticancer agents. MAOS has been shown to be especially useful in the synthesis of these molecules as it is far faster than conventional approaches. For instance, the preparation of nitrogen- and sulfur-containing heterocycles that are popular in the API structure has been accelerated by microwave-aides synthesis methods (Shu, 2023; Shalaby *et al*., 2023).

2. **Alignment with Green Chemistry Principles:** Again, what makes MAOS unique is not only the general effectiveness that is offered, but also the efficiency that is ecologically friendly. The method minimises the utilization of excessive solvents as well as energy both which are critical to the environmental footprint of conventional chemical synthesis. Moreover, MAOS minimises the formation of undesired by-products and further augments MAOS's sustainability due to developing cleaner reactions with decreased chemical waste *(Frecentese et al., 2023).* These green chemistry attributes make MAOS a preferred method for modern drug synthesis where sustainability is gradually gaining a standard.

Flow Chemistry in Drug Synthesis

Flow chemistry or continuous flow processing is a modern approach that displaces the model of batch synthesis. The basic controlling feature of flow chemistry is that the reaction occurs under a constant flow of reactants, but in a locked manner, and this offers better control in terms of safety as well as efficiency of the parameters.

Key Principles of Continuous Flow Reactions

Continuous Processing

Contrary to the batch reactions that are characterized by step-by-step, in static reactors, flow chemistry uses a continuous flow of reactants through the reactors. This system enables proper control of reaction parameters such as temperature, pressure and time and hence reactions occur in a better way. This method of control affords a decreased chance of side reactions and allows for a more consistent product quality. For instance, in processes with intermediates that are hazardous or highly reactive, Capaldo *et al.* (2023) conceptualized how continuous flow processes improve safety.

Scalability

Flow chemistry is particularly notable for its scalability, so the system will be relevant not only for laboratory experiments but also for industrial processes. This can be easily scaled up without any negative impacts on the overall activity and quality of the final product. Dent (2022) explained how complex APIS that require multiple steps and harsh conditions can be achieved in flow systems at relatively mild conditions, which is important for both purity and yield in drug manufacture, especially in view of the current highly stringent regulatory requirements for new drugs.

Automation

The incorporation of robotic systems in flow chemistry removes the complexity of processes such as screening and performing of reactions. The use of ancestral systems can facilitate real-time control and as such can allow the fast iterative exploration of reaction conditions. As other authors confirmed, automation increases the degree of replicability, especially in cases where multiple step procedures are involved and control is crucial.

Implementation in Multistep Synthesis

- One-Flow Synthesis: The latest development in flow chemistry has made it possible to perform continuous multi-step, which is referred to as one-flow synthesis. This approach also reduces the number of intermediate purification steps that are required, to a fraction of those required in traditional synthesis, which also mean greatly reduced reaction times. The authors Bloemendal *et al.*, (2020), have also shown that one-flow synthesis offered enhanced yields and shorter cycle times in production of multi-step APIs for diseases like viral infection and cancer.
- Diverse Applications: Continuous flow processes are very flexible and can be applied to most reactions including those occurring under extreme conditions. For instance, flow reactors apply in asymmetric synthesis of chiral drugs that are vital in treatments involving selected biological activities. According to Ötvös & Kappe (2021), continuous flow systems also provide a high degree of control over the rate and other conditions of the reactions, which is important for the high enantioselectivity needed in chiral drugs.

Click Chemistry in Drug Synthesis

The term click chemistry describes a conceptually elegant and modular strategy for the efficient and accurate construction of large and complex structures from readily available and easily functionalized components. Popular for its ease and effectiveness, this methodology is especially important in the assembly of drug conjugates and delivery platforms.

Concept of Click Chemistry

- **Modular Approach:** The basic rationale behind click chemistry is based on using reactions that are appended with high yield and that occur under conditions that are rather mild. Such reactions as azide-alkyne cycloadditions described above give a rather sound approach to the formation of molecular scaffolds. According to Capaldo *et al.* (2023), click chemistry is valuable for drug synthesis since it is quick and accurate to address people's needs.
- **Versatility:** Click chemistry is flexible and can be applied in a wide variety of cases related to the pharmaceutical industry. They are employed in drug conjugation where one or both drugs are connected to targeting molecules and in the construction of mulitpotent drug delivery systems. As Dent (2022) also pointed out, the modularity of click chemistry makes it possible to create new therapies, including ADCs and nanoparticles.

Applications in Drug Conjugation and Diagnostics

- **Targeted Delivery:** Among the numerous applications in which click chemistry has been greatly used is in the area of drug delivery. Thus, click chemistry makes it possible to enhance the selectivity of the drug action by attaching it to targeting moieties including antibodies or ligands. This approach minimizes adverse effect profiles and increases drug effectiveness. Ötvös & Kappe (2021) depicted how click reactions are employed in building ADCs that release cytotoxic cargo exclusively to cancer cells and sparing the healthy cells.
- **Diagnostic Tools:** In a similar manner, the modularity of click chemistry applies to diagnostics agents being built from modular components as well. These tools can be used to do baseline reactions against corresponding biomarkers to enhance specificity and or sensitivity of the diagnostic tests. Hardwick & Ahmed (2020) pointed out that click chemistry is employed for designing fluorescent probes and imaging agents to selectively detect disease biomolecules. However, both flow chemistry and click chemistry have issues with the need to be resolved in order to fully realise the potential they possess. While these methods are advantageous, they often need specialized tools and the associated equipment such micro reactors for flow chemistry and specialized reagents for click reactions, which may be out of reach of a small laboratory or even a company. Furthermore, as with most modern separation techniques, both techniques are highly generic and can be used for most kinds of chemical reactions; nevertheless, very complex or sensitive reactions may not benefit much from the techniques and may have to be performed traditionally. Additionally, the extension of flow chemistry reactions from the laboratory to production scale can be problematic, particularly for hot or quick responses; and size adaptation of click chemistry for the mass manufacturing of drugs deserves further study.

Biocatalysis in Synthesis

Enzyme mediated biocatalyst is has emerged as an indispensable technology in asymmetric synthesis with substantial advantages in generating value added emission free green chemistry products in pharmacy and agriculture. They are unique natural catalysts offering high selectivity in reactions to yield the chiral compound with precision and accuracy. These qualities make enzyme-based techniques particularly suitable for the applications in those cases where chiral compounds have to be built up to enantiopurity. The fact that enzymes work at low temperatures or under non-hazardous solvents are some of the reasons enzymatic activity has been widely embraced in green chemistry as a healthier option than regular chemical processes ever since 2024. This type of asymmetric synthesis has numerous benefits owing to the wide number of reactions that is can catalyse: optical and kinetic resolution. Both processes are essential in synthesis of enantiomerically pure compounds because some chiral pharmaceuticals cannot function as required when they exist in the wrong optical isomer form. Optical resolution,

for example, enables the separation of enantiomers while kinetic resolution entails a reaction on one enantiomer while leaving the other incorrupted (Garg *et al*., 2024). Also, the recent breakthrough discovered in artificial copper enzymes has augmented the prospects of biocatalysis since it suggests that stereochemical control in asymmetric reactions can also be attained. These artificial enzymes work at moderate reaction conditions, and this presents a viable solution in synthesizing chiral structures of high order with optimum yield (Shiri *et al.,* 2024). Another development in biocatalysis is the use of non-conventional fluids, including ionic liquids and supercritical fluids, together with photocatalysis. These changes have brought a drastic enhancement of the chiral amine manufacturing, which is important in the production of most drugs. Due to improving the reaction conditions, and the reaction rates, biocatalysis has attained higher concentration and enantiomeric excess and has then facilitated the use of these methods in industrial processes. For the purpose of environmental relevance, enzyme catalysis is in harmony with the concept of green chemistry. This is because the enzymatic reactions tend to be carried out under comparatively low energy conditions as compared to chemical substances; therefore decreasing the pollution of the environment by minimizing the formation of multiple by-products (Zhao, 2024). In addition, the combination of flow chemistry with biocatalysis can increase the sustainability of the reactions as it allows efficient flow reaction profiles, reduction in waste production and continuous synthesis that is more sustainable than batch synthesis (Garg et al., 2024). However, there are several limitations of biocatalysts: Substrates are limited only to compounds which can be handled by enzymes and enzyme stability is also a major issue. Enzymes may be sensitive to such properties as temperature, pH, and the use of solvents which make their action limited in industrial processes in the long run. Moreover, enzymes are highly selective in order that the wanted reaction takes place with minimum side reactions. Thus, the future research in enzyme engineering and optimization is required for the improvement in bio catalytic reactions. Biocatalysts is already able to provide products with high enantioselectivity, improve enzyme stability and enhance their tolerance to extreme reaction conditions, allowing a broad expansion of its application in essentially all branches of the chemical industry and becoming the foundation of environmentally friendly production (Albayati *et al.,* 2024). Thus the enzyme bio catalysis appears as a major paradigm shift in asymmetric synthesis providing higher efficiency, ecofriendly and selective transformations. Recent technologies like artificial enzymes, non- conventional media and flow chemistry have provided the new dimensions of the bio catalysis to produce the high value chiral compounds. Despite this, continuous progress in enzyme fine-tuning makes it possible to continue the growth of the bio catalysis application sphere in the pharmaceutical, agrochemical, and many other fields.

Trends in Drug Target Identification and Validation

The field of drug target identification and validation is evolving fast, mostly due to progressions in genomics, proteomics, and – new-age approaches to drug target identification that include the use of the venerable CRISPR-Cas9 system inter alia. These innovations are more effective in direction of new targets, this enhances the validation and therefore leading to enhanced therapeutic results. In the next section, we expand some of the significant trends shaping this progression in drug discovery.

Advancements in Genomics and Proteomics

- **High-Throughput Technologies:** New generation sequencing and other high through put technologies and proteomics are the some of the techniques that are changing the way targets for drugs are being discovered. These technologies allow researchers to work through large amount of biological data within significantly short span of time. For instance, the next-generation sequencing approach can detect genetic change or differential gene expression associated with several diseases. This ability can help to distinguish new targets that had been previously beyond the means to sense and distinguish which could help advance treatments (Hassan, 2023).
- **Human Genetics Integration:** The identification of novel drug targets is becoming more dependent on human genetics. Sites such as Open Targets link genetic data from big genomics projects to determine which of the predicted drug targets are worth researching. These platforms also afford the opportunity to determine which targets are most likely to produce therapeutic outcomes given diverse inputs of genomic, epigenomic and transcriptomic data. These combined considerations guarantee that the selected targets are not merely scientifically relevant but are valid for the disease process as well (McDonagh *et al.,* 2024).

CRISPR-Cas9 and Gene-Editing Technologies

- **Target Validation:** CRISPR-Cas9 technology has advanced mainly in drug target validation. This tool will help geneticists to modify the DNA of living organisms in a process that can permit targeting those genes with interest and noting the changes in their phenotypes. That is important for acknowledging or negation of involvement of specific gene in the disease pathways. Experiments which involve knocking out certain genes or activating particular genes in model organisms simply checks whether hitting on that gene will address the problem (Francis *et al*., 2024).
- **Functional Genomics:** Functional genomics, the study of all aspects of gene and gene product function in the organism, is also facilitated by CRISPR-Cas9. This technology can be used for functional studies that validate the position of distinct genes in disease progression. For instance, with help of undermining modifications in the genes and then observing the impact of such alterations on particular disorders, researchers may offer improved and more solid proofs of a gene's link to a certain illness. This increases confidence in drug targets and increases the probability that developed therapies against the targets will work (Francis *et al.,* 2024).

Multi-Omics Approaches

- **Integrated Data Analysis:** Multi-omics are one of the most interesting areas of drug target identification that use genomic, transcriptomic, proteomic, and other "omics" data. By combining such diverse steps in disease, different datasets provide researchers with comprehensive approaches targeting the relevant biological systems. This approach used in the discovering of the molecules and pathways that can be targeted for therapeutic purposes. Multi-omics analysis can also show how the differing mechanisms work together in relation to disease, and enable the selection of more suitable targets (Du et al., 2024; Mukherjee *et al*., 2024).
- **Machine Learning Applications:** Another development that is interesting is the integration of machine learning and multiple types of molecular data. The deep learning model can process large datasets from different sources and determine which other targets are most likely affect disease pathways. By training algorithms from genomics, transcriptomics, and proteomics datasets, researchers will increase the ability to accurately identify desired targets. This in turn helps increase the speed with which potential targets are pinpointed, and speeds the drug development cycle (Mukherjee *et al.,* 2024). Although technology advancements in this field provide lots of opportunities, there are yet many challenges involved in it. For example, diseases usually have complicated causes with multiple genes and environment, rendering a unique target difficult to identify. In addition, large volumes of data generated by high throughput technologies, multi omics analysis, gene editing demands robust computational tools and systems for proper analysis of data. However, there remains a considerable hurdle to develop these tools, along with overcoming the complexity of disease mechanisms. However, the combination of these technologies has completely overhauled the drug discovery process and as the technologies continue to evolve, they are poised to further optimise efficiency and precision in therapies. Thus, the future of drug target identification and validation has become more and more data driven, with genomics, proteomics, CRISPR/Cas-9, and machine learning at the root of how and when we will identify and validate drug targets that can completely change treatment strategies.

Challenges and Future Directions in Drug Discovery

The drug discovery field is dynamic and complex, and presents many challenges that must be met in order to ensure the optimal realization of its potential. It includes overcoming limits of existing approaches, dealing with regulatory and ethical considerations and explorations of new practices that can change drug development landscape. Systematic analysis and resolution of these issues would improve patient outcomes and shorten the drug development pipeline.

Limitations in Current Drug Design and Synthesis Methodologies

Outdated Methodologies in Traditional Drug Design

Conventional medicinal chemistry has utilized approaches that are now considered dated and does not make provision of maximal use of current technological development. For example, these methods often rely on a manual

approach or are time-consuming, and, therefore, less accurate than computational skills. These inefficiencies can hold up the identification of potential drug candidates especially in complex diseases where speed is of the essence (Flower, 2022).

Challenges in AI-Driven Drug Design

Officials and geeks celebrate AI as a revolutionary technique in drug discovery, but it comes with some problems. Although many chemical structures can be created within a short timeframe by using various AI algorithms, the approaches to synthesizing these molecules and analyzing their biological efficacy require significant amounts of time and money. These bottlenecks are explained by the fundamental weaknesses of AI tools that still rely on trial-and-error approaches to the experimental verification of designs (Liu *et al*., 2023).

Inadequate Molecular Screening Metrics

This is normally the case since current molecular screening methods do not always give a list of the best drug candidates. For instance, normal screening often employs metrics that exclude important cutoffs such as drug likeness and molecule effectiveness. More sophisticated approaches for Mol Filter GAN have been developed to fill this gap, but their use demonstrates the absence of adequate filtering methods in drug discovery that require a smooth integration of AI.

Regulatory and Ethical Challenges Ethical Concerns in AI Integration

The rather swift adoption of AI solutions within the drug discovery processes raises major ethical issues. There is one crucial concern in the case of AI – where to get the enormous amount of data necessary to train these systems? At many times, this information also contains details about patients and there arise issues of privacy, consent, and ownership of the patients' data. Furthermore, as decision-making in healthcare is gradually shifted into AI more attention should be paid to the fairness, interpretability and accountability of algorithms (Khan et al., 2024).

Evolving Regulatory Frameworks

Current set up of laws and regulations is insufficient to measure up to the rates of change that is being exhibited by AI and other technology in bringing about changes in the drugs discovery process. For example, currently existing regulatory frameworks aimed at analyzing new drugs invented using standard methodologies are incompatible with approaches based on artificial intelligence since they do not allow determining their safety, effectiveness, and replicability. It was noted that today there is no regulation of AI technologies as such, and the number of rules and acts provided for their functioning is insignificant; however, considering the existing trends and risks, there is an urgent need for specialized legislation that would ensure the safety and compliance with ethical norms of specific AI technologies without hampering their development (Khan *et al.,* 2024).

Future Prospects in Drug Discovery

Personalized Medicine

A new type of new drug discovery is still in the future when drugs will be discovered to respond to the patient genotype, philosophy and conditions of living. It holds a lot of potential to enhance the efficiency of therapy dramatically by targeting those remedies that are unique to particular patient, rather than singular remedy for a disease. However, following the recent development of genomics and bioinformatics, researchers are now approaching this goal (Doytchinova, 2022).

Development of Multi-Target Therapies

Conventional drugs can treat only one disease pathway, and multi-target therapy is a concept of drugs that can engage many pathways at once. In this regard, these therapies can be significant, and especially, used in the treatment of various chronic diseases such as cancer and NDs since the single target is not enough in such cases. There is a clear informative significance of studies on hybrid molecules – the compounds containing different therapies together – in terms of increasing treatment potentialities (Doytchinova, 2022).

Importance of Interdisciplinary Collaborations Bridging Disciplines for Innovation

Given the complexity of problems that the field of drug discovery poses, cross-disciplinary collaborations is emerging as a common feature. Scientists join together from various disciplines for example in biology, chemistry, computation and engineering which make their problem solving to be more thorough. Such collaborations help to boost innovation and create the conditions for finding better approaches to research (Askr *et al*., 2022).

Enhancing AI Integration Through Collaboration

To attest it, AI-supported drug discovery requires the integration of different fields of specialization. For instance, computational scientists can design and deploy AI instruments, but one needs the advice of a pharmacologist, chemist, and biologist to enhance augment such tools for pragmatic utilization. Cooperation guarantee that AI intangible assets are deployed, optimising their contributions to the advancement of drug discovery at the least compromise of scientific credibility (Askr *et al*., 2022).

CONCLUSION

This field of drug design and synthesis has been experiencing remarkable growth or development and new trends and methods defining it are surmounting old problems the traditional methods. Themodern techniques of genomics, proteomics and multi-omics have enhanced the concept of target identification and validation to a certain extent. CRISPR-Cas9 and artificial intelligence are some of the technologies that have pushed the frontiers on precision medicine and / or hybrid molecules in the course of drug discovery. These developments do not only serve the purposes of enhancing drug development, in terms of effectiveness, speed, and cost, but also the potential of promoting patient needs that remain unmet in this area. However, there are huge obstacles still present today. These include possible limitations in existing approaches, ethical factors and regulatory concerns that serve to remind patients and researchers that the development of these advancements continues after their implementation. AI and machine learning by extension has proven pivotal in so many applications yesterday, today and in future but this comes with certain inherent challenges that can only be trained by integrating best practices concerning data reliability, security, and replicability. The findings acquired from the latest developments underscore the importance of the need to incorporate the production of a high interdisciplinary collaboration to eradicate those barriers. As a result of solving the emerging tensions between computational sciences, molecular biology, and clinical research, the pharmaceutical enterprises are in a position to open new channels. New investment in early research and embracing innovation imperative are critical to keep the trajectory moving forward and adapt to the challenges of present day drug development. Therefore, the future of the drug design and synthesis will be governed by the convergence of superior methods in coordination with sound ethical principles and legal requirements. As a result, this will spur novation in the production of the drug, while promoting the development of safe, effective, and affordable drugs for humanity.

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REVIEW ARTICLE

Review on Abnormal Antibody Development and Identification in Blood Transfused Recipients

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ABSTRACT

Abnormal antibody formation against red blood cells (RBCs) in blood transfusion recipients is a significant clinical challenge, often leading to transfusion-related complications such as hemolytic transfusion reactions and delayed serological incompatibility. This comprehensive review aims to explore the mechanisms underlying alloantibody and autoantibody development in patients receiving blood transfusions. Alloimmunization occurs when the recipient's immune system recognizes donor RBC antigens as foreign, leading to the production of antibodies, particularly in individuals with multiple transfusions, such as those with sickle cell disease or thalassemia. Factors influencing antibody formation include antigenic differences, immunogenetic factors, and the frequency of transfusions. Autoantibody formation, though less common, is associated with underlying autoimmune disorders and can complicate serological testing and transfusion management. The identification of abnormal antibodies requires advanced laboratory techniques, including direct and indirect antiglobulin tests, and specialized panels to detect and differentiate between allo- and autoantibodies. This review also discusses the clinical

implications of these antibodies, emphasizing the importance of accurate identification and the use of compatible blood products to prevent adverse outcomes. Understanding the pathophysiology and diagnostic approaches to antibody formation is essential in improving transfusion safety and outcomes for patients who require repeated or chronic transfusions.

Keywords: Abnormal Antibodies, Identification of abnormal antibodies, Types of abnormal antibodies, Blood Transfusion Recipients, Risk Factors.

INTRODUCTION

Naturally occurring anti-A and anti-B antibodies are the most common red cell antibodies present in human serum or plasma. All other red cell antibodies are referred to as unexpected antibodies (1). The presence of these unexpected antibodies can lead to various adverse reactions during blood transfusions, including mild symptoms like fever and chills, and in severe cases, potentially life-threatening hemolytic transfusion reactions (2, 3). Antibody detection is a critical aspect of transfusion medicine, as it helps identify irregular or unexpected antibodies. The detection of these antibodies is essential because their presence is a major factor in the occurrence of hemolytic transfusion reactions, posing a serious risk to patient safety (4). Abnormal antibodies, often called irregular antibodies, are so named because their presence and type are not known until an antibody screening test is performed. This group encompasses most blood group antibodies, excluding ABO and certain P blood group antibodies. While some of these antibodies develop naturally, the majority are produced as part of the immune response following exposure to foreign antigens, such as those encountered during pregnancy or blood transfusions. These antibodies can lead to both acute and delayed hemolytic transfusion reactions, with numerous documented cases highlighting their potential severity (5, 6). The detection of alloantibodies is crucial for future transfusions as their presence can lead to hemolytic transfusion reactions, either acute or delayed, and can complicate the process of finding compatible blood units(7). Patients who receive multiple transfusions are at greater risk of developing alloantibodies due to repeated exposure to foreign antigens. This repeated exposure triggers an immune response, often becoming more pronounced after the second encounter, leading to a range of clinical consequences depending on the type of blood cells and antigens involved(8). Unexpected erythrocyte antibodies can belong to either the IgG or IgM class and can lead to agglutination, hemolysis, or sensitization of red blood cells. Clinically significant antibodies are mostly of the IgG type, which react at 37°C. In contrast, IgM antibodies show optimal reactivity at temperatures of 22°C or lower (9). Anti-erythrocyte antibodies are classified based on their clinical significance. Clinically significant antibodies include Rh (C, E, c, e), Kell (K, k, Ku), Duffy (Fya, Fyb, Fy3), Kidd (Jka, Jkb, Jk3), Diego (Dia, Dib, Wrb), and MNS (S, s). These antibodies are typically associated with adverse reactions in blood transfusions. Antibodies with variable clinical significance include MNS (U, Vw, Mur), Vel, Ge, Yta, and Hy, as their effects may differ depending on the context. Antibodies that are usually not considered clinically significant include Lutheran (Lua, Lub), Lewis (Lea, Leb), MNS (M, N), A1, P1, and Cw, as they rarely cause transfusion reactions. Lastly, there are antibodies with unconfirmed significance, such as Chido/Rodgers (Cha, Rga), JMH, Bg, Csa, and Xga, for which the clinical impact is not fully established (10).

Development of abnormal antibodies in transfused Recipients

Each year in the United States, more than 11 million red blood cell (RBC) transfusions are administered, making transfusion the most frequently performed procedure during hospital stays(11,12). Recent studies on transfusion thresholds have demonstrated that using restrictive hemoglobin levels is as safe, if not safer, compared to liberal thresholds for various patient groups and clinical situations. This evidence has contributed to a reduction in the number of RBC units transfused over the last ten years. Despite the overall decrease in transfusion rates, the development of alloantibodies against transfused blood products continues to pose a significant clinical challenge (13).When a patient requires a blood transfusion, red blood cell alloimmunization is typically identified. The patient's blood sample is typically examined for unexpected alloantibodies during pre-transfusion testing [14].The specificities

most commonly observed in alloimmunized patients in Western Europe and the United States are antibodies against antigens of the Rh and Kell blood group systems (15-18).Although every transfused red blood cell (RBC) unit contains hundreds of foreign RBC antigens, only a small percentage of recipients will develop detectable RBC alloantibodies. For an alloantibody to form, two key conditions must be met: one is the recipient must be exposed to a foreign RBC antigen, and second, the individual must have a specific HLA-binding motif that can present part of that foreign antigen. Various HLA types are capable of presenting different portions of RBC antigens that have been studied(19-26). Unlike human platelet glycoprotein antigen 1a (HPA-1a), which is closely linked to the HLA class II allele DRB3, RBC antigens are not restricted to a single HLA type for presentation(27).While all transfused RBC units contain foreign antigens and nearly all recipients have HLA-binding motifs capable of presenting parts of these antigens, additional factors influence who will form RBC alloantibodies. For example, it's estimated that over 99% of transfused individuals have the potential to develop at least two RBC alloantibodies due to mismatches between donor and recipient antigens and the prevalence of RBC antigens in the population. The likelihood of alloimmunization increases with the number of transfusions but eventually levels off once a person has been exposed to most of the "non-self" blood group antigens. Despite this potential, retrospective studies show that only 2% to 5% of the general populations receiving transfusions actually develop detectable RBC alloantibodies (28).

Clinical significance of abnormal antibodies

Depending on the circumstances, transfusion of red blood cells expressing an antigen that the recipient possesses alloantibodies against can have different clinical outcomes. For the duration of the transfusion recipient's life, some RBCs that appear to be incompatible may always circulate in them. Other RBCs, such as DHTRs, on the other hand, might be entirely eliminated a few days following the transfusion. The clinical team may notice a hemoglobin that returns to its Pretransfusion level, a fever, or dark urine in DHTRs. RBC alloantibodies increase the risk of transfusion-related problems in some patient populations, especially those with sickle cell disease (SCD). In this patient population, DHTRs with bystander hemolysis (also called hyper hemolysis), which involves the destruction of both the patient's own and transfused red blood cells, are a very dangerous and potentially fatal consequence. (29-31). Anti-M is a commonly found antibody of the MNS blood group system, but anti-N is very uncommon. They have relatively little clinical significance and are only rarely linked to HDN or HTR (32). In HDN, Lewis antibodies are rarely implicated. The widely mentioned high incidence of IgM type Lewis antibodies is not the main cause; rather, it is attributed to the inadequate expression of Lewis antigens on fetal cells. Nevertheless, moderate HDN cases have been linked to both anti-Lea and anti-Leb (33-34). Haemolytic disease of the fetus and the newborn (HDFN) is a condition in which the trans placental passage of maternal antibodies causes immune hemolysis of fetal/neonatal red blood cells by either anti-A and anti-B or unexpected immune antibodies that develop after sensitizing events like transfusion or pregnancy. Some of these antibodies may cross the placenta in pregnant women. (35)

Laboratory identification of abnormal antibodies

Antibody detection involves a number of procedures aimed to classify any autologous reactivity, evaluate the temperature for optimal antibody reactivity, and exclude and validate specific antibodies. Red blood cell antigen typing can also aid in antibody detection by identifying the RBC antibodies and the people who are most likely to produce them. Lastly, because it relies on the magnitude of the antibody inquiry needed, the time necessary to finish antibody identification varies greatly. (36)For routine alloantibody detection and identification, compatibility testing, and the direct antiglobulin test, the column agglutination technique was used with the ID-card LISS/coombs with six microtubes of the DiaMed-ID Microtyping System that contained polyspecific antihuman globulin AHG (rabbit anti-IgG and monoclonal anti-C3d) within the gel matrix(37). When the auto control and/or direct antiglobulin test (DAT) results were positive, the expected red cell antigens, such as E, e, Jka, Jkb, Fya, Fyb, Dia, and MNS7, were subsequently determined by red cell genotyping utilizing in-house multiplex PCR (38).To determine the specificity of antibodies, antibody identification was then carried out in CAT using a commercial 11-cell panel (Diapanel Biorad, Switzerland)(39). Traditionally, agglutination techniques in the tube are used for red cell antibody screening and identification. Newer detection methods, such different gel formats, have been created and authorized recently, are commercially available for use in blood banks, and are becoming more and more well-liked(40, 41)Gel techniques for

red cell antibody detection and compatibility testing have become a mature and well-understood technology since their introduction. It is suitable for the majority of blood type serology tests, is standardized, relatively easy to conduct, and, in contrast to tube methods, yields stable, transparent reactions that enhance result interpretation (42).

Causes and Risk Factors for Abnormal Antibody Development

Alloantibodies against one or more red cell (RBC) antigens may develop as a result of repeated blood transfusions, making subsequent transfusions more difficult (43). The recipient's immune response, antigen immunogenicity, and the quantity and frequency of transfusions all affect the likelihood of alloimmunization. There have also been reports on the impact of donor and recipient ethnic and antigenic pattern differences (44).The immune system of the recipient mediates many of the negative effects of blood transfusions. Typically, there are three stages in which this and other immune responses develop:

a. The immune system recognizes foreign substances, called antigens.
b. The antigen is processed by the immune system.
c. To eliminate the antigen from the body, the immune system launches an attack (45).

Numerous autoimmune conditions, such as systemic lupus erythematosus, rheumatoid arthritis, primary biliary cirrhosis, multiple sclerosis, autoimmune hepatitis, drug-induced lupus, autoimmune thyroid disease, and type 1 diabetes, are characterized by the presence of autoantibodies. It is obvious that both the environment and genetics have a big impact on tolerance loss (46-54). The destruction of a person's own red blood cells (RBCs) due to the presence of autoantibodies that target them is known as autoimmune hemolytic anemia (AIHA) (55-62).Nearly all red blood cells have antigens that autoantibodies typically target, and a direct antiglobulin test (DAT) can help with the diagnosis(57).

Frequency of occurrence of abnormal antibodies in variety of population

Even after Rhesus (Rh) D prophylaxis was introduced fifty years ago, obstetricians and blood transfusionists still face the difficulty of red cell immunization during pregnancy. Anti-D prophylaxis had raised hopes that the last stages of life would be free of hemolytic disease of the fetus and newborn (HDFN) caused by D antigen incompatibility. In addition to the D antigen, other blood group antigens from the Rh system (C, c, E, e, and Cw) as well as other blood group systems have gained attention. Pregnancy-related alloimmunization has been thoroughly investigated in many parts of the world, and the prevalence has been reported to range between 0.4% and 2.7% globally (63-74).

3,577 multidimensional women were examined for the presence of alloantibodies during the study period. The most prevalent phenotype in relation to the two main blood group systems (ABO and Rh) was B positive. Which shows that 394 women (11.0%) were D antigen-negative and 3,183 women (88.9%) were D antigen-positive. The prevalence of alloimmunization was 1.2% overall (45/3,577), with 51 antibodies found in 45 patients. Compared to research conducted in the West, our study found that Rh-negative women had a significantly greater rate of alloimmunization. The absence of widespread and standardized anti-D immunoprophylaxis in India is the cause of this. Anti-D, which accounted for 78.4% of all alloantibodies in our study, is thus still the primary cause of alloimmunization in our nation(75). Patients with Chronic Renal Failure (CRF) who require frequent blood transfusions frequently have the problem of red blood cell alloimmunization (76).Alloantibody production is triggered by an immune reaction brought on by the recipient's and donors genetic differences.

The recipient's immune condition, the dosage, the mode of administration, and the immunogenicity of the antigen are other variables that affect the production of alloantibodies (77-79).Many studies have shown that people with chronic renal failure are susceptible to alloimmunization; one research by Mervat Mostafa Azab *et al.* found that 9.5% of patients who received numerous transfusions had this condition(80). However, Domen and Ramirez (81) reported a low rate of antibody production (6.1%) in the same group of patients, and Shukla et al. (82) reported an RBC alloimmunization rate of 9.8% in patients with chronic renal failure receiving hemodialysis. The study included 301 individuals in total, all of whom underwent antibody screening. This comprised 62 female patients and 239 male patients. With a mean age of 43.6 years, the patients ranged in age from 12 to 79. A total of 1636 transfusions were performed, with an average of 5.5 blood units per patient, ranging from 3 to 16. 51 out of 301 patients, or 16.9% of all patients, had alloantibodies found in them (83).Since blood transfusions quickly increase a patient's ability to carry

oxygen when they have symptomatic anemia, they may be life-saving in cases of chronic kidney disease (CKD). However, alloimmunization and transfusion-transmissible infections (TTI) are possible side effects, particularly in patients who have received many transfusions. Similar to other findings, there were more men with CKD in our sample than women (82).Because of this, the reported frequency of alloantibody generation varies greatly across the globe, ranging from 1.13% to 40.4% (84). This study's 3.1% alloimmunization risk falls within the literature's reported range of 0.5 to 5.9%(85-87). Out of 22,436 cases, 340 (1.52%) had positive results from unexpected antibody screening tests. Of the individuals who tested positive for unexpected antibodies, 243 had surgery(88).

Future direction and emerging research

For many years, patients with both acute and chronic anemia have been treated with red blood cell (RBC) transfusions. One of the most popular medical procedures carried out in the developed world nowadays is transfusion (89).Depending on the patient's clinical condition and short- and long-term prognosis, the decision to undertake a medical operation poses different challenges in terms of its risks and advantages Therefore, a planned strategy is advantageous to reduce side effects like erythrocyte alloimmunization.(90). The use of DNA-based molecular techniques in transfusion medicine has been made possible by the age of genomics. The majority of the genes controlling blood group systems have now been cloned and sequenced, and DNA technology has helped to understand the molecular basis of many common blood group antigens(91).Currently, DNA analysis can be used in a variety of clinical settings. Finding rare RhD blood group antigen variants, genotyping donors for specific antigens (like Dombrock) that are difficult to determine due to antisera unavailability or weak potency, identifying RHD type fetuses (like a fetus carried by a RhD negative mother) without invasive procedures, identifying which phenotypically antigen-negative patients can receive antigen-positive RBCs, type donors for antibody identification panels, type patients who have an antigen that is expressed weakly on RBCs, and resolving A, B, and RhD discrepancies are all made easier with its help. It has been used more recently to screen large numbers of donors for antigen-negative people(92, 93) In recent years, the use of monoclonal antibody (MoAb) therapy for hematologic malignancies has grown. The FDA authorized rituximab as the first monoclonal antibody in 1997 for the treatment of cancer(94).Since then, over 25 MoAbs have been used as treatments for hematological and solid disorders in clinical settings (95).MoAbs anti-CD38 and anti-CD47 are immunoglobulins that target highly expressed epitopes on platelets and red blood cells (RBCs). They have the potential to unchain hemolytic anemia and, as an off-target consequence, interfere with pre-transfusion compatibility testing (96).In the age of novel medications, monoclonal antibodies are becoming more and more common. One off-target impact of some MoAbs has been the emergence of interferences in pre-transfusion testing. Perhaps anti-CD38 and anti-CD47 are only the beginning (97). Initiatives in personalized medicine, also known as precision medicine, have expanded globally in recent years.One could argue that since the beginning of this life-saving medical procedure, transfusion medicine has been connecting donors and recipients (98)As a result, the majority of transfusion medicine research over the past 20 years has focused on (i) storage lesion and (ii) testing and prophylaxis for pathogen safety of all blood products. A number of mechanisms behind the so-called storage lesion have been clarified by this body of research, and clinical trials have raised concerns about whether the age of stored blood units is linked to inadequate clinical outcomes for transfusion patients (99,100).

DISCUSSION

Abnormal antibody development in transfused recipients remains a critical concern in transfusion medicine. The immune system's response to foreign antigens can lead to alloimmunization, resulting in adverse transfusion reactions and complications in future transfusions. The formation of these antibodies depends on multiple factors, including the recipient's immunogenicity, transfusion history, and the antigenic profile of transfused red blood cells (RBCs).Studies have shown that patients with chronic transfusion needs, such as those with sickle cell disease, thalassemia, and hematologic malignancies, are at a higher risk of alloimmunization. The identification of these antibodies is crucial to ensuring the provision of antigen-compatible blood, thereby minimizing hemolytic transfusion reactions. Conventional serological methods, such as the indirect antiglobulin test (IAT), remain the

cornerstone of antibody detection, but molecular techniques, including genotyping, have enhanced precision in identifying alloantibodies and predicting potential incompatibilities.The challenge of identifying clinically significant antibodies remains an ongoing issue, particularly in polytransfused patients who may develop multiple alloantibodies. The adoption of extended antigen matching strategies and prophylactic antigen screening in at-risk populations can mitigate the risks associated with alloimmunization. Moreover, emerging technologies, such as next-generation sequencing (NGS) and artificial intelligence-driven predictive models, are paving the way for more precise and individualized transfusion practices.

CONCLUSION

The development of abnormal antibodies in transfused recipients poses significant challenges to safe and effective transfusion therapy. The identification and management of these antibodies require a combination of serological, molecular, and clinical strategies to ensure optimal patient outcomes. While traditional methods remain valuable, technological advancements in immunohematology provide new avenues for improved antibody detection and transfusion compatibility. A multidisciplinary approach, including collaboration between transfusion medicine specialists, hematologists, and laboratory professionals, is essential for effective antibody identification and management. Future research should focus on refining predictive models for alloimmunization, expanding antigen-matching strategies, and integrating advanced molecular techniques to enhance transfusion safety. By implementing proactive screening measures and leveraging novel diagnostic tools, healthcare providers can reduce transfusion-related complications and improve patient care outcomes.

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RESEARCH ARTICLE

Lower Limb Gait Intend Detection using Machine Learning Techniques

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ABSTRACT

Gait intend detection is a vital aspect in the development of prosthetic device, particularly in identifying different gait phases and bringing out the difference in normal and transfemoral amputations. Various research has been performed to study of the gait intend and classification of those to enhance the application of prosthetic device. In the present work, electromyography (EMG) and inertial measurement unit (IMU) data are acquired from normal volunteers in the thigh muscles such as biceps femoris, rectus femoris, semitendinosus and vastus medialis. The acquired data are pre-processed and time-domain features were extracted. An analysis is done to study these anterior and posterior muscle functions that are significant with the gait phases. Using the features, Hidden Markov Model (HMM) and Long short term memory (LSTM) were employed to predict intended gait phases. This advanced approach holds great potential to significantly improve the user experience and overall quality of life for individuals with lower limb amputations.

Keywords: Transfemoral prosthesis, Electromyogram, inertial measurement unit (IMU) sensor, Hidden Markov model (HMM), Long Short Term Memory (LSTM)

INTRODUCTION

The detection of gait intent in lower limbs is crucial for various applications, including prosthetics, rehabilitation, and robotics. Hidden Markov Models (HMMs) are widely used in this domain due to their capability to model temporal sequences. HMMs are frequently highlighted for their suitability in recognizing temporal patterns in gait sequences. Studies in [1] emphasize the model's effectiveness in capturing dynamic state transitions inherent in human gait cycles. This theme reflects the HMM's robustness in modeling spatiotemporal patterns, a critical requirement for reliable intent detection. Another significant theme is the integration of HMMs with advanced sensors, like inertial measurement units (IMUs) and electromyography (EMG). For instance, Vu & Huong in [2] reported improved accuracy in gait detection using a hybrid model combining HMMs with IMU data. This integration underscores the trend towards multimodal sensor fusion to enhance prediction accuracy.EMG signals are harnessed for understanding muscle activation patterns. Phinyomark *et al.* [3] highlight how combining EMG with machine learning enhances phase classification accuracy. Existing literature, including work by Hargrove et al. in [4], examines the application of HMMs for intent detection in powered prosthetics. There are numerous machine learning techniques performed to classify the gait phases [5, 6]. The adaptability of HMMs in machine learning environments is noted as a significant advantage for developing intuitive prosthetic control systems, enabling real-time response to user intent [7, 8].

METHOLODOLOGY

Experiemental setup

Data is collected to identify lower limb gait intent patterns from 20 healthy individuals aged 19 to 21, who were the intended group of volunteers. The activity of the thigh muscles is recorded using BIOPAC MP45 acquisition software, with a predetermined sample rate and frequency range, to capture EMG data in a controlled environment with minimal noise. The vastus medialis (channel-1), rectus femoris (channel-2), biceps femoris (channel-3) and semitendinosus (channel-4) were the four muscles from which EMG is recorded (Figure 1). For individuals with normal gait, EMG data is collected every 40 seconds which each gait cycle lasted for 5 seconds. Simultaneously, the IMU hardware interface calculated acceleration and gyroscope values [9, 10]. The current study introduces a method for gait intent detection by utilizing EMG (Electromyography) and IMU (Inertial Measurement Unit) features, focusing on analyzing both muscle activity and movement dynamics to identify a person's intended gait phase or action. As illustrated in Figure 2, the complete block diagram of the proposed methodology is presented. The acquired EMG signals are filtered using bandpass filter in the range 20-500 Hz and envelope is detected to extract time domain features. Fifteen time domain features such as average energy (ae), variance (var), standard deviation (sd), skewness (skew), interquartile value (iqav), mean absolute deviation (mad), mean absolute value (mav), variance of emg (jvar), root mean square (rms), enhanced mean absolute value (em), mean value of the square root (mvs), kurtosis (kurt), integrated emg (iemg), simple square integral (ssi) and absolute value of the summation of square root (avss) are extracted. The features help in analyzing the muscle activity in every gait phase. From the IMU, accelerometer and gyroscope values and their respective angle measurements were noted. Both EMG and IMU features are integrated and fed into machine learning models in order to train model for each gait phase. Out of 20 subjects, 15 subject data were used for training and the remaining were used in testing to predict gait.

CLASSIFIER

HIDDEN MARKOV MODEL(HMM)

Hidden Markov Models (HMMs) are mainly used in sequential detection that represent the probabilistic relationships between various phases of gait. In gait detection, the hidden states in an HMM correspond to different gait phases, such as heel strike, loading response, toe-off, terminal swing, pre-swing and terminal stance, each representing a specific phase of the gait cycle. The observed data, such as features extracted from EMG signals and IMU sensors, serve as inputs to the HMM, as depicted in block diagram Fig 3. These observations capture muscle activity and limb movements associated with each gait phase. The parameters of the Hidden Markov Model

(HMM)—such as the probabilities of starting in each state, the transition probabilities between different gait phases, and the emission probabilities that represent the chance of observing specific features given a gait phase—are determined using methods like the Baum-Welch algorithm. To forecast the most likely sequence of hidden states (gait phases) based on the observed data, the HMM employs the Viterbi algorithm, which finds the sequence of states that best explains the observed data. Additionally, by analyzing the sequence and transitions among gait phases, the HMM can Infer the user's gait intentions.

LONG SHORT TERM MEMORY (LSTM)

Long Short-Term Memory (LSTM) networks, which are a specific type of recurrent neural networks (RNNs), are particularly effective for tasks involving sequence prediction, such as recognizing and classifying gait intent. They excel in capturing the temporal patterns present in electromyography (EMG) and inertial measurement unit (IMU) data, which are crucial for detecting shifts between different gait phases, including stance and swing. The structure of the LSTM network includes several LSTM layers, as shown in Fig 4. Each layer contains units (cells) that process the input sequence one time step at a time. The cell state and hidden state are updated at each step to maintain information over time. The Cell State represents the "memory" of the LSTM, carrying information from previous time steps. Forget Gate decides what information to discard from the cell state. Input Gate determines which new information should be added to the cell state. Output Gate controls what information from the cell state is used to compute the hidden state and output. Output Layer after processing the entire sequence, the LSTM outputs a prediction for each time step or a classification for the entire sequence. This output represents the detected gait phase (e.g., stance, swing) or the overall gait pattern.

RESULTS AND DISCUSSION

A 3D stacked heatmap is a powerful visualization tool that can help in comparing various gait phases by providing a detailed and intuitive representation of how different muscle activities (from EMG data) and motion dynamics (from IMU data) vary across time. EMG from the vastus medialis, rectus femoris, biceps femoris, and semitendinosus muscles are recorded. Inertial data, such as acceleration and gyroscope values are recorded using IMUs placed on these muscles. Both EMG and IMU data are noted for six different gait phases, such as heel strike, loading response, toe-off, terminal swing, pre-swing and terminal stance. In the 3D stacked heatmap shown in figure 5, the X-axis represents gait phases for tracking how muscle activity and movement dynamics change throughout the entire gait cycle. Y-axis represents the different muscle locations (vastus medialis, rectus femoris, biceps femoris, semitendinosus). Z-axis represents different features or metrics derived from the EMG signals. Each cell in the heatmap is color-coded based on the intensity or magnitude of the metric being visualized and the values range between -1 and 1. From figure 5, it is observed that the vastus medialis showed higher activation during almost all the gait phases compared to other muscles. While the semitendonitis showed increased activity during the transition from stance to swing phase, vastus medialis and biceps femoris are activated comparatively less. This infers the significance of the muscles in each gait phase. Similarly, the vastus Medialis activated well for almost all the EMG features, whereas, the activation is signification for few of the EMG features in other muscles. IMU sensor values, specifically accelerometer and gyrometer readings, are highly beneficial in performing gait analysis. The combined data from accelerometers and gyrometers enable the precise identification of different gait phases, such as heel-strike, mid-stance, and toe-off. By analyzing the changes in acceleration and rotational velocity, specific moments within the gait cycle can be detected and studied, providing insights into how smoothly or effectively a person transitions between these phases. Table 1 refers the IMU sensor values in each gait phase. In gait analysis, which focuses on studying an individual's walking pattern, inertial measurement unit (IMU) sensors are employed to capture and integrate data on acceleration and angular velocity. This data is then visualized through graphs to analyze the dynamics of gait. The accelerometer readings capture the stimulus of gait phases, specifically stance and swing, over a 40-second duration (Figure 6). For the anterior muscles, such as the rectus femoris and vastus medialis, the accelerometer records values of ax, ay, and az. During the gait phase, the muscle movement speed ranges from -2.0 to 2.0. The x-axis acceleration varies between -0.5 and 1.0, while the y-axis acceleration typically falls between -1.5 and -

1.0. As muscle activation increases, the acceleration speed rises within the range of 1.0 to 1.5.Figure 7 illustrates the gyrometer readings that capture the stimulus of gait phases, specifically stance and swing, over a 40-second period. The gyrometer values for the anterior muscles, including the rectus femoris and vastus medialis, are represented along the axes ax, ay, and az. During these gait phases, the muscle movement speed ranges from -60 dB to 40 dB. The x-axis acceleration is recorded between 1 dB and 10 dB, while the y-axis acceleration typically falls between -60 dB and -50 dB. As muscle activation increases, the speed is observed to rise within the range of 1.0 to 1.5. Figure 8 presents the IMU sensor output for the accelerometer readings from the posterior muscles such as biceps femoris and semitendonitis. During the gait phase, the muscle movement speed along the x-axis acceleration ranges from -0.5 to 1.0, while the y-axis acceleration varies between -1.5 and -1.0. As muscle activation increases, the acceleration speed is observed to rise within the range of 1.0 to 1.5.Figure 9shows that during the gait phase, the muscle speed as measured by the gyrometer falls within specific ranges: the gyrometer x-axis values lie between 50 dB and 150 dB, the y-axis values range from 0 dB to 20 dB, and the z-axis values are between 0 dB and 10 dB.

Individuals participated in the study at their own walking speeds throughout the entire investigation. The methods examined are commonly used to detect gait events, but our co-simulation framework extends beyond a single family of algorithms. This framework is versatile and can be applied to explore additional gait event detection techniques, such as those based on Hidden-Markov Models (HMM), as well as more complex gait phase models that include additional phases. Across all stages of the 8-phase paradigm, the distribution of recognition errors remained largely consistent. Similarly, the LSTM classifier was utilized to predict gait patterns. Table 2 represents the accuracy of each classifier it has trained andtest with gait data. While this normal gait data is trained into these classifiers, the LSTM has performed with better accuracy. However, the assessment results demonstrate that the detection error events were unaffected by leveraging the contralateral side to facilitate gait event identification.

CONCLUSION

The identification of gait phases in the lower limbs will sustain the degree of gait cycle phases that meet predetermined criteria. To do this, the stages of machine learning mode are recognized. The models were tested using a 20% training dataset and a 70% validation dataset. The LSTM produced an accuracy score of 87.5%, whereas the classifier model produced a score of 85.3%. This strategy yields more precise lower limb gait phase detection findings.

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Table 1. IMU Sensor Values

IMU features	Heel strike	Loading response	Toe Off	Terminal swing	Pre swing	Terminal stance
Acceleration x value (m/s^2)	0.46	0.21	0.82	0.43	0.23	0.36
Acceleration y value (m/s^2)	1.79	1.02	1.25	1.94	1.57	0.96
Acceleration z value (m/s^2)	1.24	0.67	0.18	0.85	0.63	2.03
Gyrometer x value (dps)	20.4	3.2	0.67	9.02	5.76	2.6
Gyrometer y value (dps)	49.8	-1.77	4.42	2.5	10.47	10.99
Gyrometer z value (dps)	0.87	-2.85	9.59	52.6	1.78	0.65
Acceleration angle x (deg)	53.6	110.86	2.03	29.1	113.6	65.03
Acceleration angle y (deg)	11.8	-20.76	17.56	52.08	22.49	10.3
Gyrometer angle x (deg)	55.5	110.1	1.66	28.4	114.4	65.41
Gyrometer angle y (deg)	10.7	-20.5	17.3	18.6	24.9	9.51

Table 2 Performance Evaluation of Classifier

Classifier	Iterations	Time Elapsed	Accuracy
HMM Model	25	0.8 sec	85.3%
LSTM	35	0.6sec	87.5%

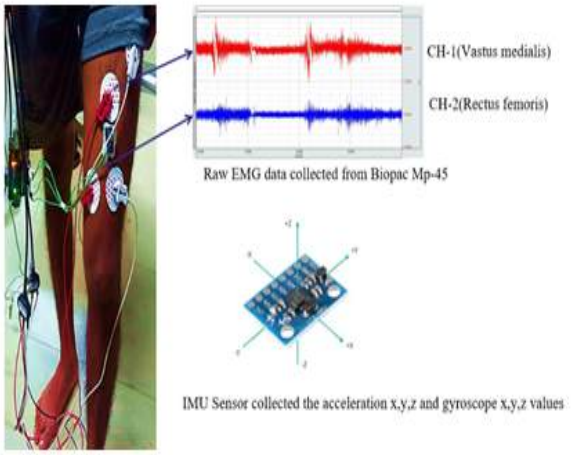


Fig1.EMG recoding in Channel 1 & 2 and Arduino interface with IMU sensor

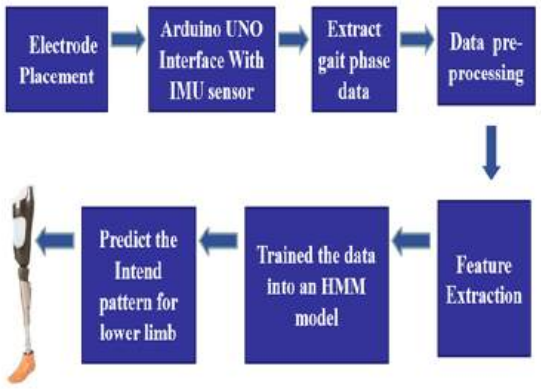


Fig. 2. Block Diagram for Proposed Methodology

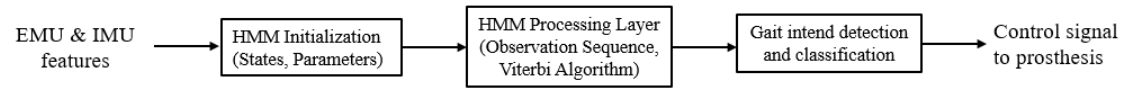


Fig 3. Block Diagram for HMM

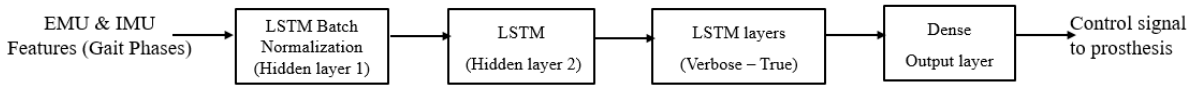


Fig 4.LSTM Network for Gait Classification

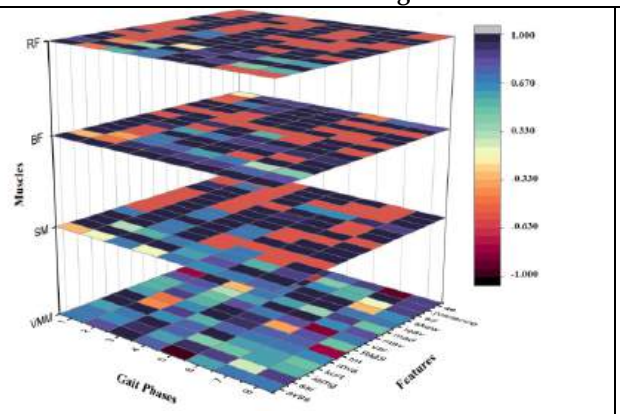


Fig 5. Comparison of muscle activation in each gait phase recognition using EMG features

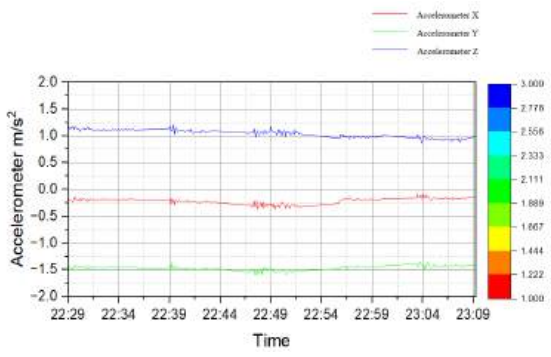


Fig 6. Anterior Muscle IMU sensor output for accelerometer.

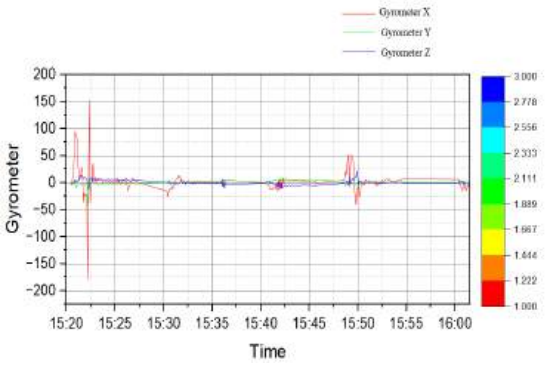


Fig 7. Anterior Muscle IMU sensor output for gyrometer

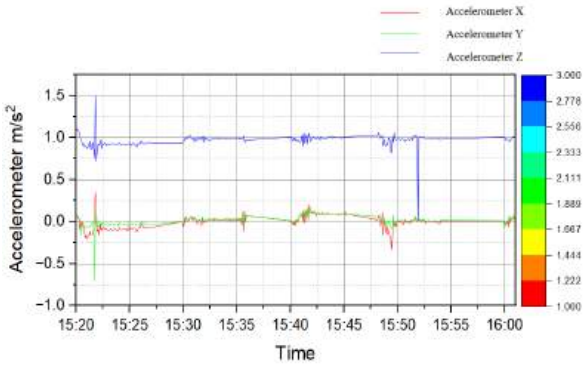


Fig 8. Posterior Muscle IMU sensor output for accelerometer.

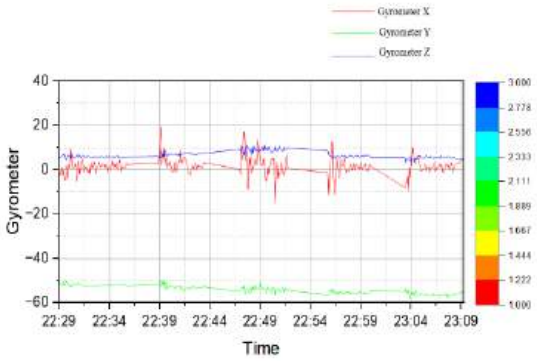


Fig. 9. Posterior Muscle IMU sensor output for gyrometer.

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RESEARCH ARTICLE

Single Blind Randamized Study to Evaluate Effectiveness of Constitutional Approach in Acid-Peptic Disorders by using Acid-Peptic Questionnaire

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ABSTRACT

Acid peptic disorders are one of the commonest disorders encountered in clinical practice, although not life threatening as other major illness. The symptoms can be distressing and cause discomfort to normal life. Diet habits including irregularity in food habits and rich food, junk food, smoking and alcohol also plays a major role in the causation of the disease in addition to psychological factors. According to Homoeopathy, it is the man who is sick and not his body and as a matter of fact he needs to be treated. It is here the concept of individualization comes into practice, where the physical as well as the mental characteristics of the individual is taken. This study has documented the prevalence, associated risk factors and the impact of this health issue along with homoeopathic constitutional medicine given to patient. An interventional single arm randomized study in the homoeopathic hospital to ascertain role of constitutional medicine in cases of acid peptic disorders was conducted by using of questionnaire. i.e., Acid peptic disorders. Total 35 patients with peptic ulcer disease were enrolled in the study. Majority of the patients were in 31-to-40-year age groups (48.6%). Mean age of the patients was 37.8years. Out of 35, 12 patients (54.0%) were female and 23 were male. Six patients (17.1%) were illiterate, 12 patients (34.2%) were educated up to secondary level. Total 27 patients (77.1%) were working in professional and semi-professional occupation and 4 patients (11.4 %) were unemployed. Socio economic status was categorised according modified Prasad's classification. Out of 35 patients, 10 (26.8%) and 10 patients (26.8 %) were belonged to lower middle and lower SE class respectively. Out of 35 patients, 19 and 5 patients were overweight and obese respectively. Only 18 patients (51.4 %) were getting sleep >8 hr / day. Total 6 patients were chronic smoker (> 14 a day) and 7 patients (20%) were heavy alcohol drinker. Out of 35 patients, 10 (29.0%) had marked improvement, 16 (46.0%) moderate improvement. Acid peptic disorders were observed in a person with high stress as a common health problem due to its prevalence, manageable nature and associated social psychological implications. After constitutional medicine

was given, out of 35 cases 29 cases were improved. 4 cases were not improved and 2 cases were withdrawn from the study. So it shows that Homoeopathic constitutional medicine has marked effect in APD.

Keywords: Acid-peptic disorders, constitution, Psychosomatic, Peptic ulcer, GERD, Gastritis, vagal hyper activity, food habits, neuro-endocrine, immunological, Individualisation

INTRODUCTION

Acid peptic disease by definition is a disorder of gastric and duodenal mucosal barrier due to hyper or hypo secretion of acid and pepsin into the gastric juice which result in destruction of mucosal and muscular layers of stomach and duodenum. Diet habits including irregularity in food habits and rich foods, smoking and alcohol also provides a major role in the causation of the disease in addition to psychological factors. Disease is an abnormal vital process, a changed condition of life, which is inimical to the true development of the individual & tends to organic dissolution [10]. Disease represents to us the reaction of the patient to the unfavorable environmental factors and this reaction manifests as signs and symptoms. The pattern of reaction is not only determined by factors that caused illness, but also by the constitution of the affected person [11]. This constitution is the resultant of the early environmental factors, right from the time of conception, acting on the hereditary factors which determined by genes [12]. This constitution is the resultant of the early environmental factors, right from the time of conception, acting on the hereditary factors which determined by genes [24]. Disease is thus a total response of an organism to adverse environmental factors, external or internal. It is conditioned by constitutional factors, inherited & acquired and it manifest itself in three spheres- emotional, intellectual and physical. This response is divided into:

a) **INDIVIDUAL RESPONSE** (characteristic symptom which denote the constitutional type)
b) **GROUP RESPONSE** (diagnostic symptoms)

The constant adaptation that required in the development of an emotionally well integrated personality may fail at various stages and this breakdown will be indicated by appropriate symptomatology. If these warning signs are not needed, then in course of time depending on the personalities different types of responses may follow.

Withdrawal response

some may, over a period of time show withdrawal from this world and create a world of their own. This is the Psychotic type of response.

Escape response

personalities which are not able to meet the demand made on them react through an escape mechanism. This constitutes the Psycho neurotic response.

Fighting response

some may fight back the challenges, which *show psycho-somatic pattern*, in which the autonomic nervous system and endocrine system play a leading role [24].

Dr. Hahnemann mentions about psychosomatic diseases in §225.

The mental aspect is primarily deranged and these conditions finding the body slightly yielding to the altered psychological conditions maintain the body in a disturbed condition and continue the psychopathological state of the patient. These are also continued in a vicious cycle by emotional cause, such as continued anxiety, worry, vexation, wrongs and the frequent occurrence of great fear and fright. Some studies have focused on a group of patients who show the personality habits of social withdrawal, suspiciousness, hostility and dependency. Their ulcers appear to develop when stress leads to increased cigar and alcohol consumption [3].

Management of Psychosomatic diseases according to Dr. Hahnemann [32, 25]

The treatment in such cases include:

1. By means of psychical remedies such as display of confidence, friendly exhortations, sensible advice
2. An appropriate diet and regimen.
3. A radical antipsoric treatment should be done in order to prevent recurrences.
4. As doctor Clarke has said, "When the mind is ill at ease the stomach cannot work as it ought, and the face grows haggard and lean and the muscles lax. Worry is one great cause of indigestion [27].
    - **Richard Hughes has said, "**We have irritated our gastric mucous membrane with alcohol and pungent condiments; we have over-heated it with scalding drinks or chilled it with ices. These are the confessions we have to make, if we are dyspeptic. No medication, however carefully chosen, will set the stomach right if these errors are persisted in; and on the other hand, if they be corrected, nature has great power of righting itself without further aid. The somewhat rigid dietary of early homoeopathic days probably played no small part in the success of the new treatment.. In all affections of the stomach, we must be dieticians first, drug-givers secondly only.
    - In sec 5- Useful to the physician in assisting him to cure are the particulars of the most probable exciting cause of the acute disease, as also the most significant points in the whole history of the chronic disease, to enable him to discover its fundamental cause, which is generally due to a chronic miasm. In these investigations, the ascertainable physical constitution of the patient (and intellectual character, his occupation, mode of living and habits, his social and domestic relations, his age, sexual function,. etc., are to be taken into consideration.
    - The last sentence of section 5 implies a distinctive approach to the study of disease conditions [32].
    - For the effective management of the case a homoeopathic physician will have to be well conversed with the diagnosis of disease, the patient as a person, and the remedy selected and administered on the law of similia [24].

MIASMATIC DIAGNOSIS OF VARIOUS FORM OF ACID-PEPTIC DISORDERS [48,49]

1. **NON-ULCERDYSPEPSIA: Psora is the predominant miasm in these cases because its only due to certain exciting causes**
2. **GASTRO-OESOPHAGEAL REFLUX DISEASE(GERD):**
3. **ACUTEGASTRITIS: Psora is the predominant miasm but in severe case it is complicated with syphilis.**
4. CHRONICGASTRITIS: Psora and tubercular miasm
5. PEPTIC ULCERDISEASE: Predominant miasm is psora in early stage of the disease then it gets converted to syphilis miasm when complication occurs. In some cases, when ulcers heal fibrosis of affected part takes place with loss of function, then the predominant miasm is sycosis.

CONSTITUTIONAL REMEDIES

Phosphorus, Nux vomica, Lycopodium, Natrum muriaticum, Kali carbonicum, Ignatia, Calcarea carb, Pulsatilla, sepia, Anacardium, Graphitis, Arsenicum album, Sulphur, Bryonia alba, Antimoniumcrudum, Abies nigra, Kali bichromicum, Carbo veg, Hydrastis canadensis, Muriaticum acidum, Robinia pseudacacia, Sulphuricumacidicum etc..

MATERIALS AND METHODS

Clinical study

The study will be carried out with detailed case study and follow up at Sainath Hospital attached to Ahmedabad Homoeopathic Medical College, Parul University, Ahmedabad.

Case definition
Cases presenting with complaints of Acid peptic diseases, cases of age 18 to 60 years and both sexes will be taken in study.

Study design
Experimental Interventional study,35 cases satisfying the case definition, inclusion and exclusion criteria. The time duration Was of 12 months.

Study period
November 2023 to November 2024

Selection of samples
Randomized sampling will be done.
All cases will be selected according to inclusion criteria.

Inclusive criteria
1. The samples will be selected from both sexes & age group between 18 to 60 years.
2. The diagnostic criteria are mainly based on clinical history, presentation and examination findings.

Exclusion criteria
1. Ulcers secondary to burns, uraemia and drugs.
2. Cases complicated with gastric ulcer, haemorrhage, perforation, and gastric outlet obstruction.
3. Malignant conditions.
4. The patients who were unwilling to give consent to participate in the study

Data Collection
It will be done by individual history taking according to Homoeopathic principles. A self-designed self-assessed questionnaire consisting of socio demographic characteristics, travel history, co morbidity patterns, health seeking behaviors, and outcome of the treatment had been prepared in English and local language.

Data Analysis
Data will be collected by proper method and analysed & processed according to tabular format. Data was entered in MS excel and appropriate statistical tests were applied.

Criteria for follow-up
- All the patients will be duly followed and details of the symptomatic changes will be recorded and prognosis will be studied for by using prepared questionnaires for assessment. (questionary for Acid-peptic disorders)
- Follow up will differ from patient to patient.
- Usually first follow up will be after 14 days interval. If necessary online or video call follow up weekly.

RESULT AND DISCUSSION

Considering the psychosomatic relationship in acid peptic diseases, a detailed history taking is necessary to obtain a psychological profile and constitutional prescription. Total 35 patients with peptic ulcer disease were enrolled in the study. Table 1 depicts Socio demographic profile of study participants. Majority of the patients were in 31-to-40-year age groups (48.6%). Mean age of the patients was37.8years. Out of 35, 12 patients (54.0%) were female and 23 were male. Six patients (17.1%) were illiterate, 12 patients (34.2%) were educated up to secondary level. Total 27 patients (77.1%) were working in professional and semi-professional occupation and 4 patients (11.4 %) were unemployed. Socio economic status was categorised according modified Prasad's classification. Out of 35 patients, 10 (26.8%) and

10 patients (26.8 %) were belonged to lower middle and lower SE class respectively. Out of 35 patients, 19 and 5 patients were overweight and obese respectively. Only 18 patients (51.4 %) were getting sleep ≥8 hr / day. Total 6 patients were chronic smoker (> 14 a day) and 7 patients (20%) were heavy alcohol drinker. Assessment of improvement among participants was evaluated with questionary of acid peptic disorders. Out of 35 patients, 10 (29.0%) had marked improvement, 16 (46.0%) moderate improvement.

Ethical issue

Study protocol was approved through Institutional Ethical Committee. Written informed consent was taken from the participants and full confidentiality for the information provided was ensured.

CONCLUSION

Acid peptic disorders were observed in a person with high stress as a common health problem due to its prevalence, manageable nature and associated social psychological implications. During this study it was found that people working at professional level (intellectually high) were suffered more acid peptic disorders. After constitutional medicine was given, out of 35 cases 29 cases were improved. 4 cases were not improved and 2 cases were withdrawn from the study. Soit shows that Homoeopathic constitutional medicine has marked effect in APD.

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Table 1: Socio demographic profile of study participants(n=35)

Age category	**Group A**	**%**
< 20	1	2.9
21 -30	6	17.1
31 - 40	17	48.6
41 - 50	7	20.0
51 - 60	4	11.4
Total	35	100.0
Minimum Age	19	
Maximum Age	60	
Mean Age	37.8	
SD	9.3	
Gender	Group A	%
Female	12	34.3
Male	23	65.7
Education level		
Illiterate	6	17.1
Primary	11	31.4
Secondary	12	34.2
Higher secondary and above	6	17.1
Occupation		
Working	27	77.1
Retired	1	2.8
Unemployed	4	11.4
Not in work force	3	8.6
SE class (Modified Prasad's classification)		
Upper	5	14.2
Upper middle	5	14.2
Middle	5	14.2
Lower middle	10	28.6
Lower	10	28.6

Table 2: Risk factors among study participants(n=35)

BMI (Kg/m²)	Frequency	Percentage
– Underweight	2	5.7
– Normal	9	25.7
– Overweight	19	54.2
– Obese	5	14.2
Sleep		
– ≥8 hr / day	18	51.4
– < 8 hr/ day	17	48.6
Smoking		
– Never	10	28.6
– Occasionally	10	28.6
– Yes, < 15 a day	09	25.7
– Yes, > 14 a day	06	17.1
Alcohol		
– Never	18	51.5
– Within recommended	10	28.5
– Over recommended	07	20

Table 3. Constitutional Wise distribution of study population(n=35)

Constitution	Frequency	%
Cabonitrogenoid	22	62.9
Hydrogenoid	7	20.0
Oxygenoid	2	5.7
Tubercular	4	11.4

Table 4. Degree of improvement after intervention(n= 35)

Degree of improvement after intervention	Frequency	%
Marked Improvement	10	29
Moderate Improvement	16	46
Mild Improvement	3	9
No Improvement	4	11
Withdrawal	2	6
Grand Total	35	100

Table 5: Stress among study participants (n=35)

Stress	Frequency	Percentage
Low	11	32
Moderate	14	40
High	20	58

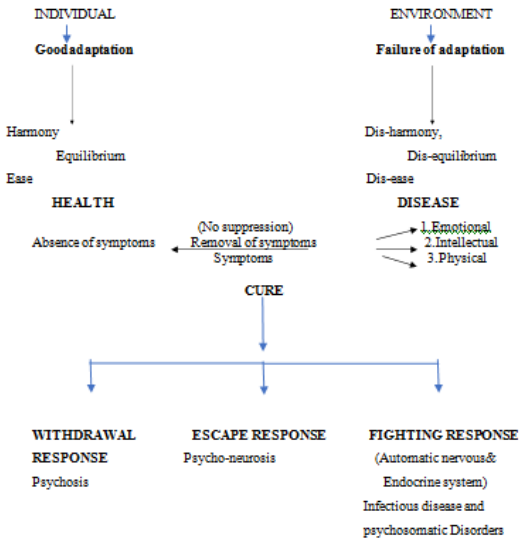


Figure: 1 The interaction between Man and Environment [24]

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RESEARCH ARTICLE

Contra - (1,2)*- (Λ, α) - Continuous Functions in Bitopological Spaces

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ABSTRACT

The aim of this article is to use (1,2)*-(Λ, α)-closed sets in BTPS to study several results of contra-(1,2)*-(Λ, α)-continuous functions.

Keywords: (1,2)*-kernel, (1,2)*-Λ-set, (1,2)*-Λ_α-set, (1,2)*-(Λ, α)-continuous, contra-(1,2)*-(Λ, α)-continuous.

INTRODUCTION

The idea of Λ-sets in topological spaces was first presented by Maki [10] in 1986. S. Jafari and A. M. Caldas [2] presented and studied the idea of "some properties of contra-β-continuous functions." Following Dontchev's [4] and Dontchev and Noiri's [5] research on the intriguing concepts of contra-continuity, Jafari and Noiri recently presented and examined the concepts of contra-α-continuity [5]. Study of (Λ,α)-closed sets were recently introduced by Caldas *et al.* [3]. The aim of this article is to use (1,2)*-(Λ, α)-closed sets in bitopological spaces to study some results of contra-(1,2)*-(Λ, α)-continuous functions.

PRELIMINARIES

Throughout this paper $(X, \tau_{1,2})$ or X will always denote bitopological spaces (briefly, BTPS).

Definition 2.1
Let **P** ⊆ X. If **P** = I ∩ J, where I∈τ_1 and J∈τ_2, then **P** is called to be $\tau_{1,2}$-open [7].

Definition 2.2 [7]
Let **P** ⊆ X. Then
(i) $\tau_{1,2}$-cl(P) = ∩ {F : P ⊆ F and F is $\tau_{1,2}$-cld}.
(ii) $\tau_{1,2}$-int(P) = ∪ {F : F ⊆ P and F is $\tau_{1,2}$-open}.

Definition 2.3
Let P ⊆ X is known as
(i) (1,2)*-SO [12] if P ⊆ $\tau_{1,2}$-cl($\tau_{1,2}$-int(P));
(ii) (1,2)*-PO [9] if P ⊆ $\tau_{1,2}$-int($\tau_{1,2}$-cl(P));
(iii) (1,2)*-αO [15] if P ⊆ $\tau_{1,2}$-int($\tau_{1,2}$-cl($\tau_{1,2}$-int(P)));
(iv) (1,2)*-βO [13] (= (1,2)*-SPO[14]) if P ⊆$\tau_{1,2}$-cl($\tau_{1,2}$-int($\tau_{1,2}$-cl(P)));
(v) regular (1,2)*-open [16] if P = $\tau_{1,2}$-int($\tau_{1,2}$-cl(P)).
The open sets complements are referred to as their corresponding closed sets.

Definition 2.4
Let P ⊆ X is called
(i) (1,2)*-g-cld [8] if $\tau_{1,2}$-cl(P) ⊆ M whenever P ⊆ M and M is $\tau_{1,2}$-open;
(ii) (1,2)*-αg-cld [6] if (1,2)*-αcl(P) ⊆ M whenever P ⊆ M and M is $\tau_{1,2}$-open in X.
(iii) (1,2)*-λ-cld [1] if P = L ∩ D, where L is a (1,2)*-Λ-set and D is a $\tau_{1,2}$-cld.
The closed sets complements are referred to as their corresponding open sets.

Definition 2.5
A function f : (X, $\tau_{1,2}$) → (Y, $\sigma_{1,2}$) is said to be (1,2)*-continuous [11] (resp. (1,2)*-α-continuous [15]) if for each $\sigma_{1,2}$-open set U of Y, f^{-1}(U) is $\tau_{1,2}$-open (resp. (1,2))*-α-open) in Y.

Definition 2.6 [6]
A function f : (X, $\tau_{1,2}$) → (Y, $\sigma_{1,2}$) is said to be contra-(1,2)*-continuous (resp. contra-(1,2)*-α-continuous, contra-(1,2)*-g-continuous, contra-(1,2)*-αg-continuous, contra-(1,2)*-λ-continuous) if for each $\sigma_{1,2}$-open set U of Y, f^{-1}(U) is $\tau_{1,2}$-cld (resp. (1,2)*-α-cld, (1,2)*-g-cld, (1,2)*-αg-cld, (1,2)*-λ-cld) in X.

CONTRA-(1,2)*-(Λ, α)-CONTINUOUS FUNCTIONS
Definition 3.1
Let P ⊆ *X* is known as (1,2)*-ker(P) = ∩ {M ∈ τ : P ⊆ M }.

Definition 3.2
Let P ⊆ 𝕏 is called (1,2)*-(Λ, α)-cld if P = I ∩ J, where I is a (1,2)*-Λ_α-set and J is an (1,2)*-α-cld. The (1,2)*-(Λ, α)-cld complements is referred to as their corresponding (1,2)*-(Λ, α)-open. We set (1,2)*-(Λ, α)O(X, x)b = {U∈(1,2)*-(Λ, α)O(X): x∈U} and (1,2)*-(Λ, α)C(*X*, x) = {U ∈ (1,2)*-(Λ, α)C(X) : x∈U}.

Definition 3.3
Let P ⊆ *X* is known as (1,2)*-Λ_α-set if P = (1,2)*-Λ_α(P), where (1,2)*-Λ_α(P) = ∩ {G ∈ (1,2)*-αO(X) ׀ P ⊆ G}.

Definition 3.4
A function f : (*X*, $\tau_{1,2}$) → (*Y*, $\sigma_{1,2}$) is said to be (1,2)*-(Λ, α)-continuous if the inverse image of every $\sigma_{1,2}$-cld in *Y* is (1,2)*-(Λ, α)-cld in *X*.

Definition 3.5

A function f : $(X, \tau_{1,2}) \to (Y, \sigma_{1,2})$ is said to be contra-(1,2)*-(Λ, α)-continuous if for each $\sigma_{1,2}$-open U of Y, $f^{-1}(U)$ is (1,2)*-(Λ, α)-cld in X.

Theorem 3.6

Let f : $(X, \tau_{1,2}) \to (Y, \sigma_{1,2})$ be a function, these conditions are interchangeable:

(i) f is contra-(1,2)*-(Λ, α)-continuous;

(ii) the inverse image of each $\sigma_{1,2}$-cld in Y is (1,2)*-(Λ, α)-open in X;

(iii) $\forall x \in X$ and every $\sigma_{1,2}$-cld V in Y containing f(x), $\exists$ (1,2)*-(Λ, α)-open M of X s.t $x \in M$ and $f(M) \subseteq V$;

Proof

(i) $\Leftrightarrow$ (ii) By definition 3.5, we obtain the result.

(ii) $\Rightarrow$ (iii) Let $x \in X$ & V be a $\sigma_{1,2}$-cld $\supseteq f(x)$. By (ii), $M = f^{-1}(V)$ is (1,2)*-(Λ, α)-open containing x s.t $f(M) \subseteq V$.

(iii) $\Rightarrow$ (i) Let $P \subseteq X$. Now $y \notin$ (1,2)*-ker(f(P)). Then $\exists\ V \in$ (1,2)*-(Λ, α)C(Y, y) s.t $f(P) \cap V = \phi$. For any $x \in f^{-1}(V)$, by (iii) $\exists\ M_x \in$ (1,2)*-(Λ, α)O(X, x) s.t $f(M_x) \subseteq V$. Then $f(P \cap M_x) \subseteq f(P) \cap f(M_x) \subseteq f(P) \cap V = \phi$ and $P \cap M_x = \phi$. We have prove that $f^{-1}(V)$ is (1,2)*-(Λ, α)-cld in X. Then f is f is contra-(1,2)*-(Λ, α)-continuous.

Remark 3.7 [6]

1. Every contra-(1,2)*-α-continuity ⇒ contra-(1,2)*-αg-continuity.
2. Every contra-(1,2)*-continuity ⇒ contra-(1,2)*-α-continuity.
3. Every contra-(1,2)*-continuity ⇒ contra-(1,2)*-g-continuity.
4. Every contra-(1,2)*-continuity ⇒ contra-(1,2)*-λ-continuity.

Theorem 3.8

Every contra-(1,2)*-λ-continuity is contra-(1,2)*-(Λ, α)-continuity.

Proof

It is obvious, since each (1, 2)*-λ-cld is (1,2)*-(Λ, α)--cld.

Theorem 3.9

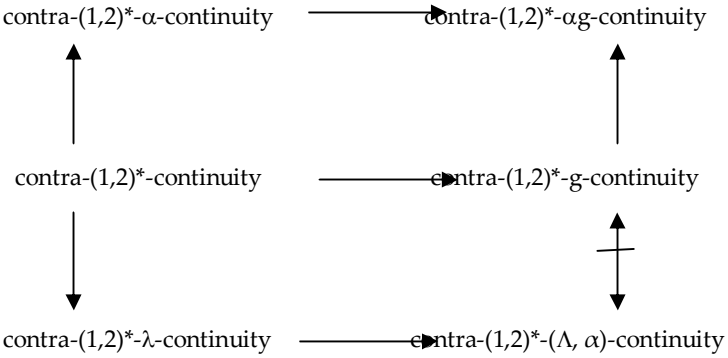
Show that contra-(1,2)*-(Λ,α)-continuous & contra-(1,2)*-g-continuous functions are independent.

Proof

It is obviously.

Remark 3.10

The following are our implications for the functions stated above.



Remark 3.11

(i) The below examples prove that contra-(1,2)*-(Λ,α)-continuous & contra-(1,2)*-g-continuous are independent.

(ii) In the diagram above, none of the implications can be reversed.

Example 3.12

Let $X = Y = \{a_1, b_1, c_1\}$, $\tau_1 = \{\phi, X, \{a_1\}\}$, $\tau_2 = \{\phi, X, \{a_1, b_1\}\}$ with $\tau_{1,2} = \{\phi, X, \{a_1\}, \{a_1, b_1\}\}$ and $\sigma_1 = \{\phi, Y, \{b_1\}\}$, $\sigma_2 = \{\phi, Y, \{b_1, c_1\}\}$ with $\sigma_{1,2} = \{\phi, Y, \{b_1\}, \{b_1, c_1\}\}$. Then the identity function $f : (X, \tau_{1,2}) \to (Y, \sigma_{1,2})$ is both contra-(1,2)*-λ-continuous and contra-(1,2)*-α-continuous but it is not contra-(1,2)*-continuous.

Example 3.13

Let X, Y and $\tau_{1,2}$ be as in Ex: 3.14 and $\sigma_{1,2} = \{\phi, Y, \{c_1\}, \{a_1, c_1\}\}$. Then the identity function $f : (X, \tau_{1,2}) \to (Y, \sigma_{1,2})$ is both contra-(1,2)*-g-continuous and contra-(1,2)*-αg-continuous but it is neither contra-(1,2)*-continuous nor contra-(1,2)*-α-continuous.

Example 3.14

Let X, Y, $\tau_{1,2}$ and $\sigma_{1,2}$ be as in Ex: 3.14. Then the identity function $f : (X, \tau_{1,2}) \to (Y, \sigma_{1,2})$ is contra-(1,2)*-αg-continuous but not contra-(1,2)*-g-continuous.

Example 3.15

Let $X = Y = \{a_1, b_1, c_1\}$, $\tau_1 = \{\phi, X\}$, $\tau_2 = \{\phi, X, \{a_1, b_1\}\}$ with $\tau_{1,2} = \{\phi, X, \{a_1, b_1\}\}$ and $\sigma_1 = \{\phi, Y, \{c_1\}, \{a_1, b_1\}\}$, $\sigma_2 = \{\phi, Y, \{a_1, b_1\}\}$ with $\sigma_{1,2} = \{\phi, Y, \{c_1\}, \{a_1, b_1\}\}$. Then the identity function $f : (X, \tau_{1,2}) \to (Y, \sigma_{1,2})$ is contra-(1,2)*-(Λ, α)-continuous but not contra-(1,2)*-g-continuous.

Example 3.16

Let X, Y and $\tau_{1,2}$ be as in Ex: 3.14 and $\sigma_{1,2} = \{\phi, Y, \{c_1\}, \{a_1, c_1\}\}$. Then the identity function $f : (X, \tau_{1,2}) \to (Y, \sigma_{1,2})$ is contra-(1,2)*-g-continuous but not contra-(1,2)*-(Λ, α)-continuous.

Example 3.17

Let $X = Y = \{a_1, b_1, c_1\}$, $\tau_1 = \{\phi, X, \{a_1\}\}$, $\tau_2 = \{\phi, X\}$ with $\tau_{1,2} = \{\phi, X, \{a_1\}\}$ and $\sigma_1 = \{\phi, Y, \{b_1\}\}$, $\sigma_2 = \{\phi, Y, \{b_1, c_1\}\}$ with $\sigma_{1,2} = \{\phi, Y, \{b_1\}, \{b_1, c_1\}\}$. Then the identity function $f : (X, \tau_{1,2}) \to (Y, \sigma_{1,2})$ is contra-(1,2)*-(Λ, α)-continuous but it is not contra-(1,2)*-λ-continuous.

Lemma 3.18

Let $P \subseteq X$, these conditions are interchangeable:

(i) P is (1,2)*-(Λ, α)-cld.

(ii) $P = L \cap (1,2)^*\text{-}\alpha\text{cl}(P)$, where L is a $(1,2)^*\text{-}\Lambda_\alpha(P)$-set.

(iii) $P = \Lambda_\alpha(P) \cap (1,2)^*\text{-}\alpha\text{cl}(P)$.

Definition 3.19

Let $P \subseteq X$ is said to be a $(1,2)^*\text{-}\alpha\text{-}T_{1/2}$ space if each singleton is (1,2)*-α-open or (1,2)*-α-cld.

Theorem 3.20

In X, these statements are interchangeable:

(i) X is a $(1,2)^*\text{-}\alpha\text{-}T_{1/2}$ space.

(ii) Each subset of X is (1,2)*-(Λ, α)-cld.

Proof

(i) ⇒(ii) Let $P \subseteq X$. Let P_1 be the collection of all (1,2)*-α-open, singletons of $X \setminus P$ and let $P_2 = X \setminus (P \cup P_1)$. Set $F = \cap_{x \in A1} X \setminus \{x\}$ and $L = \cap_{x \in A2} X \setminus \{x\}$. Since F is (1,2)*-$\alpha$-cld and L is a $(1,2)^*\text{-}\Lambda_\alpha$-set. We have, $P = F \cap L$. Then P is (1,2)*-(Λ, α)-cld.

(ii) ⇒ (i) Let x ∈ X. Claim that {x} is not (1,2)*-α-open. Then A = X \ {x} is not (1,2)*-α-cld and since P is (1,2)*-(Λ, α)-cld, then P is a (1,2)*-Λ_α-set, P = (1,2)*-Λ_α(P). We have X is the only superset of P, then P is $\tau_{1,2}$-open. Then {x} is $\tau_{1,2}$-cld and hence (1,2)*-α-cld.

Lemma 3.21

Let X be a (1,2)*-α-$T_{1/2}$ space and f : (X, $\tau_{1,2}$) → (Y, $\sigma_{1,2}$) be a function. If f is contra-(1,2)*-α-continuous (respectively. contra-(1,2)*-g-continuous, contra-(1,2)*-αg-continuous, contra-(1,2)*-λ-continuous), then f is contra-(1,2)*- (Λ, α)-continuous.

Proof

It is obviously**.**

Theorem 3.22

If a function f : (X, $\tau_{1,2}$) → (Y, $\sigma_{1,2}$) is contra-(1,2)*-(Λ, α)-continuous and Y is (1,2)*-regular, then f is (1,2)*-(Λ, α)-continuous.

Proof

Let x ∈ X & V an $\sigma_{1,2}$-open of $Y \supseteq$ f(x). Here Y is (1,2)*-regular, ∃ an $\sigma_{1,2}$-open W in $Y \supseteq$ f(x) s.t $\tau_{1,2}$-cl(W) ⊆ V. We have f is contra-(1,2)*-(Λ, α)-continuous, so by Theorem 3.6, ∃ U ∈ (1,2)*-(Λ, α)O (X, x) s.t f(U) ⊆ $\tau_{1,2}$-cl(W). We have f(U) ⊆ $\tau_{1,2}$-cl(W) ⊆ V. Then f is (1,2)*-(Λ, α)- continuous.

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REVIEW ARTICLE

Potential Role of Carbonic Anhydrase Inhibitors in Treating Various Diseases and Disorders

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ABSTRACT

CAs are ubiquitous zinc metalloenzymes that catalyze the reversible hydration of carbon dioxide into bicarbonate with protons, and they have been critical to maintaining acid base balance, making gas exchange efficient, and regulation of ion transport. CAIs, originally invented for glaucoma management have become powerful therapeutic agents to treat a vast array of disease and disorders. CAIs are extensively applied in ophthalmology for reducing intraocular pressure through inhibition of fluid secretion within the eye. Apart from this, they are also used in neurological, renal, and on cological diseases. In the treatment of epilepsy, CAIs such as acetazolamide induce anticonvulsant effects through regulation of intracellular pH and neuronal excitability. In metabolic diseases such as mountain sickness, CAIs improve respiratory efficiency through reduction in blood pH and enhanced ventilation. Recent studies also detail the applications of CAIs, particularly in the treatment of cancer, where the isoforms of CA IX and CA XII, which are expressed highly in hypoxic tumor microenvironments, have been targeted in order to disrupt the survival and invasive capabilities of the tumor. Treatment of diseases such as osteoporosis, by regulating bone resorption, and obesity, by regulating fat metabolism, has also proved promising for CAIs. The development of isoform-selective inhibitors has permitted the use of targeted therapeutic strategy, minimizing off-target effects. Advances in structure-based drug design and high-throughput screening have facilitated discovery of novel CAIs with enhanced potency and specificity. CAIs are known to possess diverse therapeutic potential, especially in the context of understanding mechanisms of action, the current clinical implications, and future possibilities for treatment across a wide spectrum of disease. Diverse roles of carbonic anhydrase and its inhibitors can help lead the way toward innovative treatments for complex pathologies.

Keywords: Carbonic anhydrase inhibitors, versatile, glaucoma, anticonvulsant, metabolic disorders, isoforms.

INTRODUCTION

Carbonic anhydrase (CA) is a zinc-containing metalloenzyme that catalyzes the reversible reaction between carbon dioxide (CO_2) and water to yield carbonic acid (H_2CO_3) that then decomposes into bicarbonate (HCO_3^-) and protons (H^+). This process is critical for maintaining acid-base homeostasis, fluid balance, and gas exchange in all tissues [1]. Isozymes and Tissue Distribution: There exist several carbonic anhydrase isozymes, each exhibiting tissue-specific localization and function [2]:

1. Cytosolic Isozymes (e.g., CA I, CA II, CA III, CA VII): Present in erythrocytes, kidneys, and muscles. CA II is the most active and is involved in renal acidification and bone resorption.
2. Membrane-bound Isozymes (e.g., CA IV, CA IX, CA XII, CA XIV): Present in the renal tubules, lungs, and gastrointestinal tract, these isozymes facilitate processes like bicarbonate reabsorption and secretion of hydrogen ions.
3. Mitochondrial Isozymes (e.g., CA VA, CA VB): These are present in the liver and take part in the synthesis of urea and gluconeogenesis.
4. Secreted Isozymes (e.g., CA VI): These are found in saliva and tears, where they help to maintain pH balance.The complex role of carbonic anhydrase and its inhibitors can be the stepping stone to innovative treatments for complex pathologies.

Carbonic anhydrase (CA) enzymes are vital for many physiological processes [3]

1. Maintaining Acid-Base Balance: CA helps regulate CO_2 and bicarbonate levels, ensuring proper pH in blood and tissues for cellular and enzymatic function.
2. Respiratory Gas Exchange: In the lungs, CA quickly converts CO_2 to bicarbonate and back, enabling efficient transport and exhalation of CO_2.
3. Renal Function: CA supports pH balance by aiding bicarbonate reabsorption and hydrogen ion secretion in the kidneys, contributing to urine acidification.
4. Fluid Secretion: CA facilitates the production of cerebrospinal fluid, aqueous humor in the eye, and gastric acid by regulating ion and water movement.
5. Bone Resorption: CA generates protons that osteoclasts use to break down bone matrix, playing a role in bone remodeling.

METABOLIC ROLES OF CARBONIC ANHYDRASE:

- Gluconeogenesis & Lipogenesis: By regulating pH, CA influences enzymes involved in glucose and fat metabolism, linking it to obesity and diabetes.
- Energy Production: CA supports mitochondrial energy production and buffering capacity, essential for cellular metabolism [4].

PATHOLOGICAL IMPLICATIONS: OF CARBONIC ANHYDRASE

- Metabolic Disorders: Dysregulated CA activity can lead to metabolic acidosis, insulin resistance, and obesity.
- Cancer: Overexpressed CA isoforms like CA IX create acidic tumor environments, aiding cancer growth and invasion.
- Neurological Disorders: Altered CA activity affects cerebrospinal fluid dynamics and is implicated in epilepsy and glaucoma.

RATIONALE FOR TARGETING CARBONIC ANHYDRASE IN METABOLIC DISEASES

Carbonic anhydrase plays a crucial role in metabolic regulation, making it a promising therapeutic target. Here's reason[5-7]:

Acid-Base Balance
CA helps maintain pH by converting CO_2 to bicarbonate. Its inhibition can correct metabolic acidosis linked to diabetes, chronic kidney disease (CKD), and obesity, improving overall metabolic health.

Energy Metabolism & Weight Control
CA influences energy expenditure by activating brown fat, which burns calories through thermogenesis. It also regulates fat storage and breakdown, potentially reducing obesity and improving insulin sensitivity.

Glucose Regulation
CA affects enzymes involved in glucose metabolism, helping control blood sugar in type 2 diabetes. It may also improve insulin sensitivity by balancing pH in tissues.

Liver Health (NAFLD)
Targeting CA could reduce liver fat and inflammation, helping manage non-alcoholic fatty liver disease (NAFLD) and prevent its progression to more severe conditions.

Heart and Kidney Benefits
CA inhibitors act as diuretics, lowering blood pressure and managing fluid retention, common in obesity and diabetes. They also slow CKD progression by countering acidosis and improving metabolic profiles.

Anti-Inflammatory & Antioxidant Effects
CA inhibitors reduce oxidative stress and inflammation, key factors in metabolic diseases like obesity and diabetes.

Proven Safety
CA inhibitors like acetazolamide have been safely used for decades in glaucoma and altitude sickness, paving the way for their use in metabolic conditions. By targeting CA, therapies can tackle metabolic diseases from multiple angles—balancing pH, regulating energy, reducing inflammation, and improving organ function.

CARBONIC ANHYDRASE ENZYME INHIBITION
Carbonic anhydrase inhibitors (CAIs) are compounds that block the activity of carbonic anhydrase (CA) enzymes, affecting acid-base balance, ion transport, and metabolism. They are widely used to treat conditions like glaucoma, altitude sickness, and epilepsy, with emerging applications in metabolic disorders. CAIs primarily bind to the zinc ion at the enzyme's active site, disrupting its ability to convert CO_2 and water into bicarbonate and protons [8].

- Competitive Inhibition: Most CAIs, like acetazolamide, directly block the active site, preventing normal enzyme activity.
- Non-Competitive Inhibition: Some CAIs bind elsewhere, altering the enzyme's shape and reducing its function.

TYPES OF (CAIS) CARBONIC ANHYDRASE INHIBITORS
1. Sulfonamides: The most common class, including drugs like acetazolamide and dorzolamide, which bind directly to the enzyme's zinc ion.
2. Thioxothiazolidinones: Selective inhibitors for specific isozymes.
3. Coumarins: Indirect inhibitors that cause conformational changes in the enzyme.
4. Carboxylic Acids and Phenols: Less common inhibitors with unique mechanisms, often involving hydrogen bonding [9].

Targeting Specific Isozymes
Selective inhibition is key to therapeutic applications since CA isozymes have specialized roles in the body[10]:

- CA II: Found in red blood cells, kidneys, and eyes, its inhibition helps lower eye pressure in glaucoma and regulates kidney bicarbonate levels.
- CA IX and XII: Overexpressed in certain cancers, targeting these supports anti-tumor strategies.

- CA V: Found in mitochondria, its inhibition could regulate glucose metabolism and aid in managing metabolic diseases.

PHYSIOLOGICAL EFFECTS OF CARBONIC ANHYDRASE INHIBITION

- Obesity: CA inhibitors (CAIs) may activate brown adipose tissue (BAT), boosting energy expenditure and supporting weight loss. They also influence fat metabolism by altering acid-base balance, helping reduce fat storage.
- Diabetes: CAIs can regulate enzymes in glucose metabolism, improving blood sugar control. Their diuretic effect further benefits diabetic patients by lowering blood pressure, a common complication.
- NAFLD: By modulating lipid metabolism, CAIs may decrease liver fat, reduce inflammation, and combat oxidative stress, improving liver health and function[11].

CA INHIBITORS UNDER INVESTIGATION FOR METABOLIC EFFECTS

1. Acetazolamide: A well-known CA inhibitor, acetazolamide has been shown to induce metabolic acidosis, increase insulin sensitivity, and reduce liver glucose production in studies. However, its side effects, like diuresis and electrolyte imbalances, limit its long-term use for metabolic disorders.
2. Methazolamide & Dorzolamide: These CAIs are being explored for their more targeted effects and potential metabolic benefits, offering a better side effect profile than acetazolamide, making them promising candidates for further use[12].
3. Combining CAIs with other antihypertensive and diuretic agents could provide synergistic effects, improving blood pressure control and fluid management while addressing potential limitations of individual drugs. Ongoing research into isozyme-selective carbonic anhydrase inhibitors (CAIs) aims to improve treatment effectiveness while minimizing side effects. By combining CAIs with other therapies, researchers hope to achieve synergistic benefits for managing complex conditions. Developing isozyme-selective CAIs could lead to more targeted treatments, enhancing efficacy and reducing adverse effects.Tailoring CAI therapy based on individual patients' specific isozyme profiles may further improve outcomes. Identifying biomarkers linked to CA activity and response to CAIs could help personalize treatment, ensuring optimal therapy for each patient. Beyond current uses, CAIs might have potential for treating other metabolic disorders, including dyslipidemia and metabolic acidosis. Preliminary research also suggests they may offer benefits for neurological conditions, like Alzheimer's and Parkinson's, due to their impact on pH regulation and inflammation. Combining CAIs with anti-inflammatory or antioxidant agents could enhance their effectiveness for chronic diseases. Advances in drug delivery, such as nanoparticles or sustained-release formulations, may also improve their safety and targeting, ensuring optimal therapeutic effects. Incorporating CAIs into clinical practice could offer alternatives for patients who don't respond to standard treatments for conditions like hypertension, fluid overload, and metabolic diseases. However, careful monitoring for side effects like electrolyte imbalances is essential. Long-term clinical trials are needed to fully assess CAIs' efficacy, safety, and potential long-term side effects. Research into new CAI compounds with improved selectivity, potency, and safety profiles is crucial for expanding their use in medical practice. Additionally, evaluating their cost-effectiveness will be important for wider adoption.

CONCLUSION

The future of carbonic anhydrase inhibitors (CAIs) is promising, with advancements in personalized medicine, expanded uses, combination therapies, and innovative delivery systems. Clinical applications will provide better treatment options, though careful monitoring and patient education are essential. Research should focus on understanding CAIs' mechanisms, assessing long-term efficacy and safety, developing new compounds, and exploring combination treatments. Continued development will optimize CAIs' therapeutic potential, improving patient outcomes across various conditions.

CONFLICT OF INTEREST

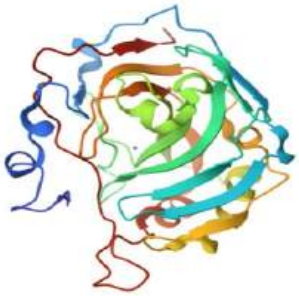
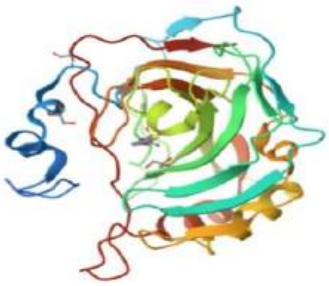
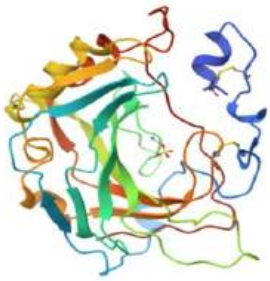
The authors have no conflicts of interest regarding this investigation.

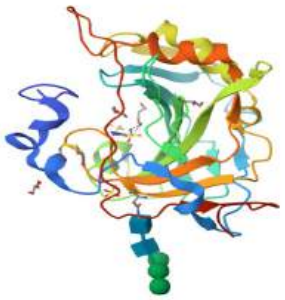
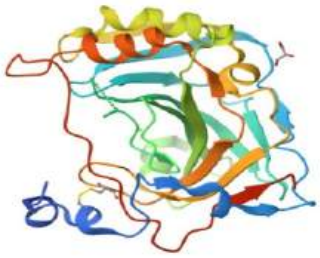
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Table 1: Different types of carbonic anhydrase enzymes

Cytosolic Isozymes	CA I	1CRM	

	CA II	1CA2	
	CA III	3UYN	
	CA VII	3MDZ	
Membrane bound	CA IV	1ZNC	

	CA IX	6FE2	
	CA XII	1JCZ	
	CA XIV		
Secreted Isozyme	CA VI	3FE4	

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RESEARCH ARTICLE

Air Quality Dynamics during Biomass Burning: A Comparative Evaluation of Sensor and Reference Monitoring Technologies

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ABSTRACT

Biomass burning substantially contributes to air pollution which releases gaseous pollutants such as carbon monoxide, nitric oxide, nitrogen dioxide, sulphur dioxide, and particulate matter ($PM_{2.5}$ and PM_{10}). These atmospheric pollutants adversely affect the environment and public health. Therefore, the sudden spikes in air quality during biomass burning were measured and the performance of a sensor-based real-time air quality monitoring device, polludrone, against a reference-grade Air Quality Monitoring Station (AQMS) was evaluated. The study result revealed that the Polludrone was more sensitive to local and transient changes in pollutants than the reference station, as it captured higher and more dynamic fluctuations. For gaseous pollutants, the Polludrone always recorded higher peaks, such as SO_2 at 202.08 μg/m³ while the reference station recorded 22.38 μg/m³ during the biomass burning event. For $PM_{2.5}$, Polludrone captured a peak concentration of 835.2 μg/m³, whereas the reference station recorded a peak of 606.5 μg/m³.The results reflect the ability of Polludrone to capture real-time variations and spatial heterogeneity in emissions during episodic events, emphasizing its utility for monitoring localized pollution sources. This highlights the significant potential of advanced sensor technologies for improving air quality monitoring systems, which can enhance public health responses to air pollution events.

Keywords: Biomass burning, Air pollution, Sensor-based monitoring

INTRODUCTION

Air pollution is defined as contamination of the atmosphere by harmful chemical, physical, or biological agents that exceed the natural capacity of the environment to disperse and dilute them [1].Globally, air pollution is a significant environmental concern owing to its detrimental effects on flora, fauna, and general ecological health [2]. The air pollutants are emitted from different sources, such as industrial, commercial, residential, domestic [3]and open burning, of biomass and domestic garbage. Biomass burning releases particulate matter (PM) directly, along with several gaseous pollutants such as nitrogen oxides (NOx), carbon monoxide (CO), methane (CH4), and volatile organic chemicals (VOCs)[4].The chemical range found in smoke from burnings differentiates it from traditional industrial pollution. A primary issue in comprehending the effects of biomass burning on air quality is the significant diversity in both the volume and content of emissions from one burning to another. Emissions can fluctuate on the basis of the quantity and fuel, meteorological conditions, and combustion circumstances. These variances result in significant ambiguities regarding the emissions from specific burnings. Upon emission, smoke experiences chemical changes in the atmosphere, modifying the composition of molecules and producing air pollutants [5], which results in various health impacts including eye irritation, chest pain or excessive breathlessness often preceding cardiac events, and increased fatigue [6]. Monitoring of air quality after biomass burning is vital for public health; it is also important to consider the limitations of existing monitoring networks and the need for equitable access to air quality information across different communities. Traditional urban air quality monitoring relies on expensive and stable monitoring devices[7].Despite their high cost, the distribution of these stations is often inadequate, even in developed countries [8]. This immediacy of air quality assessment is critical for issuing alerts and guiding public health decisions during burning events. Unlike reference stations, which typically report hourly averages once per day, real-time systems can provide continuous data streams, enabling timely responses to air quality changes [9]. Real-time systems also have the advantage of being able to monitor sudden changes in pollution levels, which can be crucial for protecting vulnerable populations such as children, elderly people, and individuals with respiratory conditions. By utilizing real-time air quality monitoring technology, authorities can better protect public health and improve overall air quality management strategies. This technology allows for more accurate and immediate interventions, ultimately leading to better health outcomes for communities. Additionally, real-time data can be used to track pollution sources and develop targeted mitigation efforts to reduce emissions. Overall, real-time air quality monitoring technology plays a vital role in ensuring public health and environmental sustainability. By identifying pollution sources and implementing effective interventions, authorities can work towards creating cleaner and healthier communities for all individuals to thrive in. The current research focuses on the performance metrics of each monitoring method, including response time, detection accuracy, and data consistency under challenging atmospheric conditions common during burning events.

Experimental Methodology

Two different types of continuous air quality monitoring systems were installed together to assess the response of individual monitoring technologies during biomass burning in the vicinity.

Study area

The study was conducted on the premises of the Ahmedabad Textile Industry's Research Association (ATIRA) which is located in the Navarangpura area of Ahmedabad, India (Fig. 1). ATIRA is recognized by the Council of Scientific and Industrial Research under the Ministry of Science and Technology, Government of India.

Instrument details

The study was performed with polludrone equipment, which is a sensor-based real-time air quality monitoring system designed by Oizom Instruments Private Limited. The gas analyzers by Horiba and BAM 1020 (Metone, USA) for particulate monitoring was used in the reference station. The detailed information of the monitors is shown in Table(1)

Installation of devices at the study area and data gathering

The installation for collocation was carried out based on the international guidelines on collocation by the United States Environmental Protection Agency. The Oizom's continuous air quality monitor "Polludrone" was installed within 10 m (30 ft) from the reference instrument in such a way that its inlet was close to the air intake of the reference instrument. A 2-feet distance was maintained between the inlets to avoid any interference caused by the suction pump/fans. The data from both monitors were retrieved from the data visualization software "Envizom".

RESULTS AND DISCUSSION

The performance of the real-time sensor-based monitoring system, polludrone, was compared against the reference-grade air quality monitoring station monitor during a biomass burning event by evaluating their response time, precision, and data reliability. By analysing sensor outputs relative to reference monitors, the study assesses the ability of sensor-based technology to capture pollutant concentration fluctuations and provides insights into their potential for real-time air quality monitoring under extreme conditions. Figure 3 shows the different stages of the impact of biomass burning on air quality i.e., (1) air quality at the initial stage of biomass burning, (2) air quality during biomass burning, and (3) air quality after a biomass burning event

Variation in the concentration of gaseous pollutants

Assessment of the carbon monoxide (CO) concentration during biomass burning events is crucial for understanding the environmental impact and combustion efficiency of these burnings. CO serves as a significant tracer for biomass burning emissions, providing insights into burning dynamics, atmospheric chemistry, and climate change implications as well as CO can help quantify carbon emissions from biomass burning, which is essential for assessing the contribution of these burnings to atmospheric carbon levels. In the present study, carbon monoxide (CO) concentrations were measured by a reference station and the polludrone device during three phases: before, during, and after the biomass burning event. Before biomass burning (15:50–16:05), the CO concentrations remained low at both monitoring stations, with the reference station recording values between 0.21 and 0.46 mg/m³, whereas the Polludrone reported slightly higher values ranging from 0.3 to 2.14 mg/m³. During the burning change to burning instead of fire in all recording higher concentrations. In particular, at 16:15, the polludrone measured 5.2 mg/m³ and reference station measured 3.0 mg/m³ concentration. The highest CO level was observed at 16:20, with the polludrone recorded 5.23 mg/m³, whereas the reference station measured 3.28 mg/m³. After the burning event (16:30–16:45), CO concentrations declined gradually. By 16:45, the polludrone reported a low of CO i.e., 0.36 mg/m³, while the reference station recorded 1.26 mg/m³ [Fig. 4 (A)]. Sulfur dioxide (SO_2) is a major air pollutant that can lead to respiratory issues and other health problems. Initially, the SO_2 concentrations were relatively stable, with the reference station recording values between 19.1 and 19.81 μg/m³, whereas the polludrone measured slightly higher levels, ranging from 19.1 to 50.99 μg/m³. The, SO_2 concentrations increased significantly at 16:10, the reference station recorded 20.49 μg/m³, whereas the polludrone measured 202.08 μg/m³, showing a substantial spike near the burning source. The highest SO_2 levels were observed at 16:15, with the Polludrone capturing 119.34 μg/m³ compared to 22.38 μg/m³ at the reference station. After the burning event (16:30–16:45), SO_2 levels declined gradually, with the reference station recording values between 15.17 and 21.69 μg/m³, while the Polludrone measured 10.46 to 38.3 μg/m³ [Fig.4 (B)].

In the case of nitric oxide (NO), the concentration was negligible at both stations, indicating minimal NO emissions. However, during the burning event (16:10–16:25), NO concentrations increased sharply, particularly in the polludrone measurements. At 16:10, the Polludrone recorded 23.92 ppb compared to 0.97 ppb at the reference station. The peak NO concentration was observed at 16:15, with the Polludrone capturing 2.68 ppb compared to 0 ppb at the reference station. After the burning event (16:30–16:45), NO concentrations declined, with the reference station consistently measuring lower levels, ranging from 0.66 to 0.36 ppb, while the Polludrone recorded 1.13 to 0.36 ppb [Fig. 4(C)] while for $NO_2$the burning event both devices showed a sharp increase in NO_2. For instance, at 16:10, the reference station measured 8.98 μg/m³, while the Polludrone measured 24.14 μg/m³. The highest NO_2 levels occurred at 16:15, with the Polludrone capturing 16.75 μg/m³ compared to 6.75 μg/m³ at the reference station [Fig. 4 (D)].

Overall, the Polludrone was more effective in detecting localized and transient peaks in emissions during biomass burning, highlighting its superior sensitivity compared to the reference station.

Variation in concentration of particulate matters

Particulate matter ($PM_{2.5}$and PM_{10}) from biomass burning contains harmful substances, including polycyclic aromatic hydrocarbons (PAHs), which pose serious health risks. Studies indicate that $PM_{2.5}$ concentrations can triple during biomass burning events, correlating with increased toxicity and potential DNA damage in human cells [10]. Therefore, an accurate measurement of PMs is vital for regulatory compliance with National Ambient Air Quality Standards (NAAQS). In the present study,$PM_{2.5}$ concentrations were relatively low, with the reference station recording stable values around 47.3 μg/m³, while the polludrone showed a 42.25 to 342.31 μg/m³. Similarly, PM_{10} levels were higher in the Polludrone readings, increasing from 101.11 to 598.43 μg/m³ compared to the reference station's consistent 143.1–629.5 μg/m³. During the burning event (16:10–16:25), both $PM_{2.5}$ and PM_{10} concentrations spiked significantly. At 16:15, the Polludrone captured the highest $PM_{2.5}$ and PM_{10} levels of 835.2 μg/m³ and 1433.5 μg/m³, respectively, while the reference station recorded much lower concentrations of 606.5 μg/m³ ($PM_{2.5}$) and 629.5 μg/m³ (PM_{10}). After the burning event (16:30–16:45), particulate matter levels gradually decreased. The reference station measured $PM_{2.5}$ levels between 606.5 and 41.21 μg/m³ and PM_{10} levels from 629.5 to 107.28 μg/m³, while the Polludrone registered $PM_{2.5}$ from 356.61 to 41.21 μg/m³ and PM_{10} from 214.27 to 107.28 μg/m³ (Fig. 5). Overall, the Polludrone recorded higher and more dynamic changes in $PM_{2.5}$ and PM_{10} levels, demonstrating its capability to capture real-time variations in particulate matter concentrations during biomass burning events[11].

CONCLUSION

The study compared air quality measurements for key pollutants (CO, NO_2, NO, SO_2, $PM_{2.5}$, and PM_{10}) during biomass burning events via a reference station and a polludrone device. The results revealed that the Polludrone consistently detected higher and more dynamic fluctuations in pollutant concentrations compared to the reference station, particularly during and immediately after the biomass burning event. For gases like CO, NO, and SO_2, the Polludrone recorded significantly higher peaks, reflecting its sensitivity to localized and transient emission spikes, while the reference station exhibited more stable and less responsive trends. Similarly, for particulate matter ($PM_{2.5}$ and PM_{10}), the polludrone detected pronounced increases during the burning event, capturing the rapid changes and elevated levels more effectively than the reference station. The disparities highlight Polludrone's capacity to capture real-time variations and spatial heterogeneity in air quality, making it a valuable tool for monitoring pollution from localized sources like biomass burning. Overall, the study emphasizes the utility of advanced sensors like the polludrone for detailed and responsive air quality monitoring during episodic pollution events.

ACKNOWLEDGEMENT

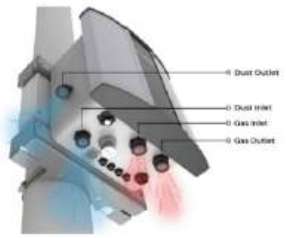
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Table 1: Product specification of the device used in the study

Device	**Polludrone**	**Horiba Reference Station**
		
Model	Oizom Polludrone	Air Quality Monitoring Station (AQMS)
Parameters	$PM_{2.5}$, PM_{10}, CO, CO_2, NO, NO_2, SO_2, O_3, Temperature, Humidity	$PM_{2.5}$, PM_{10}, CO, NO, NO_2, SO_2, O_3, Temperature, Humidity
Measurement Principles		
Particulate Matter	Oizom Dust Sensor OZPM_1	MetOne BAM 1020 Beta Attenuation Mass Monitor
Carbon Monoxide (CO)	Oizom Gas Sensor (OGS) OZCO_1 Electrochemical	Horiba APMA-370 Non-dispersive Infrared Radiation
Nitrogen Monoxide (NO)	Oizom Gas Sensor (OGS) OZNO_1 Electrochemical	Horiba APNA- 370 Chemiluminescence
Nitrogen Dioxide (NO_2)	Oizom Gas Sensor (OGS) OZNO_2_1 Electrochemical	
Sulfur Dioxide (SO_2)	Oizom Gas Sensor (OGS) OZSO_2_1 Electrochemical	Horiba APSA-370 UV Florescence (UVF)

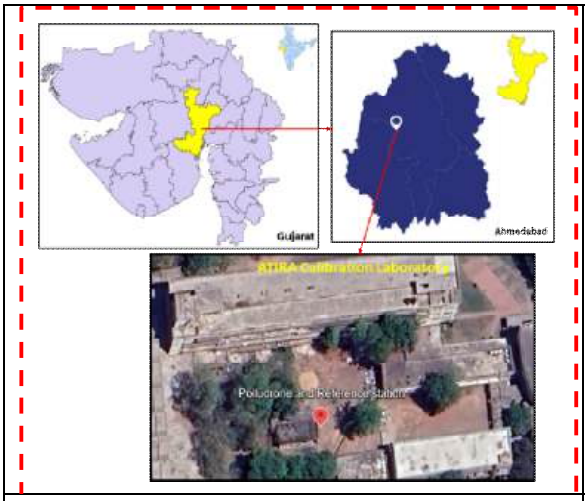


Figure 1: map showing study area (atira)



Figure 2: installed air quality monitoring devices at atira



Figure 2: Air quality at different stages of biomass burning event

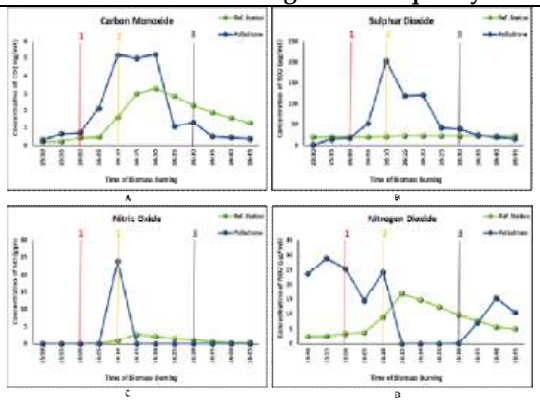


Figure 3 variation in concentration of gaseous pollutants during biomass burning a) concentration of carbon monoxide b) concentration of sulfur dioxide c) concentration of nitric oxide d) concentration of nitrogen dioxide

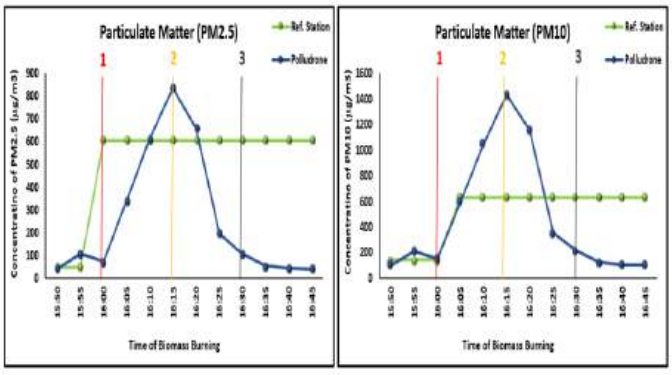


Figure 4: concentrations of $pm_{2.5}$ and pm_{10}

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RESEARCH ARTICLE

A Study on Profile Characteristics and Marketing Behaviour of Mango Growers in Dharmapuri District of Tamil Nadu

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ABSTRACT

The horticulture sector has become one of the major drivers of economic development as it is more remunerative than the agricultural sector. For people all around the world, fruit crops are crucial to their national food security. Mango (*Mangifera indica*) is a significant fruit crop that leads India in the area and production in India. The mango, often known as the King of Fruits, is the most popular fruit in the world. The major districts producing mango in Tamil Nadu are Krishnagiri, Dindugal, Theni and Dharmapuri. The present study was conducted in Karimangalam and the Palacode blocks of Dharmapuri district. A proportionate random sampling procedure was applied to select 120 respondents from twelve selected villages, six each from these two blocks. A well-structured interview schedule was used for the collection of data. The study comprises of fifteen independent variables. The collected data were analysed and tabulated using appropriate statistical tools. Majority of the respondents were middle aged and had formal education. They had agriculture as their major occupation with a medium level of annual income. They possessed marginal farms, cultivated mango under an area of more than 2 acres but less than 3 acres and had a medium level of farming experience, social participation, information source utilization, innovativeness, risk orientation, scientific orientation and economic motivation and market perception. They were poor in decision making behaviour. Majority of the respondents were found to be medium in

their overall marketing behaviour. The constraints viz., price fluctuation, exploitation by the middleman, lack of knowledge on value addition, difficulty in transporting produce to distant markets/export to other countries, lack of cold storage facilities and lack of timely marketing information were faced by majority of the mango growers in the marketing of mango.

Keywords: Horticulture, Mango, King of Fruits, Fruit and Marketing Behaviour.

INTRODUCTION

One of the most significant commercial fruit crops in the country is the mango (*Mangifera indica*), which is a member of the Anacardiaceae family. Bangladesh's national tree is the mango, while India's national fruit is the mango. Another name for it is the "king of fruits."A nutrient-dense food with several health advantages is the mango. Because of their nutritious benefits, mangos are widely appreciated in a variety of food processing sectors. Vitamins A and C are abundant in mangoes. The total soluble sugar content of an excellent mango cultivar is 20%. Mango fruit has around 1% protein and an acidity level between 0.2 and 0.5%. Mangoes may have anticancer qualities, according to studies. Mangoes contain bioactive substances called polyphenols and carotenoids, which have been demonstrated to have the ability to stop the proliferation of cancer cells and prevent the creation of tumours. Because of their high potassium content and low salt content, mangoes help to keep blood pressure readings within normal ranges. Additionally, mangoes' fibre, antioxidants and polyphenols have been linked to better cardiovascular health, including a lower risk of stroke and heart disease. The area cultivated under fruit crops constitutes about 20% of the total horticulture crop area in Tamil Nadu. The other major mango-growing districts are Dharmapuri, Dindigul, Tiruvallur and Theni. Dharmapuri district is one of the potential districts for the cultivation of horticultural crops and forms a major horticultural belt in the state. The total area under mango cultivation is 16509 ha. Mango is the major horticulture crop grown in this district. The district accounts for nearly one-third of the area under the mango and nearly one-half of the mango yield in the state. Palacode and Karimangalam are the major areas where mango is cultivated. The popular mango varieties in Dharmapuri district are Banglora, Alphonso, Totapuri, Banganapalli, Senthura, Malgova and Neelam. In India the scope for increasing the production and productivity of mango is high. A study on the marketing behavior of mango growers would help us to identify the gaps and enable the extension scientists and policymakers to devise strategies to improve the production and productivity of mangoes. In this context, the present study was taken up to assess the marketing behaviour and the constraints experienced by the mango growers in the marketing of mango. Keeping this view, the present study was conducted in Dharmapuri district with the following specific objectives.

SPECIFIC OBJECTIVES

1. To study the profile characteristics of the mango growers.
2. To study the marketing behaviour of mango growers.
3. To find out the relationship between profile characteristics with their marketing behaviour of mango growers.

MATERIALS AND METHODS

Dharmapuri district in Tamil Nadu was purposively selected for the study as large area is available under mango cultivation in Dharmapuri district and Majority of the farmers and agricultural labourers are directly or indirectly involved in mango cultivation which forms the basis for the agrarian economy of Dharmapuri district. Dharmapuri district consists of ten blocks and In these ten blocks, Karimangalam and Palacode blocks were selected based on the major areas under the mango crop. A list of villages for the selected block was collected from the Department of Statistics. From the list of villages, six villages were selected from each block where the maximum number of farmers engaged in mango cultivation. The six villages from Karimangalam block the other six villages under the Palacode

block were selected. A total of 120 samples were selected from the twelve villages by using proportionate random sampling. A total of 15 Independent variables were selected for this study and They are age, educational status, occupational status, annual income, farm size, area under mango cultivation, farming experience, social participation, innovativeness, risk orientation, scientific orientation, economic motivation, information source utilization, market perception and decision-making ability and the Dependent variable Marketing Behaviour was selected. The Statistical tools and methods used for the collection of data were Arithmetic Mean, Percentage analysis and Cumulative frequency method.

RESULTS AND DISCUSSION

PROFILE CHARACTERISTICS OF MANGO GROWERS

Majority of respondents were young to middle aged (80.00 per cent) and possessed formal education (65.00 per cent). They had low to medium level of annual income (88.33 per cent) with agriculture as their primary occupation (75.00 per cent). They possessed marginal farms (70.84 per cent) with 2.1-3 acres of land under mango cultivation (39.17 per cent). They had medium to high level of farming experience (77.80 per cent). The mango growers were found to be medium in many of the characteristics like social participation (53.34 per cent), innovativeness (49.17 per cent), risk orientation (50.83 per cent), scientific orientation (50.00 per cent), economic motivation (46.67 per cent), information source utilization (54.17 per cent) and market perception (45.00 per cent). They had low decision-making ability (55.83 per cent). The distribution of respondents according to their overall Profile characteristics of mango growers was given in Table.1

MARKETING BEHAVIOUR OF MANGO GROWERS

The ability or propensity of a single farmer to recognize market trends in order to sell product for higher profits is known as marketing behaviour. It is observed that more than one-third (40.83 per cent) of the respondents had a medium level of marketing behaviour, followed by high (31.67 per cent) and low (27.50 per cent) levels of marketing behaviour. The distribution of respondents according to the overall marketing behaviour was given in the Table.1

ITEM-WISE MARKETING BEHAVIOR

Marketing behaviour consisted of eleven dimensions viz., time of sale, use of additional channel, price fixing criteria, consumer segmentation, publicity, price fall, record keeping, expenditure incurred, place of market, collection of money and source of market information. The results for various dimensions are discussed as follows. The distribution of respondents according to item-wise marketing behaviour is given in Table.2.

Time of sale

Majority of the farmers preferred to sell their produce soon after harvest (62.50 per cent) followed by around thirty per cent of the farmers (27.50 per cent) who used to sell their produce whenever they are in need of cash. Only 10.00 per cent of them sell their produce when the price is attractive. The farmers need immediate cash from marketing of their produce as they need to invest the same in further agricultural operations like preparation of field for next cropping, buying inputs and paying of wages etc., Hence they would have preferred to sell their produce soon after harvest.

Use of additional channel

Majority of the respondents used additional channel (75.00 per cent) for marketing their produce. They not only rely upon any one channel for marketing, they also used additional channels like Friends and relatives, small vendors, retail shops etc., for marketing their produce. The remaining 25.00 per cent of the respondents have not used any additional channels other than the key commission agents.

Price fixing criteria

Majority of them have chosen the right criteria in fixing the prices for their produce. Around half the proportion of the respondents (48.33 per cent) used to fix the prices based on the cost of production followed by 30.83 per cent of the respondents who had some price fixation based on the demand for the produce. Only (20.84 per cent) of the respondents who fixed prices based on personal need for money. They could get only poor returns for the produce when they opt for last strategies i.e, based on personal need for money.

Consumer segmentation

It could be revealed that almost Half the proportion of the respondents (50.83 per cent) have exclusive consumer segmentation for their produce. While for the remaining 49.17 per cent of the respondents, there is no consumer segmentation. As they depend on commission agents for marketing, there was no nessessity for them to segment the consumers.

Publicity

It could be revealed that around forty per cent of the respondents have spent money on publicity, whereas, majority of the respondents (60.83 per cent) did not spent money on publicity for the produce. Before harvest, the farmers used to publicize their produce through advertisements in newspaper, distribution of leaflets and also through social media. This would enable the buyers to assess that quantity and quality of fruits before they come for buying. In addition, some of the farmers arrange for temporary shops on the Dharmapuri-Bangalore highways so as to have direct marketing. Most of them sell their produce to the commission agents as a whole and hence they did not have the nessessity of spending on publicity for the produce.

During Price fall

Majority of the respondents (71.66 per cent) sell their produce at the same price as whatever is existing in the market. One-fifth of them (19.17 per cent) preferred to go for processing when the prices were low. Only a little proportion of the respondents (9.17 per cent) used to distribute their produce to friends and neighbours free of cost. As the majority of them do not have adequate knowledge and skill in mango processing and value addition, they don't prefer to go for processing.

Record keeping

Majority of the respondents (90.00 per cent) were not maintaining records for various marketing activities. Whereas, only 10.00 per cent of them were maintaining records for their cash inflow, outflow and other financial transactions. As majority of the respondents were not aware of the importance of record keeping, they were not maintaining proper farm records.

Expenditure incurred on transport

It could be observed that around fifty per cent of the respondents (47.50 per cent) spent much cost for transporting their produce from production to marketing spot. This was followed by 20.00 per cent of the respondents who spent more cost and 16.67 per cent of them spent less cost on transport. Least cost incurred on transport was reported by 15.83 per cent of the respondents respectively. As the market centres were located far away from the fields, the farmers need to spend much cost for transporting their produce from production to delivery point. The least expenditure incurred on transport might be due to the fact that few of the farmers were having their own vehicles for transporting their produce.

Place of Market

Majority of the respondents (65.83 per cent) preferred to sell their produce locally as they do not have the affordability to bear the transport cost. Around one-fifth of them (18.34 per cent) preferred to sell their produce to the wholesalers and 15.83 per cent of them sold their produce to retailers. As they could get immediate and one-time payment from wholesalers, farmers preferred them for marketing their produce. Retailers are least preferred due to delayed payment.

Collection of money

It could be revealed that nearly half the proportion of the respondents (48.33 per cent) get their money a week after sales followed by 29.17 per cent of them collected money immediately after sales and 22.50 per cent of the respondents used to collect money a month after sales. The collection of money after sales depends upon the place of market to whom the farmers sell their produce.

Sources of market information

It could be observed that most of the respondents (85.00 per cent) received information from their relatives and friends followed by 78.33 per cent of the respondents had information from local marketing centres,74.17 per cent of the respondents had received information from retailers, commission agent / brokers (65.00 per cent). This was followed by other sources like regulated market (60.83 per cent), agricultural extension agency (38.33 per cent), mobile advisory services (37.50 per cent), newspaper (19.17 per cent), internet- agricultural websites (19.17 per cent) and AIR/DD (14.17 per cent) respectively.It may be concluded that the most preferred sources of getting market information by the farmers are relatives and friends, local marketing centres, regulated market, retailers and commission agent/brokers.The findings revealed that most commonly used personal-localite channels for getting market information by the mango growers were family members, relatives and friends. This might be due to the close proximity and frequent interaction. Hence, it may be concluded that a majority of the respondents received market information from their relatives and friends.

RELATIONSHIP OF PROFILE CHARACTERISTICS OF THE RESPONDENTS WITH THEIR MARKETING BEHAVIOUR

Out of 15 independent variables studied, only eight variables, viz., educational status, farming experience, innovativeness, risk orientation, scientific orientation, economic motivation, information source utilization and market perception were found to have a positive and significant relationship with their marketing behaviour of mango. Results of multiple regression analysis indicated that all the independent variables together explained 55.60 per cent of the variations towards marketing behaviour, only eight variables, viz., educational status, farming experience, innovativeness, risk orientation, scientific orientation, economic motivation, information source utilization and market perception were found to have a positive and significant contribution with their marketing behaviour of mango. The relationship of the profile characteristics of the respondents with their marketing behaviour is given in the Table.3

SUMMARY AND CONCLUSION

The findings on characteristics of the mango growers would help the extension personnel of the Department of Horticulture, Government of Tamil Nadu in understanding the mango growers and designing appropriate strategies to increase the mango production in Dharmapuri District. The characteristics namely educational status, farming experience, innovativeness, scientific orientation, economic motivation, risk orientation, information source utilization and market perception were found to have a positive and significant relationship with the marketing behaviour of mango growers. Hence, these factors may be taken into consideration by the extension system in organizing training programmes for mango growers in future. The majority of the respondents had medium levels of marketing behaviour, hence it is suggested to organize exclusive training programmes for the marketing of mango. The farmer may be trained on various marketing dimensions like consumer segmentation, price fixing criteria, use of additional channels, publicity, price fall, record keeping, expenditure incurred on transport, place of market information and source of market information, it is suggested to establish commodity groups at village level to promote marketing strategies for mango growers.

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Table.1 The distribution of respondents according to the overall Profile characteristics of mango growers in mango cultivation (N=120)

S.NO	VARIABLES	CATEGORY	NUMBER	PERCENT
1	AGE	Young	36	30.00
		Middle	**60**	**50.00**
		Old	24	20.00
2	EDUCATIONAL STATUS	Illiterates	19	15.83
		Functionally literates	23	19.17
		Primary school education	25	20.83
		Middle school education	**32**	**26.67**
		Secondary school education	16	13.33
		Collegiate education	5	4.16
3.	OCCUPATIONAL STATUS	**Agriculture as primary**	**90**	**75.00**
		Agriculture as secondary	30	25.00
4.	ANNUAL INCOME	Low	51	42.50
		Medium	55	45.83
		High	14	11.67
5.	FARM SIZE	**Marginal**	**85**	**70.84**
		Small	23	19.16
		Big	12	10.00
6.	AREA UNDER MANGO CULTIVATION	Upto 1 acre	15	12.50
		1.1 to 2 acres	26	21.66
		2.1 to 3 acres	**47**	**39.17**
		3.1 to 4 acres	20	16.67
		4.1 to 5 acres	12	10.00
7.	FARMING EXPERIENCE	Low	27	22.50
		Medium	**55**	**45.83**
		High	38	31.67
8.	SOCIAL PARTICIPATION	Low	28	23.33
		Medium	**64**	**53.34**
		High	28	23.33

9.	INNOVATIVENESS	Low	35	29.17
		Medium	**59**	**49.17**
		High	26	21.66
10.	RISK ORIENTATION	Low	34	28.34
		Medium	**61**	**50.83**
		High	25	20.83
11.	SCIENTIFIC ORIENTATION	Low	31	25.83
		Medium	**60**	**50.00**
		High	29	24.17
12.	ECONOMIC MOTIVATION	Low	36	30.00
		Medium	**56**	**46.67**
		High	28	23.33
13.	INFORMATION SOURCE UTILIZATION	Low	38	31.67
		Medium	**65**	**54.17**
		High	17	14.16
14.	MARKET PERCEPTION	Low	29	24.17
		Medium	**54**	**45.00**
		High	37	30.83
15.	DECISION MAKING ABILITY	**Low**	**67**	**55.83**
		Medium	31	25.83
		High	22	18.34
16.	OVERALL MARKETING BEHAVIOUR	Low	33	27.50
		Medium	**49**	**40.83**
		High	38	31.67

Table.2.The distribution of respondents according to the Item-wise marketing behavior of mango growers in mango cultivation (N=120)

S.No.	ITEM WISE MARKETING BEHAVIOUR		Number	Per cent
1	**Time of sale**	**Soon after harvest**	**75**	**62.50**
		When the price is attractive	12	10.00
		When they need of cash	33	27.50
2	**Use of additional channel**	**Existence of additional channel**	**90**	**75.00**
		Absence of additional channel	30	25.00
3	**Price fixing criteria**	**Based on cost of production**	**58**	**48.33**
		Based on demand for the produce	37	30.83
		Based on personal need for money	25	20.84
4.	**Consumer segmentation**	**Existence of consumer segmentation**	**61**	**50.83**
		Non-existence of consumer segmentation	59	49.17
5.	**Publicity**	Expenditure incurred on publicity	47	39.17
		No expenditure incurred	**73**	**60.83**
6.	**During Price fall**	Go for processing	23	19.17
		Sell at same price	**86**	**71.66**
		Distribute to Friends and neighbours at free of cost	11	9.17
7.	**Record keeping**	Maintaining Records	12	10.00
		Not maintaining Records	**108**	**90.00**

8.	**Expenditure incurred on transport**	More (> 10000)	24 **57** 20 19	20.00 **47.50** 16.67 15.83
		Much (6000-10000)		
		Less (1000-5000)		
		Least (< 1000)		
9.	**Place of market**	**Local**	**79**	**65.83**
		Retailer	19	15.83
		Wholesaler	22	18.34
10.	**Collection of money**	Immediately after sales	35	29.17
		A week after sales	**58**	**48.33**
		A month after sales	27	22.50
11.	**Source of market information**	**Relatives and friends**	**102**	**85.00**
		Local marketing centres	94	78.33
		Regulated market	73	60.83
		Commission agent/brokers	78	65.00
		Retailers	89	74.17
		Agricultural extension Agency	46	38.33
		News paper	23	19.17
		AIR/DD	17	14.17
		Internet- Agricultural Websites	23	19.17
		Mobile advisory services	45	37.50

Table.3. Relationship of characteristics of the respondents with their marketing behavior (N=120)

S. No	Variables	'r' values	Standardized regression coefficient	Standard error	't' values
X_1	Age	0.016NS	0.032	0.845	0.337NS
X_2	Educational status	**0.271****	0.192	0.562	**2.927****
X_3	Occupational status	0.096NS	0.366	0.412	1.125NS
X_4	Annual income	-0.083NS	-0.173	1.121	-1.432NS
X_5	Farm size	0.018NS	0.116	1.165	0.931NS
X_6	Area under mango cultivation	0.171NS	-0.214	2.014	-0.891NS
X_7	Farming experience	**0.269****	0.111	0.296	**2.666****
X_8	Social participation	0.101NS	0.712	1.016	1.426NS
X_9	Innovativeness	**0.186***	0.311	0.612	**1.967***
X_{10}	Risk orientation	**0.231***	0.431	1.975	**1.938***
X_{11}	Scientific orientation	**0.207***	0.816	1.462	**1.791***
X_{12}	Economic motivation	**0.207***	1.400	2.562	**1.830***
X_{13}	Information source utilization	**0.213***	0.361	1.647	**2.077***
X_{14}	Market perception	**0.194***	0.100	0.226	**2.260***
X_{15}	Decision making ability	0.033NS	-0.031	0.819	-0.302NS

R^2= 0.556 a = 4.561 F= 6.418**

*** Significant at 5.00 per cent level ** Significant at 1.00 per cent level NS-Non-Significant**

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RESEARCH ARTICLE

The Effect of Comprehensive Corrective Exercise Program and Alexander Technique on Upper Crossed Syndrome among Office Workers

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ABSTRACT

Office workers are commonly suffering from Upper Crossed Syndrome (UCS), a postural ailment brought on by extended sitting and muscular imbalances. It results in rounded shoulders, forward head posture, and shoulder and neck discomfort. Corrective exercise regimens aid in pain relief, muscle balance restoration, and posture improvement. This study examines how well the Alexander Technique (AT) and the Comprehensive Corrective Exercise Program (CCEP) manage UCS. The aim of this study is to determine the most effective approach for treating office workers postural deviations. A total of 50 office workers with UCS were allocated into two groups, to receive both AT or CCEP interventions. The REEDCO Posture Assessment Scale, Neck Disability Index (NDI), and Visual Analog Scale (VAS) were used to measure neck and shoulder pain, postural deviations and functional improvements. To determine the significance of the improvements in each group, statistical analysis was performed. According to the statistical analysis, the values were analyzed using the paired and unpaired t tests. Both intervention were effective in addressing posture, enhancing shoulder function, and lowering neck and shoulder pain. All evaluated measures showed significantly greater improvements in the CCEP group, though ($P < 0.0001$). According to the results, CCEP significantly improves neck and shoulder pain, postural deviations, and functional improvements as measured by the Visual Analog Scale (VAS), REEDCO Posture Assessment Scale, and Neck Disability Index (NDI).

Keywords: Corrective exercise regimens aid in pain relief, muscle balance restoration, and posture improvement.

INTRODUCTION

Damage to the musculoskeletal system has been identified as the primary issue affecting younger people. Musculoskeletal problems, which primarily affect the thoracic and cervical regions, can result from mental, visual, and postural problems. Musculoskeletal distress is also linked to masculinity and physical activity.[1]Upper Cross Syndrome (UCS) is characterized by weakness in the serratus anterior, middle, and lower trapezius, deep neck flexors, scalene, rhomboids muscles as well as the pectoralis major, upper trapezius and levator scapula emuscles tightness. A common condition known as upper cross syndrome is linked to poor posture, which also causes imbalances in the musculoskeletal system.[2] Upper crossed syndrome can causes numerous clinical manifestations and complications such as temporomandibular joint disorders, scapular instability, cervical degenerative diseases, cervical antiarch, cervical headaches, and neck pain.[3] Vladimir Janda (1923–2002) suggested that upper crossed syndrome(UCS) is characterized by unusual posture, postural deviations (forward head and shoulder posture, increased thoracic kyphosis), and specifically changed patterns of movement (scapular dyskinesis) and muscular activation (especially in the neck, trunk, and scapular muscles).[4,5] Poor posture at work can lead to problems with the muscles in the upper limbs and neck. Bad postures at work, extended laptop sitting, unusual working conditions, a lack of breaks or rest during the workday, and extended working hours can all contribute to upper cross syndrome. Upper Cross syndrome will develop gradually if none of these factors are managed.[6]CCEP is founded on a novel strategy called the Comprehensive Approach, which aims to innovate by leveraging the advantages and disadvantages of earlier strategies. In fact, the system view, which is responsible for providing essential information about a system's overall behavior and performance through the interactions between its numerous components, is the foundation of the comprehensive approach.[7]In a complex system like the human movement system, movement is produced by the interaction of the articular, muscular, and neurological subsystems. Therefore, when evaluating and treating musculoskeletal problems like UCS, it is essential to consider the relationships between these subsystems that ultimately give system performance and overall behavior.[8,9]

A common postural imbalance among office workers, Upper Crossed Syndrome (UCS) is brought on by extended sitting, bad ergonomics, and sedentary work habits. It is characterised by weakness in the lower trapezius, deep neck flexors and serratus anterior muscles, as well as rigidity in the pectoral, levator scapulae, and upper trapezius muscles. These muscular imbalances disable physical well-being and productivity to resulting in shoulder dysfunction, neck pain, and decreased thoracic mobility. The increasing incidence of UCS among office workers emphasises the necessity of efficient treatments to deal with musculoskeletal pain and postural dysfunction. The Alexander Technique (AT) and comprehensive corrective exercise have both demonstrated promise in enhancing posture and lowering musculoskeletal discomfort. Targeted stretching, strengthening, and neuromuscular retraining are all components of comprehensive corrective exercise that help rebuild muscle balance, while the Alexander Technique focusses on tension relief, movement re-education, and postural awareness. Although UCS is managed using both strategies, few comparative research has been done on how beneficial they are, especially when it comes to office workers. The goal of the Alexander technique is to help someone become more aware of their body and use that awareness to perform more effectively. Alexander technique training sessions involve posture exercises ranging from sitting and lying down to more dynamic positions like standing and walking, as well as unique activities like studying, playing the guitar, and working at a desk.[10] This method focuses primarily on education rather than treatment and employs the teacher-student paradigm rather than the therapist-patient paradigm. People can modify their bad habitual movement patterns and become sensorimotorly aware of their posture by using the Alexander technique.[11,12]By using this technique, the individual learns to recognize the causes of the body's tension response, avoid bad habits, and substitute them with effective movement patterns that are based on timing, direction, and stress reduction, with a focus on the head, neck, and trunk.[13,14] This study's objective is to assess whether comprehensive corrective exercise program and Alexander technique to improve UCS in this population. We intend to compare these two strategies in order to determine which is best for symptom relief and posture correction, which will ultimately improve office workers' musculoskeletal health and quality of life.

MATERIALS AND METHODS

Office workers aged 20-50 years with upper crossed syndrome (UCS) were recruited through a screening process and provided informed consent to participate. 50 people, both male and female, were selected based on the inclusion and exclusion criteria, and their informed consent was acquired after they were briefed on the procedure's safety and ease of use and had their baseline characteristics taken into consideration. Total duration of the study: 6 weeks. Convenient recruitment sampling is the method used in this study. Male and female participants with symptoms such as shoulder pain, neck pain, or postural abnormalities who are between the ages of 20 and 50 are included. People who have had major surgery within the last six months, experienced injuries or illnesses that lasted longer than six months, or had severe chronic conditions like osteoporosis or rheumatoid arthritis are excluded. Subjects willing to participate were randomly assigned into two groups, comprehensive corrective exercise program (n=25) and Alexander technique (n=25), following the sample calculation based on physical examination and symptoms of posture deviations, neck and shoulder pain among the office workers. Participation at the 12th session, the post-test results were provided, the scores were reassessed, and the study's results were measured using the Neck Disability Index (NDI) to measure the impact of neck pain on daily activities, the REEDCO Posture Assessment Scale to evaluate postural deviations, and the Visual Analog Scale (VAS) to assess the intensity of neck and shoulder pain. Foam roller, swiss ball, dumbells and chair are the materials used for this study. Willingness of the subject to proceed with the procedure with or without rest, was prioritized during the assessment process.

Intervention

The six-week workout regimen consisted of three sessions per week, each lasting roughly an hour. Both groups warmed up for ten minutes before each workout, and they cooled down for five minutes at the end. All of the workouts were done under observation. Even though the participants didn't do any extra workouts at home, it was important to avoid keeping poor posture.

Comprehensive Corrective Exercise Program (CCEP) Group

Comprehensive Corrective Exercise Program (CCEP): Three stages of design were used to create the CCEP: initial, improvement, and maintenance. As long as the movements are executed well, During these phases, the workouts' frequency and intensity are raised. Scapular muscles were the cognitive focus of the first phase's exercises (i.e., Attention's inward focus). The participants were told to return their scapular positions to normal and motion by relaxing overactive muscles and isometrically contracting underactive muscles. Participants started utilizing various training postures to incorporate upper extremity movements when their muscle balance returned to normal under static settings. Activation & Mobility and Strength & Stability are the two stages of this rehabilitation program. For the purpose of to improve shoulder movement, Phase 1 begins with Foam Roll Arm Abduction at progressively greater angles (45°, 90°, and 135°). Control and activation are enhanced by Standing Diagonal Flexion, Side-Lying External Rotation, Military Press, and Side-Lying Forward Flexion. Phase 2 uses resistance to increase stability and strength. Lying Prone V, T, and W Exercises strengthen the scapular muscles, Abduction on a Balance Board integrates balance and control, Standing Diagonal Flexion, External Rotation with Tera-band, and Abduction on a Training Ball enhance dynamic stability, and Side-Lying External Rotation and Forward Flexion with Dumbbells add load. This methodical strategy confirms a gradual return to full function.[9]

Alexander Technique

Two certified instructors supervised the AT training program, which consisted of 18 sessions spanned over six weeks and included a daily at-home program. The method concentrated on enhancing body use through manual guidance and spoken instructions during activities such as walking, standing, sitting, and playing an instrument. In the early sessions, breathing techniques, muscle tension inhibition, and spine awareness were prioritized. In order to improve posture and movement efficiency, dynamic movements were introduced during mid-training. By the time it was all

over, students had integrated improved movement patterns into daily activities by applying AT principles to tasks. The intervention was guided by verbal, visual, and proprioceptive cues throughout.[10,11]

Outcome measures

Three primary measurement instruments are used in assessments to analyze posture, neck pain, and how these factors affect day-to-day functioning. The effect of neck discomfort on functional tasks such as lifting, reading, and working is measured by the Neck Disability Index (NDI).Through an analysis of head, shoulder, and spinal alignment, the REEDCO Posture Assessment Scale assists in identifying postural deviations. Neck and shoulder pain is measured using the Visual Analog Scale (VAS), which ranges from 0 (no pain) to 10 (worst pain). Important information about the degree of discomfort and postural imbalances is provided by these evaluations. The information gathered is useful for designing focused pain management and posture correction interventions.

RESULTS

The Neck Disability Index (NDI), REEDCO Posture Assessment Scale and Visual Analog Scale (VAS) indicate a significant in reducing pain in neck and shoulder, improving function of shoulder and correcting the posture deviation. Table 1 comparison of the post-test values between the Comprehensive Corrective Exercise Program (CCEP) Group and the Alexander Technique (AT) Group using the REEDCO Posture Assessment Scale. The CCEP Group had a mean score of 85.2 with a standard deviation (SD) of 4.2, whereas the AT Group had a lower mean score of 73.8 with an SD of 5.8, according to the data. For this comparison, the estimated t-value was 8.72. The findings are regarded as highly statistically significant, with a P-value of 0.0001, indicating that CCEP is significantly more effective in improving posture. Table 2 comparing the post-test results for the two groups using the Neck Disability Index (NDI). The CCEP Group's mean score was 12.2, with an SD of 3.2, whereas the AT Group's was higher, at 18.7, with an SD of 4.5. The comparison's t-value was -6.15, and the P-value was 0.028. These results show a statistically significant difference, indicating that CCEP is better than the Alexander Technique at reducing neck disability. Table-3 Comparing the two groups' post-test results using the Visual Analog Scale (VAS) to measure pain is highlighted. With a mean score of 2.4 and an SD of 0.6, the CCEP Group outperformed the AT Group, which reported a mean score of 3.6 and an SD of 0.9. The t-value of -6.08 and P-value of 0.032 for the comparison verified statistical significance. These findings suggest that people in the CCEP Group had more pain relief than those in the AT Group. All things considered, the information in all three tables supports CCEP's exceptional efficacy in enhancing posture, lowering neck impairment, and easing discomfort. The results are considered statistically significant. This shows that, when comparing both the invention Comprehensive Corrective Exercise Program (CCEP) shows significant in reducing pain in neck and shoulder, improving function of shoulder and correcting the posture deviation.

DISCUSSION

A screening procedure was used to find office workers with upper crossed syndrome (UCS) who were between the ages of 20 and 50. The trial lasted for six weeks in total. This study employed a convenient recruitment sampling technique. Participants between the ages of 20 and 50 who have symptoms including neck discomfort, shoulder pain, or postural irregularities are included, regardless of gender. In a randomized controlled experiment, Foad Seidi *et al.* examined the effects of a Comprehensive Corrective Exercise Program (CCEP) on alignment, muscle activation, and movement pattern in males with Upper Crossed Syndrome (UCS)(2020). The findings revealed notable changes in posture, including rounder shoulders and less forward head position. The imbalance between weak and hyperactive muscles was corrected when muscular activation patterns improved. Additionally, participants showed improved cervical stability and scapular control, which improved movement efficiency. According to the study, remedial exercises are a successful non-invasive treatment for UCS. Although long-term adherence should be investigated, the RCT design improves dependability. The necessity of early management to avoid musculoskeletal problems is highlighted by these findings. A research conducted among University of Lahore Doctor of Physical Therapy (DPT) students to ascertain the prevalence and risk variables associated with the development of UCS. The findings

revealed a significant prevalence of UCS in this population, with risk factors including prolonged sitting, poor ergonomic practices during computer use, and a sedentary lifestyle. These results underscore the importance of addressing ergonomic and lifestyle factors to prevent UCS.Shahid *et al.* (2015) Ian Kutschke's (2010) study investigated at how Alexander Technique (AT) training affected the posture and biomechanics of the neck and shoulders in healthy people. The results demonstrated better shoulder and cervical alignment, which decreased muscular tension and forward head posture. AT improved muscular activation efficiency, movement coordination, and postural control. Participants' neuromuscular balance improved and their stiffness decreased, encouraging more fluid movement. The method could aid in avoiding musculoskeletal pain and postural dysfunctions. Although advantageous, further study is required to determine long-term impacts and compare it to alternative approaches. All things considered, AT enhances movement awareness, biomechanics, and posture. A research by Seidi *et al.* (2014) assessed how corrective exercise therapies affected the angle of thoracic hyperkyphosis. Significant changes in thoracic alignment were shown in their study, indicating that certain workouts may aid in postural correction. They also saw increased muscular activity, which is important for maintaining good posture. These results demonstrate how well corrective exercises work to rectify postural abnormalities. The study highlighted that such types of treatments could help lessen the thoracic spine's excessive curvature. Their findings also lend credence to the use of corrective exercises in the treatment of postural issues. In particular, organized exercise regimens may help with ailments like Upper Crossed Syndrome (UCS). According to the results of the current study, shoulder and neck discomfort can be effectively reduced by using the Alexander Technique and the Comprehensive Corrective Exercise Program (CCEP). Both procedures also help to correct postural deviations and enhance shoulder function. However, the study discovered that CCEP was more successful in reaching these results when comparing the two strategies. In particular, CCEP demonstrated a more significant decrease in shoulder and neck pain, indicating its superiority as a pain treatment strategy. Furthermore, shoulder function significantly improved for those who adhered to CCEP. Additionally, the program outperformed the Alexander Technique in treating postural deviations. All things considered, CCEP appears to be a more effective way to treat musculoskeletal problems.

CONCLUSION

This study examined the effects Alexander Technique (AT) and the Comprehensive Corrective Exercise Program (CCEP) affects Upper Crossed Syndrome (UCS) among office workers. The results show that CCEP was significantly improved in all assessed parameters, even if both therapies helped to reduce discomfort, enhance shoulder function, and posture correction. According to post-test results from the Visual Analog Scale (VAS), Neck impairment Index (NDI), and REEDCO Posture Assessment Scale, CCEP produced better posture changes, less neck impairment, and more pain reduction than AT. These findings' statistical significance emphasizes how CCEP may be a more successful solution for office workers with UCS. These results highlight the importance that organized corrective exercises are for treating postural abnormalities brought on by extended desk labor. It is advised that these findings be further verified in future research with bigger sample numbers and longer follow-ups.

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Table.1 Comparsion between the post test values of CCEP Group & AT Group in REEDCO

REEDCO		MEAN	SD	T-VALUE	P-VALUE
CCEP GROUP	POST- TEST	85.2	4.2	8.72	p < 0.00001
AT GROUP	POST- TEST	73.8	5.8		

Table 2. Comparsion between the post test values of CCEP Group & AT Group in NDI.

NDI		MEAN	SD	T-VALUE	P-VALUE
CCEP GROUP	POST- TEST	12.2	3.2	-6.15	p = 0.028
AT GROUP	POST- TEST	18.7	4.5		

Table 3. Comparsion between the post test values of CCEP Group & AT Group in VAS.

VAS		MEAN	SD	T-VALUE	P-VALUE
CCEP GROUP	**POST- TEST**	2.4	0.6	-6.08	p = 0.032
AT GROUP	**POST- TEST**	3.6	0.9		

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RESEARCH ARTICLE

The Efficacy of a Self-Instructional Module (SIM) on Home Care Management for Caregivers of Patients Undergoing Hemodialysis in a Designated Community in West Bengal

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ABSTRACT

Caregivers for hemodialysis patients play a crucial role in home care management, but many do not receive the necessary training and support. The goal of this study was to determine the efficacy of a Self-Instructional Module (SIM) in improving caregiver knowledge, confidence, competence, and quality of life (QoL) while reducing stress. A quasi-experimental pre- and post-test design was used with 30 caregivers from a specific community in West Bengal. Structured questionnaires and validated scales were used to assess knowledge, confidence, stress, and quality of life prior to and following intervention. The results showed a significant improvement in caregiver knowledge, with high knowledge levels increasing from 6.7% (pre-test) to 53.3% (post-test).Confidence levels also grew, with high confidence rising from 6.7% to 33.3% and tension falling from 16.7% to 6.7%. In addition, quality of life improved, with good QoL increasing from 13.3% to 23.3%. The data show that SIM is an effective intervention for enhancing caregiver skills and reducing stress, which leads to better patient outcomes and caregiver well-being. This study underlines the importance of structured educational programs for care givers of hemodialysis patients.

Keywords: Self-Instructional Module, Home Care Management, Hemodialysis, Caregiver Stress, and Quality of Life.

INTRODUCTION

Hemodialysis is a life-saving treatment for patients with end-stage renal disease (ESRD). However, it creates significant challenges for caregivers, who must oversee home care, ensure medication adherence, and assist with daily tasks. Caregivers are frequently stressed physically, mentally, and financially due to the intricacy of hemodialysis care. The goal of this study is to assess the efficacy of a Self-Instructional Module (SIM) in home care management for caregivers of hemodialysis patients. The module provides crucial information and skills to assist caregivers manage home care more effectively, thereby increasing the quality of life for both caregivers and patients.

Need for the Study

The growing number of patients undergoing hemodialysis, as well as caregivers' critical role in home management, highlight the significance of this research. Caretakers frequently lack appropriate training and direction, resulting in challenges and a worse quality of life for both patients and caregivers. There is a scarcity of structured and accessible educational resources for caregivers of hemodialysis patients. The SIM aims to fill this gap by providing caregivers with the knowledge and skills needed to effectively manage home care.

Objectives of the Study

1. To assess the SIM's effectiveness in improving home care management knowledge among patients undergoing hemodialysis.
2. Evaluate the SIM's impact on caregiver confidence and competence in managing hemodialysis patients' home care needs.
3. Determine any differences in caregiver stress, burden, and quality of life before and after the intervention.

Hypothesis

H_0: There is no significant difference in caregivers' awareness of home care management before and after the SIM.
H_1: The SIM enhances caregivers' knowledge and confidence in home care management.

Assumptions

1. Caregivers for hemodialysis patients will have varying levels of knowledge about home care management.
2. Caregivers will find the SIM useful and understandable.
3. Caregivers will actively participate in the study by completing the required pre- and post-assessments.

Delimitations

1. The study solely included caregivers for hemodialysis patients, not those with other chronic diseases.
2. The study was conducted in a specific geographic location, limiting its generalizability.

METHODOLOGY

This study will use a quantitative research design with a pre-test and post-test to assess the effectiveness of a self-instructional module (SIM) on home care management for caregivers of hemodialysis patients. A quasi-experimental methodology will be used, with the SIM presented to a specific set of caregivers and changes in their knowledge, confidence, and burden measured pre- and post-intervention. A structured questionnaire will be used to collect data on key topics such as hemodialysis basics, dietary restrictions, signs of complications (e.g., infection, fluid overload), emergency management (e.g., addressing low blood pressure), and daily care practices. The study will take place in a specific community in West Bengal, with a focus on caregivers who manage hemodialysis patients at home. A convenience sampling approach will be used to pick 30 caregivers based on inclusion criteria and willingness to participate. This methodology intends to provide measurable insights on the SIM's impact on caregiver competencies in managing home care for hemodialysis patients.

Independent Variable

The Self-Instructional Module (SIM) on home care management for hemodialysis patients.

Dependent variable

The SIM's effectiveness is measured by increased caregiver knowledge, confidence, and competence, as well as reduced stress and burden.

Inclusion Criteria

1. The primary caregivers for hemodialysis patients.
2. Caregivers who can read and follow written instructions in the SIM.
3. Caregivers who agree to engage in pre- and post-assessments and complete the SIM.

Exclusion Criteria

1. Caregivers who do not directly care for hemodialysis patients at home.
2. Caregivers who have severe cognitive or language obstacles to understanding the SIM.
3. Caregivers who do not give informed permission.

Data Collection Tools

1. Structured Questionnaire: To measure caregivers' understanding of home care management.
2. Confidence and Competence Scales: Assess caregivers' perceived competence to manage home care duties.
3. Stress and Burden Scales: To assess caregivers' stress and burden levels.
4. Quality of Life Assessment: To assess changes in caregivers' QoL.

Prepare for Data Analysis

Descriptive statistics include frequency, percentage, mean, and standard deviation for demographic characteristics and knowledge levels.

Inferential statistics

To compare pre- and post-test results, utilize paired t-tests or Wilcoxon signed-rank tests.

Correlation Analysis

Investigate the relationship between knowledge improvement and confidence/competence levels. Significance level: $p < 0.05$. According to demographic data, the majority of caregivers are middle-aged (41-50 years), female (60%), and have completed high school. The most majority (40%) are the patient's spouses, with 60% living with the patient, implying direct daily caregiving responsibilities. While 40% have 2-5 years of caring experience, 26.7% have no prior understanding of hemodialysis, highlighting the significance of formal training. The findings show that a Self-Instructional Module (SIM) can effectively improve caregivers' knowledge and confidence, resulting in better home care management. The mean knowledge score increased from 12.5 (pre-test) to 24.8 (post-test), with the average percentage rising from 41.7% to 82.7%. This demonstrates a significant improvement in caregivers' knowledge following the SIM intervention. The table reveals a considerable increase in caregiver confidence ratings following the SIM intervention. The proportion of caregivers with high confidence rose from 6.7% (pre-test) to 33.3% (post-test), while those with poor confidence fell from 66.7% to 16.7%. The mean stress score declined from 22.5 (pre-test) to 15.2 (post-test), and the average percentage decreased from 75% to 50.7%. This implies a significant decrease in caregiver stress levels following the SIM intervention. The table shows an improvement in caregivers' quality of life following the SIM intervention. The proportion of caregivers with good QoL increased from 13.3% (pre-test) to 23.3% (post-test), while those with poor QoL decreased from 40% to 16.7%.

CONCLUSION

The study emphasizes the usefulness of self-instructional modules (SIMs) in assisting caregivers of hemodialysis patients in improving their knowledge, confidence, and home care skills. The pre- and post-test results showed that caregivers learned more about hemodialysis basics, diet, problem identification, emergency management, and daily care activities. The SIM also reduced the caretakers' burden. The study, which was done in a West Bengal town, shows how successful such training programs are in assisting caretakers. More research with larger populations is needed to validate these findings and look into potential long-term benefits.

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Table 1: Frequency and Percentage-wise Distribution of Demographic Variables (N = 30)

Demographic Variable	Category	Frequency (N)	Percentage (%)
Age	< 20	2	6.7%
	21-30	5	16.7%
	31-40	8	26.7%
	41-50	10	33.3%
	51 and above	5	16.7%
Gender	Male	10	33.3%
	Female	18	60%
	Other	2	6.7%
Educational Level	No formal education	4	13.3%
	Primary	6	20%
	High school	7	23.3%
	Undergraduate	7	23.3%
	Graduate	6	20%
Occupation	Employed	8	26.7%
	Unemployed	7	23.3%
	Retired	5	16.7%
	Homemaker	7	23.3%
	Other	3	10%
Relationship to Patient	Spouse	12	40%
	Child	7	23.3%
	Parent	5	16.7%
	Sibling	4	13.3%
	Other	2	6.7%

Years of Caregiving Exp.	0-1 years	6	20%
	2-5 years	12	40%
	6-10 years	8	26.7%
	11+ years	4	13.3%
Previous Knowledge	None	8	26.7%
	Some	10	33.3%
	Good	7	23.3%
	Expert	5	16.7%
Living Situation	With patient	18	60%
	Not with patient	8	26.7%
	Lives separately	4	13.3%

Table 2: Frequency and Percentage-wise Distribution of Caregivers' Knowledge Levels Before and After the SIM Intervention

Knowledge Level	Pre-Test Frequency (N)	Pre-Test Percentage (%)	Post-Test Frequency (N)	Post-Test Percentage (%)
Low (0-50%)	18	60%	2	6.7%
Moderate (51-75%)	10	33.3%	12	40%
High (76-100%)	2	6.7%	16	53.3%

Table 3 shows the mean, standard deviation (SD), and mean percentage of caregiver knowledge scores before and after the SIM intervention.

Assessment	Maximum Score	Mean Score	Standard Deviation (SD)	Mean Percentage (%)
Pre-Test	30	12.5	3.2	41.7%
Post-Test	30	24.8	2.7	82.7%

Table 4 shows the frequency and percentage-wise distribution of caregiver confidence levels before and after the SIM intervention.

Confidence Level	Pre-Test Frequency (N)	Pre-Test Percentage (%)	Post-Test Frequency (N)	Post-Test Percentage (%)
Low (0-50%)	20	66.7%	5	16.7%
Moderate (51-75%)	8	26.7%	15	50%
High (76-100%)	2	6.7%	10	33.3%

Table 5 shows the mean, standard deviation (SD), and mean percentage of caregiver stress levels before and after the SIM intervention.

Assessment	Maximum Score	Mean Score	Standard Deviation (SD)	Mean Percentage (%)
Pre-Test	30	22.5	3.5	75%
Post-Test	30	15.2	2.8	50.7%
Assessment	Maximum Score	Mean Score	Standard Deviation (SD)	Mean Percentage (%)
Pre-Test	30	22.5	3.5	75%
Post-Test	30	15.2	2.8	50.7%

Table 6 shows the frequency and percentage-wise distribution of caregivers' quality of life (QoL) levels before and after the SIM intervention

QoL Level	Pre-Test Frequency (N)	Pre-Test Percentage (%)	Post-Test Frequency (N)	Post-Test Percentage (%)
Poor (0-50%)	12	40%	5	16.7%
Moderate (51-75%)	14	46.7%	18	60%
Good (76-100%)	4	13.3%	7	23.3%

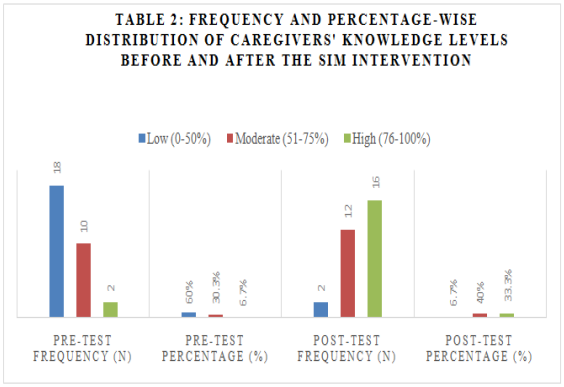


Fig:1

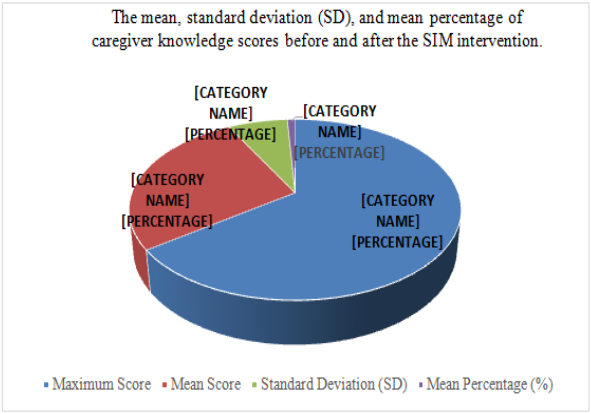


Fig:2

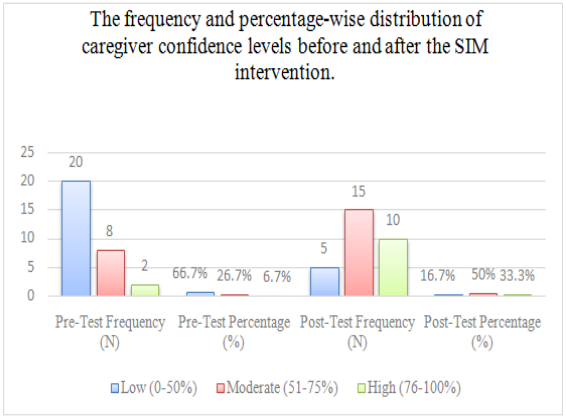


Fig:3

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RESEARCH ARTICLE

Converting an Image to Text : A Machine Learning - based Conversion System

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ABSTRACT

This paper introduces an innovative approach to automatically detect errors in the conversion of images to textual content using machine learning. Leveraging advanced image analysis and deep learning algorithms, our proposed method identifies discrepancies and inaccuracies introduced during the image-to-text process. By training a robust model on diverse datasets, we achieve high accuracy in pinpointing errors, enhancing the reliability of the resulting textual output. The system demonstrates versatility in handling various types of images and effectively identifies and rectifies common errors such as misinterpretations and omissions. Our approach not only contributes to improving the accuracy of image-to-text conversion but also offers a scalable solution for real-world applications, paving the way for more dependable automated text generation from visual inputs. Experimental results underscore the efficacy of our method in providing a comprehensive and automated solution for image-to-text error detection.

Keywords: Machine Learning, Random Forest, Ada Boost, XGBoost

INTRODUCTION

This paper employs an innovative approach to enhance the accuracy of image-to-text conversion utilizing machine learning, particularly leveraging Convolutional Neural Networks (CNN). This methodology incorporates advanced image analysis and deep learning algorithms to automatically detect errors introduced during the conversion process. (Husain et al., 2019) Additionally, the proposed CNN-based model is trained on diverse datasets, achieving exceptional accuracy in pinpointing discrepancies and enhancing the reliability of the generated textual content. It demonstrates versatility in handling various image types and excels at identifying and rectifying common errors like misinterpretations and omissions. Moreover, beyond refining image-to-text accuracy, the paper provides a scalable solution for real- world applications, contributing to the advancement of dependable automated text generation from visual inputs. Experimental results underscore the efficacy of the CNN-based algorithm, establishing a comprehensive and automated approach for detecting errors in image-to-text conversion (Saleem et al., 2023) . This has promising implications for improved accuracy and reliability across diverse contexts. To extend the capabilities of the model, additional algorithms such as Random Forest (RF) and AdaBoost could be integrated. Random Forest is an ensemble learning method that operates by constructing multiple decision trees during training and outputting the mode of the classes. AdaBoost, on the other hand, is an ensemble learning method that builds a strong classifier by combining multiple weak classifiers. Integrating these algorithms could potentially further enhance the accuracy and robustness of the image-to-text conversion system, offering improved performance in error detection and correction.

RELATED WORK

Deep learning has revolutionized image processing, with Convolutional Neural Networks (CNNs) demonstrating remarkable success in various image enhancement tasks (Okarma & Kopytek, 2023) . Studies by (Kastryulin et al., 2022) and (Du et al., 2023) showcase the effectiveness of CNNs for noise reduction and image deblurring. However, these approaches often focus on specific error types. Recent work by (Woldamanuel,2023) explores a multi-task learning framework for joint error detection and correction, achieving promising results, but further improvement in accuracy and generalizability is desired. (Kannan et al., 2023) Existing image-to-text conversion systems often rely on Optical Character Recognition (OCR) technologies, which can encounter challenges in accurately interpreting complex images, handwriting, or non-standard fonts. These systems may struggle with context-aware error detection and correction, leading to inaccuracies in the generated text. Moreover, conventional OCR methods lack the ability to dynamically adapt to diverse image types and may not effectively handle nuanced errors. The existing image-to-text conversion systems, primarily relying on Optical Character Recognition (OCR) technologies, exhibit several disadvantages:

Accuracy Challenges with Complex Images

OCR systems may struggle to accurately interpret complex images, especially those containing intricate graphics, backgrounds, or multiple layers of text. This limitation can result in errors or inaccuracies in the converted text.

Difficulty with Handwriting and Non-Standard Fonts

OCR technologies often encounter difficulties in accurately recognizing handwritten text or non-standard fonts. This limitation is particularly pronounced in scenarios where the handwriting is illegible or the fonts are unconventional, leading to errors in the converted text.

Lack of Context-Aware Error Detection and Correction

Conventional OCR methods may lack the ability to perform context-aware error detection and correction. As a result, they may overlook subtle errors or fail to rectify them appropriately, leading to inaccuracies in the generated text.

PROPOSED METHODOLOGY

The proposed system comprises three key stages: pre-processing, error detection, and error categorization. During pre-processing, images undergo necessary scaling and normalization. The error detection stage utilizes a pre-trained CNN model specifically designed to identify various image quality issues. (Okarma & Kopytek, 2023) The model architecture will likely involve convolutional layers for feature extraction followed by fully connected layers for classification. The training process involves feeding the model with a diverse dataset of images with associated ground truth labels indicating the specific error types present.(Husain et al., 2019) A suitable loss function, such as categorical cross-entropy, will be employed to guide the model learning process. Finally, the trained model classifies incoming images and categorizes the detected errors (e.g., noise type, blur level, compression format). The proposed image-to-text conversion system introduces a pioneering approach leveraging Convolutional Neural Networks (CNN) to address limitations observed in existing systems. (Kastryulin *et al.,* 2022) By incorporating advanced image analysis and deep learning algorithms, our system aims to significantly enhance accuracy in detecting and correcting errors during the conversion process. The utilization of CNN allows the model to learn intricate patterns, improving its ability to interpret diverse image types, handwriting, and non- standard fonts. Furthermore, the proposed system prioritizes adaptability and versatility. It includes modules specifically designed to handle various languages, fonts, and writing styles, ensuring a more comprehensive and context-aware error detection and correction process, (Wold amanuel, 2023). Additionally, scalability and integration aspects are emphasized, enabling seamless incorporation into real-world applications. This innovative system promises to surpass existing methods by providing a more accurate, adaptable, and user-friendly solution to image-to-text conversion challenges, offering potential advancements in diverse fields reliant on precise text generation from visual inputs.

DATA SET

The COCO-Text dataset is a large-scale dataset for text detection and recognition in natural images. It's part of the COCO (Common Objects in Context) dataset family, which is widely used for various computer vision tasks. Here's a detailed explanation of the COCO-Text dataset:

OVERVIEW

- Purpose: The COCO-Text dataset is designed to facilitate research in the areas of scene text detection, recognition, and understanding. Release: The dataset was first introduced in 2016.
- Source: It extends the original COCO dataset by annotating text instances in natural scenes.

DATASET COMPOSITION

- Images: The dataset includes 63,686 images, originally part of the COCO dataset, annotated with text information.
- Annotations: It contains over 173,589 text instances.
- Text Attributes: Each text instance is annotated with several attributes:
- Transcription: The actual text content.
- Legibility: Whether the text is legible or illegible.
- Type: Differentiation between machine-printed text and handwritten text.
- Language: The language in which the text is written.

ANNOTATION DETAILS

- Bounding Boxes: Text instances are annotated with bounding boxes that define the region of the image containing the text.
- Polygons: Some annotations include polygonal boundaries for more precise localization of text instances, especially useful for curved or irregularly shaped text.
- Segmentation: In addition to bounding boxes, the dataset includes segmentation masks for text regions, aiding in pixel-level text detection tasks.

DATASET SPLITS

- Training Set: Contains a majority of the images for model training.
- Validation Set: A subset of images used to tune model parameters and evaluate performance during development.
- Test Set: A distinct set of images used for final evaluation of model performance.

CHALLENGES AND USE CASES

- Scene Text Detection: Identifying the location of text within natural images.
- Text Recognition: Transcribing the detected text regions into digital text.
- Text Segmentation: Precisely delineating the text regions at the pixel level.
- Multilingual Text Understanding: Dealing with text in multiple languages, which is a common occurrence in natural scenes.

TOOLS AND BENCHMARKS

- Evaluation Metrics: Commonly used metrics for evaluating models on the COCO-Text dataset include precision, recall, and F-measure for text detection, as well as accuracy for text recognition.
- Benchmarking: The dataset is often used in competitions and benchmarking challenges, providing a standard dataset for comparing the performance of different text detection and recognition algorithms.

APPLICATIONS

- Robust Reading Systems: Enhancing OCR systems to read text in various contexts such as street signs, advertisements, and product labels.
- Augmented Reality: Developing applications that can recognize and augment textual information in real- time.
- Accessibility Tools: Creating tools for visually impaired individuals to read text from their surroundings using computer vision.
- Autonomous Systems: Enabling autonomous vehicles and robots to understand and interact with their environment through text information.

ACCESS AND USAGE

- Availability: The COCO-Text dataset is publicly availableand can be accessed through the official [COCO- Text website](https://bgshih.github.io/cocot ext/).
- Licensing: The dataset is released under a permissive license, allowing researchers and developers to use it for academic and commercial purposes, adhering to the terms specified by the COCO dataset.

MACHINE LEARNING

Machine learning (ML) is a branch of artificial intelligence (AI) that focuses on the development of algorithms and models that allow computers to learn from and make predictions or decisions based on data. ML algorithms can be broadly categorized into three types: supervised learning, unsupervised learning, and reinforcement learning. Supervised learning involves training a model on labeled data, where the algorithm learns to map inputs to outputs. Unsupervised learning involves finding patterns and relationships in unlabeled data. Reinforcement learning involves training an agent to make decisions in an environment to achieve a goal. Two popular supervised learning algorithms are AdaBoost and Random Forest. Let's dive into each of them:

AdaBoost (Adaptive Boosting)

AdaBoost is an ensemble learning method that combines multiple weak classifiers to create a strong classifier. A weak classifier is a model that performs slightly better than random guessing. The basic idea behind AdaBoost is to sequentially train a series of weak classifiers on various weighted subsets of the training data. After each iteration, the weights of incorrectly classified instances are increased, so the next classifier focuses more on these instances. The final strong classifier is a weighted sum of the weak classifiers, where the weights are based on the classifiers'

accuracy. AdaBoost is particularly effective in binary classification problems and can adapt to complex decision boundaries.

Random Forest

Random Forest is another ensemble learning method that uses multiple decision trees to improve the classification (or regression) accuracy. Each tree in the Random Forest is trained on a bootstrapped subset of the training data (sampling with replacement), and at each split, a random subset of features is considered. During the training process, the trees are grown to their maximum depth, resulting in low bias but high variance individual trees. The final prediction of the Random Forest is obtained by aggregating the predictions of all trees (e.g., averaging for regression or voting for classification). Random Forest is known for its high accuracy, scalability, and ability to handle high-dimensional data and large datasets. In summary, AdaBoost and Random Forest are powerful machine learning algorithms that leverage the concept of ensemble learning to improve prediction accuracy. AdaBoost focuses on combining multiple weak classifiers sequentially, while Random Forest combines multiple decision trees trained on different subsets of data and features to make robust predictions.

Advantages

- Exceptional Accuracy: Achieves high accuracy in error detection and correction, ensuring reliable text generation.
- Versatility: Handles diverse image types effectively, enhancing adaptability in different scenarios.
- Scalability: Provides scalable solutions for real-world applications, facilitating widespread adoption.
- Automated: Offers automated error detection and correction, reducing manual intervention and improving efficiency.

PERFORMANCE METRICS

In machine learning, various performance metrics are used to evaluate the effectiveness of models, especially for classification tasks. Here are the key metrics along with their formulas:

Accuracy

Formula: $\text{Accuracy} = \frac{TP+TN}{TP+TN+FP+FN}$

Where:

- TP = True Positives
- TN = True Negatives
- FP = False Positives
- FN = False Negatives

Measures the overall correctness of the model.

Precision (Positive Predictive Value):

Formula: $\text{Precision} = \frac{TP}{TP+FP}$

Measures the proportion of positive predictions that are actually correct.

Recall(True Positive Rate):

Formula: $\text{Recall} = \frac{TP}{TP+FN}$

Measures the proportion of actual positives that are correctly identified.
Sensitivity

$$\text{Formula: Sensitivity} = \frac{TP}{TP+FN}$$

Sensitivity is another term for Recall, so the formula is the same.
Specificity (True Negative Rate)
Measures the proportion of actual negatives that are correctly identified.

$$\text{Formula: Specificity} = \frac{TN}{TN+FP}$$

F1 Score
The harmonic mean of Precision and Recall, used to balance the two metrics.

$$\text{Formula: F1 Score} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

$$\text{Simplified: F1 Score} = \frac{2 \times TP}{2 \times TP + FP + FN}$$

These metrics help in understanding the performance of classification models from different perspectives:

RESULTS AND DISCUSSION

The system's performance will be evaluated using benchmark datasets containing high-quality images and their degraded versions with varying error types. Metrics like accuracy, precision, and recall will be employed to assess the effectiveness of error detection. Additionally, qualitative results will be presented, showcasing original images, detected errors, and potentially the post- correction outputs after feeding the categorized errors into specific enhancement algorithms. The system's performance is compared with existing methods to highlight its advantages in table 1. The Figure 1 highlights the performance of the different metrics used to compare the algorithms like light bgm, Adaboost, Random forest and Xgboost. The proposed system offers an automated and data-driven approach to error detection, potentially leading to more efficient and accurate image quality enhancement pipelines. However, limitations exist. The system's performance heavily relies on the quality and diversity of the training data. Additionally, the chosen CNN architecture and hyperparameter tuning can influence accuracy.

CONCLUSION

This paper presented a machine learning- based system for error detection in images, aimed at enhancing overall image quality. The system employs a deep learning model to identify and categorize various image quality issues. Future work explores incorporating the system into real-time image processing pipelines and investigating more advanced deep learning architectures for further performance improvement.

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Table 1: Comparative Analysis Table.

ALGORITHM	Accuracy	Precision	Recall	F1 score	Sensitivity	Specificity
LIGHTBGM	0.8	0.79	0.6	0.5	0.4	0.55
XGBOOST	0.87	0.75	0.69	0.6	0.7	0.65
ADABOOST	0.95	0.89	0.93	0.9	0.87	0.86
RANDOMFOREST	1.02	1.95	1.97	1.09	0.96	0.95

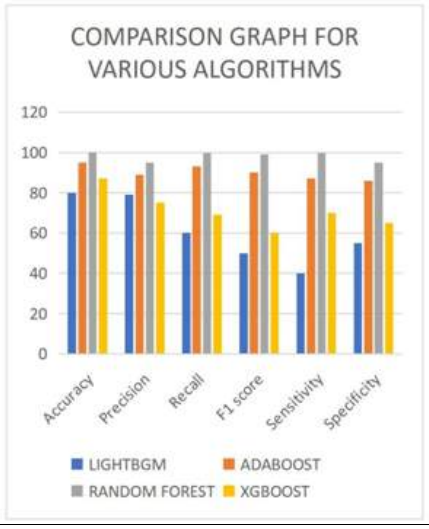


Figure 1: Comparison Graph for the Performance Metrics

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SHORT COMMUNICATION ARTICLE

Aesthetics of Siddha Nanoscience and Pharmacokinetics

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ABSTRACT

Siddha medicine is one of the most ancient systems of medicine. It is a gift to mankind by the great Siddhars. Aesthetics is the philosophy that deals with the realm of creation, perception and appreciation of beauty. Aesthetics is an element of not only art but also of medicine, lifestyle, technology, nutrition and fashion. Pursuing Siddha medicine itself is an aesthetic experience. It is present in every concept of Siddha starting from diagnosis to preparation and administration of the medicine. There is beauty in the five element theory and creation of universe. The science of Alchemy and elixir science itself is the essence of aesthetic. The nanoscience interplay in the process of purification of the raw drugs and preparation of medicines is an atomic beauty. Industry based synthetic nanoparticles cannot match the rate of absorption, great efficacy, less toxicity and synergistic mechanism of siddha formulations. The exquisiteness of a single medicine exhibiting different pharmacological actions with different adjuvants leaves us in awe. Such is the significance and beauty of the drug delivery science of Siddha. The atomic interactions is being unraveled by recent researches and is shedding light on the nanoscience and drug delivery of Siddha. Using research and literature findings in this paper we wanted to portray it's aestheticism and convey that Siddha medical students and practitioners are gifted with the aesthetic experience of being a tool that delivers this science for the benefit of the mankind.

Keywords: Siddha, aesthetics, nanoscience, pharmacokinetics, adjuvant, nanoparticle.

INTRODUCTION

Aesthetics is defined as the philosophy dealing with the realm of creation, perception and appreciation of beauty[1]. Beauty doesn't have a precise definition; it is often what captures one's heart and soul through their eyes. Aesthetics play a vital role in not only art but it encompasses various fields including medicine, fashion, technology, nutrition and lifestyle. Pursuing the most ancient system of medicine that has saved the lives of many humans since thousands of years itself is an aesthetic experience. Aesthetic experience refers to the study of state of mind, emotion, response and attitude, all of which is experienced by a Siddha physician the moment a patient approaches. Aesthetic is prevalent in every concept of Siddha right from building a Siddha physician, diagnosis, medicine preparation and treatment. "I, an universe of atoms, an atom in the universe" this simple yet fascinating quote by Richard Feynman reminds us about the beautiful concept of macrocosm and microcosm. There is allure in the concept of creation of universe and the five element theory. There is exquisiteness in the process of purification of raw drugs and transforming it into life-saving medicines. Kayakalpam (Elixir science) itself is the essence of aesthetic, the raw simple measures mentioned by the great Siddhars that is to be incorporated in everyday life to prevent diseases and lead a blissful life. The science of Alchemy devised by Siddhars, who were the scientific pioneers thinking ahead of time, involves transformation of base elements into silver or gold with the aim to provide solution to ailments that had been deemed as incurable. This science of conversion leaves us in awe and a mind full of appreciative thoughts for its atomic beauty. Siddha formulations chiefly involve raw drugs from these 4 domains –plant, animal, metal, and mineral origin. The preparation of Siddha medicines is an art – beautiful and complex. It begins right from the identification of the raw drug.In case of herbs, it involves observing the morphological characteristics which allows us to enjoy the beauty of nature and feel grateful to use the rich flora present in this universe to save mankind. Identification paves way to the next step that is the physiochemical conversion of the phytocompounds to remove the toxicity and enhance the efficacy of the drug. Purification procedure (Suddhi) is scientific transformation at its peak. For Example, *Semecarpus anacardium* is a medicinal plant used in Siddha Medicines and is known for its anti-cancer property. It is compared to mercury owing to its significant therapeutic benefits.

It is a highly poisonous plant having irritant action. Recent research studies including LC-MS analysis have revealed that the concentration of Anacardic acid and other compounds, responsible for toxic effects was found to be reduced in the purified sample compared to the raw sample. Further research has proven that the anti-cancer activity was enhanced in the purified sample, thereby asserting the immense significance of the purification procedure[2]. The process of reducing the toxic phytoconstituents and enhancing the therapeutic action at the atomic level is an artistic masterpiece. Metallo-mineral preparations generally include metals, metallic-salts, minerals, gems and salts as the ingredients. Purification of raw metals usually involves various procedures dealing with few herbal extracts or animal products for a particular time period to obtain the desired chemical constituents network and structure to exhibit highly potent action without any toxic effects in the prescribed dose. Researchers have proven the significance behind purification methods and siddha nanoscience using techniques such as Fourier Transformed Infrared Spectroscopy, Scanning Electron Microscopy, Inductively Coupled Plasma Optical Emission Spectrometry and X-Ray Diffraction. FTIR is an analytical technique which detects the functional group present in the sample, aiding in the confirmation of active principles present[3]. SEM can be used to obtain information on particle size distribution. XRD is a useful technique to determine the elemental diffraction pattern[4]. ICP-OES is used for detection of trace metals and concentration of each element in the medicine[5].How were the divine Siddhars able to visualize the interactions taking place at the molecular level with no research advances? How was this possible centuries ago? How has it always been so accurate? These questions itself imply the beauty and strength of our ancient knowledge and science. In recent years, the Pharma Industry and Pharmaceutical Scientists have shifted their focus to developing nanoparticles from herbals as it is found to have higher permeability, targeted action and greater efficacy. However, the science of nanotechnology has always been the foundation of Siddha medicines. The evidence dates back several thousand years to one of the most ancient texts, "Thirumanthiram," in which the accurate size of an atom was mentioned by the great Siddhar

Thirumoolar as follows;
"Meviya seevan vadivadhu sollidil
kovin mayironru noorudan kooritu
meviya kooradhu aayiram aayinal
aaviyin kooru noorayira thondre"
A strand of cow's hair cut into 100 parts, one part of this is again cut into 1000 parts and then one part from this is further cut into 10000 parts. This text reveals that one part obtained from this is equivalent to the size of an atom[6].Nanoparticle based drug delivery has been the core of Siddha Medicines since centuries. The medications in Siddha are classified into two types – Internal and External. Parpam (Oxide form of metal/mineral), Guru (Philosopher's powder or Universal Powder capable of converting base metals to gold), Kattu (consolidation of metals and minerals into medicine), Chunnam (a caustic oxide preparation), Kuligai(a small pill), Chendhooram (sulfide form of metal/mineral) are some of the unique higher order internal medicines developed based on the principles of nanotechnology[7,8].Individually a metal is toxic in its raw state. However, after subjecting the metallic ingredient to purification and medicine preparation procedures it is converted into nanoparticles. Thus, higher order medicines are safe when taken in prescribed dose with the help of this ancient nanoscience. Preparation of Parpam is the classic graceful example of nanotechnology. The initial step being purification is followed by incineration/calcination, trituration, palletization and combustion (Pudam heating process). The process of calcination is of great significance from the perspective of nanotechnology as it is responsible for reducing the size of the particles aiding in efficient absorption. Trituration with specific herbal extracts enhances the therapeutic efficacy. This step is vital as it facilitates the homogenous mixing, causing various changes at the physiochemical level and chemical interactions at the particulate level. Later, the solid mass is converted into pellets, followed by drying, and is subjected to controlled combustion using cow dung cakes. The number and size of the cow dung cakes used is specific to a formulation. Controlled combustion with the help of cow dung cakes, which steadily increases and decreases the temperature, is a majestic phenomenon with fire and atoms interacting to deliver us the gift of Siddhars. Such is the precision of the medicine preparation procedure beautifully doing its role in the creation of a work of art that saves lives. Industry based synthetic nanoparticles and Siddha nanomedicines aren't the same. Synthetic nanoparticles can never match our formulations rate of absorption, high efficacy, low toxicity, synergy mechanism and the theory of single medicine multiple adjuvants.

Medicine preparation procedure also involves the concept of friend and foe. Synergistic drugs act as friends whereas antagonistic drugs act as foe to the chief raw drug. This concept is the base of the procedure called "Maaranam". It involves altering the atomic network of the chief drug by using the antagonist and then enhancing the action of the altered network using the synergistic drug. This process reminds us of the beautiful quote "Behind every atom of this world hides an infinite universe". Inside that infinite universe there is a plethora of potential and opportunities hidden which has been calculated and unleashed through the science of Siddha. The infinite potential of the infinite universe behind each atom has been resurrected to benefit the mankind. Siddha Pharmacokinetics itself is an amazing phenomenon of science and philosophy. As per Siddha system, the site of absorption of the drug depends upon the property of the compounds. Drugs which possess the property of cold, heavy or unctuous get absorbed in stomach. Medicines having dry, cold and light properties are absorbed at the colon[9]. After the administration of a drug, it is divided into two fractions – absorbable and excretable fractions. There is a common misconception that Siddha Metallo-mineral formulations affect renal system. However, that is not the case, the quantity of metal that can be absorbed and excreted by the body has been accurately calculated and kept in mind right from the preparation procedure. Absorbable fractions go through the seven body constituents, the first being blood, and are circulated throughout the body. Excretable fractions are properly eliminated from the body with no ill effects on the renal system when administered at the prescribed dose. Our formulations beautifully exhibits the phenomenon of single medicine multiple adjuvant theory which is lacking in the manufactured nanoparticles. A specific type of vehicle for drug transportation throughout the body is devised and called Anubanam (Adjuvant). Anubanam accompanies the drug and aids in its absorption, distribution and metabolism converting the drug into particles of smaller size. Individual based treatment regimen is the uniqueness of Siddha. Based on the principles of the humoral theory, five elements and six tastes, the treatment plan for an individual is amazingly crafted with the perfect adjuvant to balance

the humors. Only in this system can we find the beauty of treatment, not for the disease but for the individual. A recent research study revealed based on the calculation of drug efficacy index of Poonaikaali Chooranam that it is capable of decreasing Vadham majorly but Pitham to a minor degree without any adjuvant. Whereas when administered along with the adjuvant milk it is capable of decreasing the altered Pitha Thodam to a good degree, indicating the importance of the adjuvant in drug delivery[10]. The interactions and interplay unfolding at the atomic level, despite being naked to the human eye, radiates beauty and awe to my eyes through its action and recent researchers proving it to the world. Such is the beauty of Siddha Science, which speaks for itself by endorsing aestheticism in every concept and every moment of this journey of being a Siddha physician, gifting this aesthetic experience to us -Siddha medical students and practitioners, who are the blessed tools delivering the fruits of this experience to the mankind.

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RESEARCH ARTICLE

Smart Homes Energy Consumption Prediction using Hybrid Prophet Algorithm and Adaptive Optimization

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ABSTRACT

The integration of smart homes with smart grids underscores the critical need for precise and timely predictions of energy consumption, essential for optimizing resource allocation and bolstering overall energy efficiency. This research work is an approach to enhance energy consumption predictions within smart homes by integrating time series forecasting capabilities of the Prophet algorithm with adaptive optimization techniques – ADAM (Adaptive Moment Estimation), SGD, ADAGRAD, and RMSPROP. Utilizing the Pecan dataset, the proposed hybridized model undergoes rigorous evaluation against traditional Prophet and baseline models. Metrics such as Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE) serve as comprehensive benchmarks for assessing the model's performance. The hybridized model demonstrates a notable enhancement in accuracy and efficiency in predicting energy consumption.

Keywords: Energy Consumption, Prophet, time series forecasting, optimization techniques.

INTRODUCTION

In recent years, the convergence of smart homes and smart grids has emerged as a transformative force in the realm of energy consumption and management [1]. The interconnection of these two technological domains presents a unique set of challenges and opportunities, chief among them being the imperative for accurate and timely

predictions of energy consumption. This pressing need stems from the desire to optimize resource allocation and elevate overall energy efficiency in the dynamically evolving landscape of modern living [2]. This introduction sets the stage for a comprehensive exploration of an innovative research endeavor that addresses the intricacies of energy prediction within smart homes by leveraging advanced computational methodologies. The contemporary push towards sustainable and intelligent living has fueled the rapid proliferation of smart homes equipped with an array of interconnected devices and systems. Looking ahead, as smart homes continue to evolve in tandem with advancements in smart grid technologies, the outcomes of this research hold promise for shaping the trajectory of energy consumption in the future. By providing a nuanced understanding of the challenges and opportunities in predicting energy consumption within smart homes, this study contributes to the broader discourse on the role of data science and computational modeling in the pursuit of sustainable and intelligent living [3]. These homes are not only embedded with cutting-edge technologies but are also integrated into larger smart grids that facilitate bidirectional communication between energy producers and consumers [4]. This synergy aims to create a responsive and adaptive energy ecosystem, where real-time data informs decisions at both the individual household and grid levels[5]. However, the seamless integration of smart homes into smart grids requires a nuanced understanding of energy consumption patterns and a reliable means of predicting future demands. Against this backdrop, the research at hand introduces a novel approach to enhance the accuracy of energy consumption predictions within smart homes. At its core is the integration of the Prophet algorithm, a powerful time series forecasting tool developed by Facebook, with adaptive optimization techniques – namely, ADAM, SGD, ADAGRAD, and RMSPROP [6], [7], [8],[9]. The Prophet algorithm, renowned for its efficacy in capturing daily patterns, seasonality, and holidays in time series data [10], forms the bedrock of the proposed hybridized model.

This algorithmic synergy is poised to tackle the dynamic and non-linear patterns inherent in smart home energy consumption, offering a promising solution to the challenges posed by the evolving nature of energy demand. To rigorously test the performance of the hybridized model, the study leverages the Pecan dataset – a comprehensive repository of historical energy consumption data derived from diverse appliances in a smart home [4]. This dataset, rich in its diversity and depth, provides a robust foundation for evaluating the proposed model against traditional Prophet and other baseline models. Importantly, the evaluation employs a suite of metrics, including Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE)and Root Mean Squared Error (RMSE), ensuring a comprehensive and nuanced assessment of the model's predictive capabilities. The combination of Prophet with adaptive optimization algorithms brings a unique strength to the predictive modelling framework. Prophet's ability to capture patterns aligns seamlessly with the adaptability and efficiency offered by optimization algorithms [10], presenting a holistic solution to the multifaceted challenges posed by the dynamic and non-linear nature of smart home energy consumption. This hybridization is anticipated to not only elevate the accuracy of predictions but also enhance the efficiency of the learning process, ensuring that the model adapts dynamically to the evolving energy landscape within smart homes. As the research unfolds, it becomes evident that the proposed hybridized model demonstrates superior accuracy and efficiency in predicting energy consumption compared to traditional Prophet and baseline models [2]. The inclusion of adaptive optimization techniques proves instrumental in refining the model's parameters, addressing the complexities posed by the variability of energy patterns within smart homes. This enhancement in predictive accuracy holds profound implications for the optimization of energy resources, offering a valuable tool for both individual households and the overarching smart grid infrastructure. The broader significance of this research extends beyond the realms of predictive modelling and algorithmic innovation. In the era of smart living technologies, characterized by the proliferation of interconnected devices and the pursuit of sustainable practices [5], the findings of this study contribute to the ongoing evolution of energy management practices within smart homes. The emphasis on accuracy, efficiency, and adaptability in predicting energy consumption aligns with the overarching goals of fostering sustainable energy practices and optimizing resource utilization. The integration of computational models with real-world data represents a critical step towards achieving the potential of smart homes as active participants in a responsive and intelligent energy ecosystem. Ultimately, this research sets the stage for a more informed and efficient utilization of energy resources, fostering a harmonious integration of technology and sustainability in the contemporary landscape of smart living.

REVIEW OF LITERATURE

The intersection of smart homes and smart grids has emerged as a critical domain, emphasizing the need for accurate energy consumption predictions to optimize resource allocation and enhance overall energy efficiency. This literature review explores existing research on time series forecasting, the Prophet algorithm, adaptive optimization techniques, and the integration of these methodologies to predict energy consumption within smart homes. In order to increase the electrical energy's efficiency, [11] presents an optimization strategy for devices that use electricity.[12] have conducted studies to pinpoint the issues with energy management that arise when a house is automated.[13] highlights forecasting and clustering techniques, such GRU and LSTM, to improve PV management and save maintenance costs in already-existing MG systems.[14] uses machine learning techniques, such as BERT, to categorize spam emails with high accuracy. With an accuracy of 97.94%, the results show that the Bi-LSTM model performs better than the others, indicating its efficacy in spam identification.[15]In order to improve sEMG data, this study uses the Savitzky-Golay filter. To forecast missing data, hybrid neural networks that include LSTM and GRU are employed. The findings show that for both long and short datasets, the GRU-LSTM model had superior prediction accuracy, achieving 99.25% and 98.91%, respectively. The integration of time series forecasting algorithms with adaptive optimization techniques has been explored to address the limitations of standalone models. Recent research has applied hybrid models to enhance accuracy in energy consumption predictions, particularly within the context of smart homes [16].Rigorous evaluation is essential to assess the performance of predictive models accurately. Common metrics such as Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) provide comprehensive benchmarks for comparing different models [17].The application of hybrid models extends beyond time series forecasting, with studies showcasing their effectiveness in optimizing energy management practices in various contexts, including industrial settings [18].

Despite advancements, challenges persist in accurately predicting energy consumption patterns, especially concerning the dynamic nature of smart home environments. Researchers have identified opportunities for further improvement, such as the incorporation of real-time data and advanced machine learning techniques [19]. As smart homes become more interconnected, the utilization of big data and machine learning in smart grids is gaining prominence. Research in this area explores how these technologies can enhance the efficiency and reliability of energy distribution [20].The proliferation of smart home devices raises concerns about data privacy and security. Studies have delved into the challenges associated with safeguarding sensitive information and ensuring the secure functioning of smart home ecosystems [21].Adding to this rich tapestry of literature, recent studies by Yuen et al. [22] investigated advanced machine learning techniques for energy forecasting in smart homes, emphasizing the role of ensemble methods in enhancing prediction accuracy. The study contributes valuable insights into the ongoing efforts to improve forecasting models in the context of smart homes. Furthermore, the work of Wang et al. [23] explored the application of explainable artificial intelligence (XAI) techniques in interpreting energy consumption patterns within smart homes. This line of research addresses the increasing importance of transparency and interpretability in predictive models, aligning with the broader goals of fostering user trust and understanding in smart home energy management systems. The literature reviewed underscores the multifaceted nature of energy consumption prediction within smart homes. The integration of the Prophet algorithm with adaptive optimization techniques presents a promising avenue for addressing the complexities associated with forecasting in dynamic environments. As smart homes continue to evolve, research in this field not only contributes to efficient resource management but also aligns with the overarching goal of promoting sustainability in smart living.

DESCRIPTION OF THE PROBLEM AND PROPOSED SOLUTION

Description of the problem

Accurate energy consumption forecasting is crucial for modern smart homes to maximize energy utilization, minimize environmental effects, and cut expenses. However, because household energy use is dynamic and influenced by several factors, including occupancy patterns, weather variations, and appliance usage, standard forecasting algorithms sometimes find it difficult to adjust. Higher carbon footprints, higher expenses and ineffective

energy management might result from an inability to accurately forecast energy demand. The difficulty is in creating a reliable forecast model that can adjust to shifting influencing factors in addition to capturing past trends of energy use. Decisions on energy management may be less than ideal if current models are unable to attain high accuracy and adaptability.

PROPOSED SOLUTION

This work suggests a hybridized forecasting model that blends adaptive optimization methods with the Prophet algorithm's advantages to overcome these difficulties. The following section clearly explains the methodology that is followed in this work.

METHODOLOGY OF THE PROPOSED WORK

The methodology employed in this study aims to enhance energy consumption predictions in smart homes through the integration of the Prophet algorithm with adaptive optimization techniques, including ADAM, SGD, ADAGRAD, and RMSPROP. The study leveraged the Pecan dataset, a comprehensive collection of historical energy consumption data from diverse smart home appliances, which encompassed the energy consumption of each appliance recorded every 15 minutes from the year 2012 to 2019. The framework of the study involves several key steps: This work has utilized the Pecan dataset, a rich repository of energy consumption data from various smart homes. The dataset covered the time span from 2012 to 2019, capturing detailed information on the energy consumed by each appliance in 15-minute intervals. This extensive temporal coverage provides a holistic view of energy consumption patterns over the years. As a next step, the Prophet algorithm is implemented as it is recognized for its proficiency in capturing daily patterns, seasonality, and holidays in time series data. Adaptive Optimization techniques such as ADAM, SGD, ADAGRAD and RMSPROP are integrated to enhance the adaptability and efficiency of the Prophet algorithm in handling dynamic and non-linear patterns in smart home energy consumption. In the next step, the hybridized model is trained using the integrated Prophet algorithm and optimization techniques on the detailed Pecan dataset. The dataset is divided into training and testing dataset in the proposition of 70 and 30 respectively. The training process aimed to optimize the model parameters for accurate and efficient predictions, considering the high-frequency energy consumption data recorded every 15 minutes. A suite of evaluation metrics, including Mean Absolute Percentage Error (MAPE), Mean Absolute Error (MAE), and Root Mean Squared Error (RMSE) are employed to assess the performance of the hybridized model. Developed baseline models, including traditional Prophet and potentially other existing models, for comparison purposes. These models served as benchmarks to gauge the improvement achieved by the proposed hybridized model, considering the granular 15-minute data.

A rigorous comparative analysis by evaluating the hybridized model against traditional Prophet and baseline models are conducted. This analysis provided insights into the accuracy and efficiency of energy consumption predictions, considering the high-frequency nature of the dataset. Ethical standards are adhered, including data privacy and confidentiality, throughout the study. Any potential biases in the dataset or model outputs were carefully considered and addressed. The practical implications of the study's findings on energy management practices within smart homes connected to smart grids were investigated. Examination was done on how accurate predictions could lead to more efficient resource utilization, potentially reducing overall energy costs and environmental impact. The broader implications for sustainable living and the integration of smart technologies into everyday life was also taken into consideration. By following this comprehensive methodology, the study aimed to provide a thorough assessment of the proposed hybridized model's ability to accurately predict energy consumption in smart homes. This approach, considering both the detailed and high-frequency nature of the dataset and ethical considerations, contributes valuable insights to the field of energy management practices within the context of smart grids and smart homes, with potential implications for sustainable and efficient living. This research work is implemented using Python.

Pseudocode

Constructing pseudocode for a comprehensive methodology involves outlining the procedural steps without adhering to a specific programming syntax. The following pseudocode provides an overview of the described methodology:

1. Load Pecan Dataset from 2012 to 2019 // Time-stamped energy consumption data for each appliance every 15 minutes
2. Initialize Prophet Algorithm
3. Initialize Adaptive Optimization Techniques (ADAM, SGD, ADAGRAD, RMSPROP)
4. Integrate Optimization Techniques with Prophet Algorithm
5. Split Dataset into Training and Testing Sets
6. Train Hybridized Model using Integrated Algorithm on Training Set
7. Initialize Evaluation Metrics (MAPE, MAE, MSE, RMSE)
8. Predict Energy Consumption on Testing Set
9. Calculate Evaluation Metrics for Hybridized Model
10. End of Pseudocode

RESULTS

The hybridized model, integrating the Prophet algorithm with adaptive optimization techniques (ADAM, SGD, ADAGRAD, and RMSPROP), demonstrated significant enhancements in accuracy and efficiency compared to traditional Prophet and baseline models. The predictions of energy consumption within smart homes exhibited improved alignment with actual consumption patterns, showcasing the efficacy of the proposed approach. The graphical representation of the actual data and prediction using prophet algorithm with various optimizer discussed above is shown in Fig 1. The evaluation metrics for different models predicting energy consumption within smart homes are presented in Table 1.

RMSE (Root Mean Squared Error)

The Prophet with SGD model exhibits the lowest RMSE at 0.145, indicating superior accuracy in predicting energy consumption. This result suggests that the model's predictions are closer to the actual values, minimizing the squared differences between them. Fig 2. Shows the graphical representation of RMSE that is obtained by combining prophet algorithm with optimization techniques like ADAM, SGD, ADAGRAD and RMSPROP.

MAE (Mean Absolute Error)

The graphical representation of the MAE of various models in shown in Fig 3. Prophet with SGD again outperforms the other models, yielding the lowest MAE of 0.307. This finding signifies the model's effectiveness in minimizing absolute errors, providing more precise estimates of energy consumption.

MAPE (Mean Absolute Percentage Error)

Prophet with ADAM achieves the lowest MAPE at 1.517%, indicating its capability to make predictions with the smallest percentage of errors relative to the actual values. This suggests that Prophet with ADAM offers accurate forecasts with minimal relative discrepancies. The values obtained for various models are shown in Fig 4.

DISCUSSION

The consistently low MSE and MAE values for Prophet with SGD underscore its dominance in accuracy among the models. This suggests that the integration of Stochastic Gradient Descent (SGD) optimization significantly enhances the model's predictive performance. Hence Prophet with SGD Dominates Accuracy. Prophet with ADAM can be taken when Precision is considered. Prophet with ADAM excels in achieving the lowest MAPE, emphasizing its precision in predicting energy consumption with minimal percentage errors. This characteristic is crucial for

applications where relative accuracy is a priority. The choice between Prophet with SGD and Prophet with ADAM depends on the specific priorities of the application. If absolute accuracy is paramount, Prophet with SGD is preferred, while Prophet with ADAM is favoured for minimizing relative errors. The findings have practical implications for smart home energy management, emphasizing the significance of tailored model selection based on specific objectives. These results contribute to the ongoing advancements in predictive modelling techniques within the context of smart living technologies.In summary, the results demonstrate the effectiveness of incorporating advanced optimization algorithms, particularly SGD and ADAM, in enhancing the accuracy and precision of energy consumption predictions for smart homes.

CONCLUSION

In conclusion, the comparative evaluation of energy consumption prediction models within smart homes reveals compelling insights into their respective performances. Notably, models integrating adaptive optimization techniques, such as Prophet with SGD and Prophet with ADAM, surpass the traditional Prophet model in terms of Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE). Prophet with SGD stands out with the lowest RMSE and MAE values, indicating its exceptional accuracy in forecasting energy consumption. The incorporation of adaptive optimization algorithms consistently leads to a significant reduction in prediction errors, as evidenced by markedly lower MAPE values across all enhanced models compared to the baseline Prophet model. Prophet with ADAM, in particular, achieves the lowest MAPE, signifying its precision in predicting energy consumption with minimal percentage errors. These findings underscore the efficacy of leveraging adaptive optimization algorithms in conjunction with the Prophet algorithm, showcasing the potential for improved accuracy and efficiency in energy consumption predictions for smart homes. The results provide valuable guidance for practitioners and researchers seeking optimal models for smart home energy management, with Prophet with SGD demonstrating notable promise in minimizing prediction errors. As the smart home landscape continues to evolve, these findings contribute to advancing predictive modelling techniques and optimizing resource utilization within the realm of smart living.

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Table 1. Evaluation metrics of various hybridized models

Metrices	Prophet	Prophet with ADAM	Prophet with SGD	Prophet with ADAGRAD	Prophet with RMSPROP
RMSE	0.25	0.219	0.145	0.337	0.165
MAE	0.17	0.4	0.307	0.508	0.34
MAPE	22.87	1.517	1.137	1.833	1.297

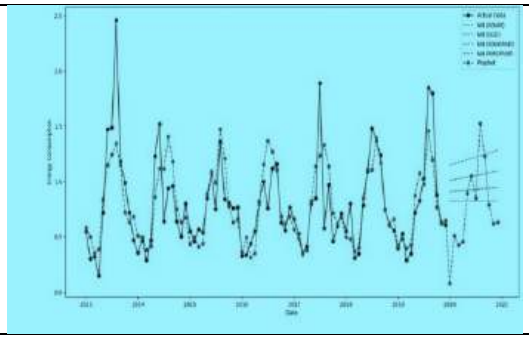


Fig 1: Comparative graph representing actual data using prophet and optimizers

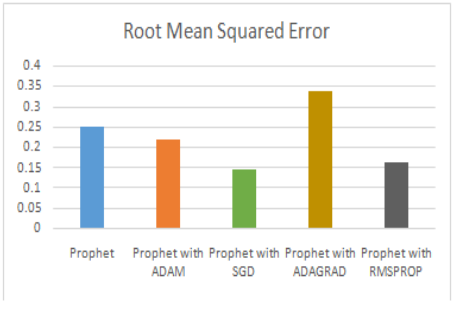


Fig 2. Graphical representation of Root Mean Squared Error of the models

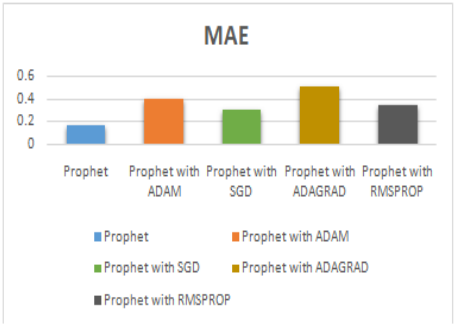


Fig 3. Graphical representation of Mean Absolute Error of the models

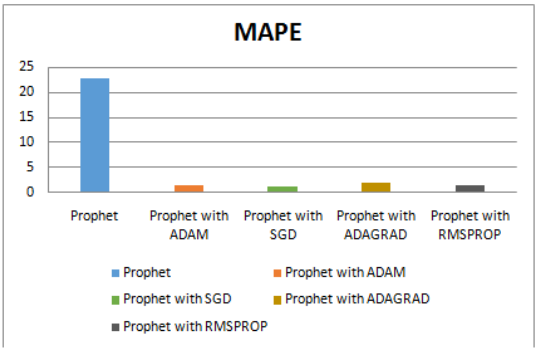


Fig 4. Graphical representation of Mean Absolute Percentage Error of the models

RESEARCH ARTICLE

Effect of Myostaal Liniment Application on Knee Muscle Strength in Janu Sandhigata Vata (Knee Osteoarthritis) : Case Series

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ABSTRACT

Sandhigata vata (osteoarthritis (OA)) is one of the common conditions seen in elderly people. Prevalence of osteoarthritis in India is more about 22% to 39%. All were diagnosed case of Idiopathic kneeOA according to clinical guidelines of American college of Rheumatology(ACR). Patients having baseline knee pain more than 40mm on VAS. Patients have Grade1or 2in radiological findings according to Kellgren and Lawrence classification of osteoarthritis. On basis of ACR criteria and On the basis of radiographic finding. Local application of *Myostaal liniment* was done thrice or twice a day for90days. Therapy showed highly significant (P <0.001) beneficial effect on the clinical features and muscles strength. At baseline visit Right knee muscle strength was 8.200±2.159 which increased significantly to 11.300±2.943 and Left knee muscle strength was 8.250±2.358 which increased significantly to 10.680±2.721 on day 90. VAS pain score at baseline was 56.500±7.762, which reduced significantly to 25.000±9.220 on day 90. WOMAC combined score at baseline was 26.500±12.619, which reduced significantly to 7.100±7.816(73.20%) on day 90. WOMAC pain score at baseline was 6.400±3.353, which reduced significantly to 1.900±2.548 on day 90, while, WOMAC stiffness score at baseline was 1.600±1.562, which reduced significantly to 0.100±0.300on day 90. WOMAC difficulty score at baseline was 18.500±9.373, which reduced significantly to 5.100±5.147on day 90. Reduced strength in the muscle groups

surrounding the knee is significant because it causes progressive of knee OA. This shows significant improvement in muscle strength by local application of *Myostaal liniment*.

Keywords: *Bahyasnehan*, Muscle strength, Dynamometer, VAS, WOMAC

INTRODUCTION

Osteoarthritis (OA) is a disorder characterized by progressive joint deterioration in which all the structures of a joint undergo pathological changes. The pathological sine qua non of OA is hyaline articular cartilage loss accompanied by increasing thickness and sclerosis of the subchondral bone plate, outgrowth of osteophytes at the joint margin, stretching of the articular capsule, and weakness of the muscles bridging the joint. There are numerous pathways that lead to OA, but the initial step is often joint injury in the setting of a failure of protective mechanisms.[1] In India, OA of knee is a common condition, with a prevalence between 22% to 39% that gradually increases with age [2] . Knee OA is believed to be a result of the failure of chondrocytes to maintain homeostasis between the synthesis and degradation of the extracellular matrix.[3] There are two types of therapy for knee osteoarthritis: non-surgical and surgical. When non-surgical treatments are no longer effective, surgical intervention is indicated. Non-surgical measures include nonsteroidal anti-inflammatory drugs (NSAIDs), COX-2 inhibitors, Glucosamine sulphate, moderate exercises which helps in strengthening the muscles and weight loss. [4] Surgical treatment options include osteotomy, unicompartmental knee arthroplasty (UKA), total knee arthroplasty (TKA) these are the treatment of choice in severe cases when conservative therapy is ineffective.[5] *Janu Sandhigata Vata* is often compared with osteoarthritis (OA) of knee joint. *Sandhigatavata* is first described by *Acharya Charaka* as *Sandhigata Anila* with symptoms of *Shotha* (swelling) which on palpation feels like a bag filled with air and *Shula* (pain) on *Prasarana* and *Akunchana (extension and flexion)[6]*

Patients Information

Ten diagnosed patients of *Sandhigatavata* (osteoarthritis), affecting knee joints, according to the American college of Rheumatology (ACR)[7] were selected from the outpatient department (OPD) of *Kayachikitsa* between July 2022 to October 2022. Informed consent of the patients was obtained before commencing the study. The enrolled patients were advised to withdraw the use of NSAID's before starting the Ayurvedic treatment. However, in case of severe pain patients were asked to take tablet paracetamol 500 mg.

Clinical Findings

All were diagnosed case of Idiopathic kneeOA according to clinical guidelines of American college of Rheumatology(ACR). All patients had baseline knee pain more than 40mm on VAS. Patients have Grade1or 2in radiological findings according to Kellgren and Lawrence classification of osteoarthritis.

Timeline

Local application of *Myostaal liniment* was done thrice or twice a day for 90 days. The composition of *Myostaal liniment* is outlined in table 1.

Diagnostic assessment

Improvement in muscle strength was assessed in every follow up and after completion of treatment with Dynamometer. Pain assessment was done with visual analogue scale (VAS) score, for the assessment of stiffness, pain and activity use Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score.[9]

Therapeutic Intervention

Local application of *Myostaal liniment* was done thrice or twice a day for 90 days

Follow-up and Outcomes

Total 10 patients were registered for study. And all patients had pain in both knee. In this study, seven patients were between 60 to 70 years of age while the remaining three were between 40 to 55 years of age. Among them 6 patients were male and 4 were female. Two patients were known cases of hypertension and one was type 2 diabetic. Both the patients were receiving medicines for the same. Majority of patients were having *Madhyama Koshtha (n = 6)* and were having regular bowel habit. All female patients had attained menopause. Muscle strength improved in all of the patients. At baseline the mean muscle strength of extensor muscles of Rt knee was 8.2 kg and 8.25 kg in Lt knee. It gradually improved and at the end of 90 days was 11.3 kg in Rt knee and 10.68kg in Lt knee. ($p < 0.05$) (table 2) The maximum improvement in muscle strength was by 6 kg (92.30 percent as compared to baseline), while minimum improvement was by 2.5 kg(71.42 percent as compared to baseline). It was also observed that muscle strength started to show improvement after day 30, after starting the treatment. Additionally, every patients got relief from pain. At baseline mean VAS score value was 56.5 and at the end of 90 days the VAS score value decreased and reached 25.00(table 3). The maximum improvement was 83.33 percent as compared to baseline according to VAS score. On the basis of WOMAC scale, there was 70.31 percent improvement in pain,93.75 percent improvement in stiffness and 72.43 percent improvement noted in activities. The WOMAC scale demonstrated that relief from pain, stiffness, and difficulty performing activities had significant outcomes.(table 4) It was noted that all clinical aspects produced highly significant results even after 30 days of treatment (initial follow-up), but muscle strength showed a substantial result. In initial stage seven patients took ayurvedic medicine for pain relief for 3 to 4 days. During three month moreover 3 patients took allopathic analgesic medicine, among three patients one had fever and body pain for two days so he took allopathic medicine and other two patients took for knee pain.

DISCUSSION

The disease with the greatest incidence of the joints in people worldwide is osteoarthritis. Its pathophysiology is yet unknown, and it is not now reversible. Prevention is the greatest medicine for osteoarthritis of the knee.. In this study 70% patients were found in 61 - 70 years of age group. *Sandhigata Vata* starts at the age of 40 which is stage of *Madhya Vaya*. Occurrence of *Janu Sandhigatavata* is also found more prevalent in certain occupations such as heavy vehicle driving .[10] In *Prakruti* wise distribution shows that *Vata-Kapha* predominance was found in 60% of patients. In the current study, among the chief complaints *Sandhishula* (pain)was found in all cases. *Vata Dosha*, which is accountable for all forms of pain (*Shoola*), will aggravate in *Sandhigata Vata*. Other symptoms like *Akunchana Prasaranajanya Vedana* (pain during extension and flexion) & *Hantisandhigati* (restricted movement of joint) which are brought by aggravated *Vata Dosha* and *Kapha Kshaya*. In systematic review *Ayurvedic* managements have shown moderate to good evidence for reducing pain, functional impairment, and joint stiffness in *Janu Sandhigatvata*.[11] *Bahya Snehana* (external oil application)'s advantageous effects were also discovered and reported in *Janu sandhigatvata*.[12]. Reduced strength in the muscle groups surrounding the joints is significant because it causes a progressive loss of function.[13] And a tool that measures force is a dynamometer. To measure the power of specific muscles or muscle groups, handheld dynamometers are utilised. [14] There are several ways to increase muscle strength including exercise, massage, and protein supplements. Due to decreasing physical strength and co-existence other health ailments such as diabetes, hypertension, ischemic heart diseases etc. there is limitation to perform exercises or protein intake. Hence, in elderly age, massage is better suited over others. One of the ancient and very effective home remedy for pain management and increasing muscle strength is massage. Muscular architecture is the most crucial factor for muscle function[15] and massage therapy raised the muscle's EMG(electro myography) activity and changed the structure's surface.[16] Similar results are seen with massage therapy, which enhances proprioceptive function.[17] Solumiks Pharmaceuticals Limited produces the exclusive ayurvedic medicine known as *Myostaal Liniment*. *Myostaal liniment* has qualities that are anti-inflammatory, analgesic, anti-arthritic, and muscle relaxing. It has a well-balanced mixture of substances that are beneficial for osteoarthritis. In this study, highly substantial effects were discovered in both knee joints for muscle strength, *Sandhishula* (joint pain), *Sandhishotha* (inflammation of joint), *Sandhigraha* (restricted movement of joint), and *Sandhisphutana* (joint crepitus). *Myostaal liniment* contains *Mahanarayan Taila, Nirgundi Taila, Gandhapur Taila, Tailaparni Taila, Devadaru Taila*,and *Sarala*. *Taila*

has opposite properties of *Vata* which are *Snigdha ,Guru, Mrudu*. Mahanarayan taila is ayurvedic medicated oil prepared using sesame oil as a base and processed in several medicinal herbs that improves strength of the muscles, bones and joints. It has about 58 ingredients.[18] *Mahanarayan Tail* shows significant effect on pain relief and muscle tone.[19]It has remarkable effect on inflammation also on the basis of in vitro study.[20] One of the *Vata* and *Shoolhar Taila* described in the *Charak Samhita* is *Nirgundi Taila*[21] *Nirgundi* root and bar extracts contain large amount of the alkaloid nishindine, which has anti-inflammatory and analgesic properties[22] Nirgundi taila is one of the vata and shoolahara taila explained in Charaka samhita. Nirgundi taila is one of the vata and shoolahara taila explained in Charaka samhita. Composition of *Ghandhapura Tail* (Wintergreen oil) are Methyl salicylate 99.5 %,Paraffin,Aldehyde or ketone Ester ,Secondary alcohol. It has analgesic effect and reduces inflammation by interacting with body mechanism.[23] According to *Ayurveda*, being an *Ushna Virya* herb, it pacifies *Vata. Tailaparni taila (Eucalyptus oil)* is an important *Vedanahar Dravya***.** It has Ushna Virya and *Snigdha Guna.* Analgesic effects of essential oils of Eucalyptus was proven by animal study.[24] *Devadaru Tail* has also *Ushna* and *Snigdha* properties. Animal research has demonstrated the anti-inflammatory and analgesic effects of *Devadaru Tail*.[25] Experts from the IAFA (Institute of Applied Food Allergy) have also successfully demonstrated the anti-inflammatory and anti-allergic properties of *Devadaru*. Analgesic and anti-inflammatory activity of alcohol extracts of P. roxburghii bark has been shown in experimental animal models Analgesic and anti-inflammatory activity of alcohol extracts of *Sarala* (P. roxburghii) has been shown in experimental animal models.[26] It has *Ushna, Snigdha, Madhur* and *Katu* qualities that are also helpful to calm the *Vata*.

CONCLUSION

It can be concluded from the present study that *Sandhigatavata* is manageable by local application of *Myostaal liniment*. This demonstrates the treatment's consistent efficacy. Since *Sandhigatavata* is *Yapya* (manageable) in nature, this therapy must be used repeatedly. The management of *Sandhigatavata* is safe and successful with this therapy. In order to obtain more accurate results, the study's patient and objective parameters should be expanded.

Informed Consent
It was taken prior to the study

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Conflict Of Interest: Nil
ACKNOWLEDGEMENT: NIl

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Table 1: Composition of *Myostaal liniment*

Composition of *Mayostaal liniment*	**Each 10 ml contains**
Mahanarayan Tail	4.0ml
Nirgundi Tail(Oil of Vitex negundo)	4.0ml
Gandapura Tail(Oil of Gaultheria fragrantissima)	1.0ml
Tailaparna Tail(Oil of Eucalyptus globulus)	0.5ml
Devadaru Tail(Oil of Cedrus deodara)	0.3ml
Sarala(Pinus longifolia)	0.2ml

Table 2: Effect of therapy on Muscle strength on the basis of Dynamometer

	MEAN±SD	
	RIGHT KNEE	LEFT KNEE
AT 0 DAY	8.200±2.159	8.250±2.358
AT 30 DAY	10.130±2.815	9.750±3.887
AT 60 DAY	11.45±3.657	10.880±2.586
AT 90 DAY	11.300±2.943	10.680±2.721
p value	$p < 0.05$	$p < 0.05$

Table 3: Effect of therapy on Pain on the basis of VAS score

	MEAN±SD				**RELIEF %**
	At 0 Day	At 30 Day	At 60 Day	At 90 Day	
VAS	56.500± 7.762	51.000 ± 9.434	33.500 ± 11.413	25.000± 9.220 ($p < 0.05$)	44.24±9.04

Table 4: Effect of therapy on pain, stiffness and activity on the basis of WOMAC

WOMAC	**Mean ±SD**				
	At 0 day	**At 30 Day**	**At 60 Day**	**At 90 Day**	**Relief %**
PAIN	6.400 ± 3.353	5.600 ± 3.323	2.900 ± 2.300	1.900 ± 2.548 ($p < 0.05$)	70.31%
STIFFNESS	1.600 ± 1.562	0.600 ± 1.020	0.100 ± 0.300	0.100 ± 0.300 ($p < 0.05$)	93.75%
DIFFICULTY SCORE	18.500 ± 9.373	15.000 ± 9.370	6.600 ± 5.181	5.100 ± 5.147 ($p < 0.05$)	72.43%
TOTAL SCORE	26.500 ± 12.619	21.800 ± 13.197	9.600 ± 7.605	7.100 ± 7.816 ($p < 0.05$)	73.20%

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RESEARCH ARTICLE

The Effect on Hydromagnetic Flow of Heat Radiation Across a Spinning Porous Disc in a Porous Media that Generates / Absorbs Heat Internally: (PST and PHF Scenarios)

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ABSTRACT

The thermal radiation effects on the electrically conducting grey fluid's continuous laminar convective hydromagnetic flow over a rotating porous disk in a porous material are reviewed using an external uniform magnetic field and heat generation/absorption. When the disc is subjected to a perpendicular magnetic field, we expect a consistent suction over its surface. A nonlinear ordinary differential equation solution can be obtained by applying the suitable similarity transformation suggested by von Karman to the governing nonlinear partial differential equations. This includes heat transmission situations such as the Prescribed Surface Temperature (PST) and the Prescribed Heat Flux (PHF) events. The numerical solutions, derived from a fourth-order Runge-Kutta based shooting method, are graphically depicted using graphs. The Prandtl number, the quantity of heat produced or absorbed, the medium porosity, the suction parameter, the radiation parameter, and the impacts on fluid temperature and velocity are all well investigated in this domain. These effects are depicted using graphs. Tables illustrating the effects of different settings are provided for the Nusselt number and related skin-friction coefficients. Every result is consistent with the previously mentioned sources.

Keywords: Radiation, Heat Transfer, Laminar flow, Rotating Disk, PST, PHF

INTRODUCTION

Laminar spinning discs are extensively studied in a variety of applications, including rotors, turbines, jet engines, flywheels, cars, pumps, compressors, and many more. Takhar et al. [1] characterize the behavior of an axisymmetric body when it rotates within a forced flow field, the centrifugal force causes the fluid close to all over the surface to be propelled outward in a radial direction. The fluid flowing axially then takes the place of this fluid. As a result, the fluid's axial velocity is higher around a rotating body than it is around a stationary one. Increasing the axial velocity of the fluid improves its convective heat transfer from the body. Utilizing this idea, workable solutions for enhancing heat transmission have been created. Hickman [2] demonstrated, for instance, the usefulness of spinning condensers for spacecraft power plants and seawater distillation in a zero-gravity setting. Von Karman [3] introduced the original rotating disc problem, which is the one that scholars have researched the most in the literature. It concerns the motion of viscous flow caused by an endless rotating disc in which the fluid is at rest far from the disc. The problem's scope is then expanded to include a situation where the fluid is spinning as a solid body much above the disc, with suction or injection at the disc surface. Numerous researchers, including those listed in [4]–[7], have addressed the rotating disc and stability difficulties theoretically, numerically, and empirically. A brief overview of the body of open literature on this subject is provided below to help readers better comprehend the work done and its relationship to other works. According to Maleque and Sattar [8], a constant laminar convective flow with different properties is caused by a porous rotating disc. In a porous rotating disc flow, Turkyilmazoglu discussed the exact solutions for the incompressible viscous fluid [9]. Geothermal, industrial, and technological uses of magnetohydrodynamic viscous flows include magnetohydrodynamic (MHD) generators and accelerators, high temperature plasmas, cooling nuclear reactors, and liquid metal fluids. Consequently, there has been a surge of interest in measuring the impact of magnetic fields on heat transfer and flow in a variety of geometries.

Metals in liquid form, water mixed with a little amount of acid, and other fluids with electrically conductive properties are examples of these. Kafoussias and Nanousis [11] reported on the study of micropolar fluid MHD laminar boundary layer flow over a permeable wedge, whereas Watanabe and Pop [10] presented numerical results of MHD free convection flow over a wedge in the presence of a magnetic field. Yih [12] further on the previous work of Watanabe and Pop by taking into account the convection flow generated by MHD adjacent to a non-isothermal wedge while considering magnetic and viscous dissipations, stress, and effort. Attia and Hassan [13] looked studied hydromagnetic flow caused by a revolving disc. Over the last few years, many researchers have taken an interest in the topic of heat transport in porous materials. A great number of geophysical and industrial procedures, however, make use of porous media. The Darcy model is typically employed in situations where the velocity is low. The Darcy-Forchheimer drag force model is necessary in high-porosity regimes at higher velocities. Magnetohydrodynamic convection from rotating discs And other substances embedded in porous medium finds real-world use in gaseous diffusion boundary cooling, magnetic materials processing, filtration, energy systems, and centrifuges. There have been several excellent articles on hydromagnetic convection in porous media saturated with electrically conducting fluids. Rashad [14] examined how hydromagnetic free convection was affected by thermosphoretics and thermal radiation in a porous medium. There are several real-world applications for fluid flow across porous material boundaries, such as managing boundary layers and transpiration. The suction exerted through the surface is well known to be one of the mechanisms for stabilizing fluid flows. By postponing the separation, suction in fluid dynamics is relevant to many technical applications, such as rotating equipment, ships, and submarines. For aircraft wing laminar turbulent control, it is of utmost importance. Hassanien et al. [15] and [31] used a vertical flat plate embedded in a porous material to study the heat transfer characteristics of mixed convection flow. The comparable solutions for Hiemenz flow across porous surfaces are outlined by Chamkha and Khaled [16] in their explanation of hydromagnetic mixed convection heat and mass transport. Attia has lately studied heat transfer and constant flow over a revolving disc in a porous media [17] and [33]. Moreover, the fluid participating in radiative heat transfer may exhibit electrical conductivity due to ionization caused by elevated operating temperatures. Consequently, studying the effect of the magnetic field on such a flow is crucial because of its relevance in application domains where heat radiation and magnetohydrodynamics are coupled. A nuclear reactor

containment vessel uses a magnetic field to cool the first wall, which separates the hot plasma from the wall, and an electrical furnace uses a magnetic field to fuse metals. Problems in studying these phenomena have led to an incomplete understanding of how radiation affects the boundary layer flow of a radiating fluid surrounding a body. There are three main challenges to studying fluid radiation. Radiation is first absorbed and then emitted within and outside of a system during radiative heat transmission. Because of this, predicting fluid absorption is quite challenging. When it comes to absorbing and emitting fluids, wavelength is the main factor that affects their absorption coefficients. Incorporating a radiation component into the energy equation results in a nonlinear partial differential equation that presents significant processing difficulties. The influence of radiation on convective fluxes was extensively studied. Investigating the effect of radiation on the mixed convection flow of an optically dense incompressible fluid over a heated vertical plate that was kept at a constant surface temperature and free stream velocity, Hossain and Takhar [18] looked at this subject. Under the assumption of a suction boundary condition, Hossain and Pop [19] investigated how radiation affects the free convection of an optically dense viscous incompressible fluid along a heated inclined flat surface that is kept at a constant temperature inside a saturated porous medium. Abbas investigated how radiation affected MHD flow in a porous medium [20]. Using the differential approximation, Takhar et al. [21] studied gas dissipative radiative convection in a porous medium, which has applications in geothermal energy systems. For the purpose of solar collector dynamics, Chamkha [22] investigated how solar radiation affects the convection of porous media on a vertical surface. Using the Rosseland model, Mohammadein et al. [23] investigated the effects of radiative flux on free convection in porous substrates.

The rate of heat transmission from a heated surface can be significantly affected in some real-world scenarios by internal heat generation/absorption and thermal radiation [24] and [25]. For instance, in fluids, exothermic or endothermic chemical reactions can have an effect due to internal heat production and absorption [24] and [25]. Under the assumption of internal heat generation and absorption, the issue of hydromagnetic heat transfer over a continuously expanding surface was studied by Abo-Eldahab and Aziz [25]. Under the conditions of buoyancy, thermal radiation, and heat generation or absorption, Chamkha [26] studied the issue of constant hydromagnetic boundary layer flow using an accelerating semi-infinite porous surface. Moreover, Molla et al. [27] and [32] examined magnetohydrodynamic natural convection flows on a spherical surface that generate heat. Convective heat transfer is contingent upon the nature of the thermal boundary conditions imposed; generally, the boundary surface is exposed to either a specified temperature or a designated heat flow. Nonetheless, the wall heat flux is known in many issues, especially those that deal with cooling nuclear and electrical components. Predicting the wall temperature as the wall heat flow changes is one of the goals of heat transfer theory since overheating, burnout, and meltdown are significant challenges in these situations. Controlling this wall temperature dispersion is the design goal. In contrast to a surface with a predetermined wall temperature, the scenario of a regulated heat flux rate at a surface is easy to quantify in a laboratory and is frequently approximated in real-world applications. The convection inside the boundary layer of a porous regime of a spinning disc is studied in this context in relation to magnetic fields, heat production or absorption, and thermal radiation. In order to further involve the heat transfer community, the authors state that additional study is required in this area. In two ways, this effort seeks to improve upon the recent work in Ref. [13]. For the cases of prescribed surface temperature (PST) and prescribed heat flux (PHF), a closed heat-transfer analysis is given. We analyze the influence of thermal radiation on temperature distributions. Reference [28] indicates that numerous unique similarity temperature solutions have been identified for both PST and PHF scenarios. These solutions frequently serve as the foundation for initial estimations to address tangible physical issues. This study assumes the sheet's temperature exceeds that of the fluid. This endeavor seeks to quantitatively address the aforementioned nonlinear challenge.

Formulation of the Problem Mathematically

This research looks at the radiation and internal heat generation/absorption in a continuous, axially symmetric, incompressible flow of a homogeneous electrically conducting fluid around a cylindrical body immersed in a porous medium, with heat transfer mediated by a revolving porous disc. In the positive z-direction, the fluid is assumed to extend endlessly. As illustrated in Fig.I, let (r,ϕ,z) be the set of cylindrical polar coordinates. Furthermore, allow

the disc to rotate at a constant angular velocity Ω while being situated at z=0. As (r,ϕ,z) grows, the flow velocity components are (u, v, w) . The rotating disc surface temperature T_w is maintained at a constant level. The free stream is sustained at a uniform temperature T_∞ and pressure P_∞ at a distance from the surface. It is assumed that the fluid is grey in color; it is Newtonian in nature and acts as a heat sink and radiator simultaneously. Assuming a low magnetic Reynolds number (Rm << 1), the external uniform magnetic field B_0 is orientatedperpendicular to the disk's surface. The speed of the electrically conducting fluid produces a negligible induced magnetic field. Additionally, across the whole range, a consistent suction is maintained across the surface of the disk.

By making these assumptions, the following equations can be expressed to describe the energy, flow in a laminar incompressible boundary layer: momentum, continuity,

$$\frac{\partial u}{\partial r}+\frac{u}{r}+\frac{\partial w}{\partial z}=0, \tag{1}$$

$$u\frac{\partial u}{\partial r}-\frac{v^2}{r}+w\frac{\partial u}{\partial z}+\frac{1}{\rho}\frac{\partial p}{\partial r}=\nu\left(\frac{\partial^2 u}{\partial r^2}+\frac{1}{r}\frac{\partial u}{\partial r}-\frac{u}{r^2}+\frac{\partial^2 u}{\partial z^2}\right)-\frac{\sigma B_0^2}{\rho}u-\frac{\mu}{K}u, \tag{2}$$

$$u\frac{\partial v}{\partial r}+\frac{uv}{r}+w\frac{\partial v}{\partial z}=\nu\left(\frac{\partial^2 v}{\partial r^2}+\frac{1}{r}\frac{\partial v}{\partial r}-\frac{v}{r^2}+\frac{\partial^2 v}{\partial z^2}\right)-\frac{\sigma B_0^2}{\rho}v-\frac{\mu}{K}v, \tag{3}$$

$$u\frac{\partial w}{\partial r}+w\frac{\partial w}{\partial z}+\frac{1}{\rho}\frac{\partial p}{\partial z}=\nu\left(\frac{\partial^2 w}{\partial r^2}+\frac{1}{r}\frac{\partial w}{\partial r}+\frac{\partial^2 w}{\partial z^2}\right)-\frac{\mu}{K}w, \tag{4}$$

$$u\frac{\partial T}{\partial r}+w\frac{\partial T}{\partial z}=\frac{\kappa}{\rho C_p}\left(\frac{\partial^2 T}{\partial r^2}+\frac{1}{r}\frac{\partial T}{\partial r}+\frac{\partial^2 T}{\partial z^2}\right)-\frac{1}{\rho C_p}\frac{\partial q_r}{\partial z}+\frac{Q}{\rho C_p}(T-T_\infty), \tag{5}$$

The constraints that define the problem's perimeter are given by

$$\left.\begin{aligned} &u=0,\quad v=\Omega r,\quad w=w_0, && \text{at } z=0,\\ &T=T_w=T_\infty+D_1\left(\frac{r}{l}\right)^2 && \text{(PST-case) at } z=0,\\ &-k\frac{\partial T}{\partial z}=q_w=D_2\left(\frac{r}{l}\right)^2 && \text{(PHF-case) at } z=0,\\ &u\to 0,\ v\to 0,\ T\to T_\infty,\ p\to p_\infty && \text{as } z\to\infty, \end{aligned}\right\} \tag{6}$$

The characteristic length is denoted as l, whereas D_1 and D_2 represent constants. In this context, κ denotes heat conductivity, while ν = μ/ϱ signifies the ambient fluid'skinematic viscosity. Additionally, σ refers to electrical conductivity, C_p represents specific heat at constant pressure, T indicates temperature, ϱ stands for fluid density, and K indicates the permeability of the porous medium. The expression $Q(T-T_\infty)$ denotes the quantity of heat generation or absorption per unit volume, where Q is a constant, and q_r signifies radiative heat flux. The Rosland approximation can be used to write radiation for a densely opaque layer.

$$q_r=-\frac{4\sigma^*}{3\kappa^*}\frac{\partial T^4}{\partial z}, \tag{7}$$

as the mean absorption coefficient and the Stefan-Boltzmann constant are represented by κ^* and σ^* respectively. The assumption is that the temperature changes in the flow are sufficiently large for the statement to be represented as a linear function of temperature T^4. This is achieved by expanding T^4 in a Taylor series around T_∞ excluding terms with higher-order variables. Thus

$$T^4 \cong 4T_\infty^3 T - 3T_\infty^4, \tag{8}$$

to (7) and (8), (5) becomes

$$u\frac{\partial T}{\partial r} + w\frac{\partial T}{\partial z} = \frac{k}{\rho C_p}\left(\frac{\partial^2 T}{\partial r^2} + \frac{1}{r}\frac{\partial T}{\partial r} + \frac{\partial^2 T}{\partial z^2}\right) - \frac{16\sigma^* T_\infty^3}{\rho C_p 3\kappa^*}\frac{\partial^2 T}{\partial z^2} + \frac{Q}{\rho C_p}(T - T_\infty), \tag{9}$$

Similarity Transformation

$$\left.\begin{aligned} &\eta = z(\Omega/\nu)^{\frac{1}{2}}, \quad u = \Omega r F(\eta), \quad v = \Omega r G(\eta), \\ &w = (\Omega\nu)^{\frac{1}{2}} H(\eta), \quad p - p_\infty = 2\mu\Omega P(\eta) \text{ and} \\ &T - T_\infty = \Delta T\theta(\eta) \qquad (PST - case) \\ &T - T_\infty = \frac{D_2}{k}\left(\frac{r}{l}\right)^2 \sqrt{\frac{\nu}{\Omega}}\theta(\eta) \quad (PHF - case) \end{aligned}\right\} \tag{10}$$

where ν represents a constant fluid's kinematic viscosity and $\Delta T = T_w - T_\infty$.
Eqs. (1)-(3) and (9) in the instance, by simplifying,

$$2F + H' = 0, \tag{11}$$

$$F'' - HF' - F^2 + G^2 - (A + M)F = 0, \tag{12}$$

$$G'' - HG' - 2FG - (A + M)G = 0, \tag{13}$$

$$\text{and} \quad \frac{\theta''}{Pr}\left(1 + \frac{4}{3R_d}\right) - H\theta' + L\theta = 0. \quad \text{(for PST \& PHF cases)} \tag{14}$$

It is possible to rephrase the boundary conditions (6) as

$$\left.\begin{aligned} &F(0) = 0, \quad G(0) = 1, \quad H(0) = W_s, \\ &\theta(0) = 1 \qquad \text{(PST-case)}, \\ &\theta'(0) = -1 \quad \text{(PHF-case)}, \\ &F(\infty) = G(\infty) = \theta(\infty) = p(\infty) = 0. \end{aligned}\right\} \tag{15}$$

where $M = \frac{\sigma B_0^2}{\Omega\rho}$ stands for the magnetic parameter, $A = \frac{\nu}{\Omega K}$ denotes the parameter for porosity, $\Pr = \frac{\mu C_p}{\kappa}$ represents the Prandtl number, $R_d = \frac{\kappa^*\kappa}{4\sigma^* T_\infty^3}$ is a measure of radiation, $L = \frac{Q\rho C_p}{\Omega}$ stands for the coefficient of heat generation or absorption and $W_s = \frac{w_s}{\sqrt{\nu\Omega}}$ represents a uniform suction parameter.

The no-slip requirement of viscous flow applies to the disk's surface, according to equation (15). As shown in Eqs. (15), all fluid velocities must disappear far from the disc surface, with the exception of the induced axial component. By applying the boundary conditions provided by equations (15) to the system of equations (11) through (14), the three components of the flow velocity can be ascertained. If necessary, the pressure distribution can be found using equation (4). The disparity in temperature between the wall and the fluid around it causes heat transmission [30]. According to continuity considerations, the temperature at the disk's surface must equal T in order for the energy problem to have boundary conditions. T goes to T_∞ a great separation from the disc, where T_w is the ambient fluid temperature.

The Newtonian formulas provide the Nusselt number and the skin friction coefficients:

$$\tau_t = \left[\mu\left(\frac{\partial v}{\partial z} + \frac{1}{r}\frac{\partial w}{\partial \phi}\right)\right]_{z=0} = \mu G'\Omega(Re)^{\frac{1}{2}},$$

$$\tau_r = \left[\mu\left(\frac{\partial u}{\partial z} + \frac{1}{r}\frac{\partial w}{\partial \phi}\right)\right]_{z=0} = \mu F'\Omega(Re)^{\frac{1}{2}},$$

Consequently, the tangential and radial skin frictions (both PST & PHF cases) are given by

$$(Re)^{\frac{1}{2}} C_{f_t} = G'(0), \qquad (16)$$

$$(Re)^{\frac{1}{2}} C_{f_r} = F'(0), \qquad (17)$$

The rate of heat transmission for the PST instance is specified by

$$q = -\left(k\frac{\partial T}{\partial z}\right)_{z=0} = -k\Delta T\left(\frac{\Omega}{\nu}\right)^{\frac{1}{2}}\theta'(0), \qquad (18)$$

Therefore,Nusselt number (Nu) is defined as

$$(Re)^{-\frac{1}{2}} Nu = -\theta'(0). \qquad (19)$$

here $\mathrm{Re}(=\Omega r^2/\nu)$ denotes Reynolds number of rotation.

Numerical Approaches to Solving

Second-order, extremely non-linear boundary value problems are represented by equations (11)–(14). Consequently, the optimal numerical shooting method is developed by means of a fourth-order Runge-Kutta integration approach. The process begins with a preliminary estimate value, η, and continues with the use of a particular set of parameters to solve the problem and obtain F ′ (0),G ′ (0) & θ ′ (0) in the PST case and F ′(0),G ′ (0) & θ(0) in the PHF case, respectively. The numerical answer is obtained in this computation using a step size of 0.001 and five decimal accuracy criteria for convergence.

FINDINGS AND ANALYSIS

Thermal radiation, heat generation and absorption, and hydromagnetic convective flow of an electrically conducting grey fluid across a rotating porous disc in a porous media with an external uniform magnetic field are all addressed in the numerical solutions. Applying the shooting method with a fourth-order Runge-Kutta integration technique, the system of equations can be numerically solved. based on the conditions at the border (15) level, from (11) to (14).

An exhaustive understanding of its radial velocity F, tangential velocity G, axial velocity H, and temperature θ has been given by giving numerical values to the parameters encountered in the physical problem. Suction parameters take values - 1, -2, -3, & -4, while magnetic parameters take values 1, 2, 3, & 4 to be realistic. Prandtl number values are 0.71, 1, 2, & 7.03 (particularly for air, where Pr = 0.71 denotes 20o C and one atmospheric pressure); radiation parameter values are 1, 5, 10, 15, and heat generation/absorption parameter values are -0.2, -0.1, 0.1 & 0.2; and permeability parameter values are 0 (no porous medium), 0.5, 1.0 & 1.5 (high porous medium). For the example of PST & (Pr = 0.71, M = 0.0, A = 0.0, L = 0.0, Rd = 109),We have compared our radial skin friction, tangential skin friction, and Nusselt number to data that has already been published [29] in order to evaluate the accuracy of the numerical approach. Table 1 displays the results of the comparison, which show a good agreement. For specific values of different governing parameters, Table 2-13 shows how the Nusselt numbers $-\theta'(0)$ (in the PST example) and $\theta(0)$ (in the PHF case) behave, as well as the radial and tangential skin friction coefficients $F'(0)$ and $G'(0)$.

Both Tables 2 and 3 indicate that in the PST case, the rate of heat transfer $-\theta'(0)$ increases as the magnetic field parameter M grows, whereas in the PHF example, the surface temperature $\theta(0)$, tangential skin-friction $G'(0)$, and radial skin-friction $F'(0)$ drop. When the suction parameter Ws increases, the surface temperature $\theta(0)$ (PHF), tangential skin-friction $G'(0)$, and radial skin-friction $F'(0)$ all rise. However, the rate of heat transfer $-\theta'(0)$ (PST scenario) remains constant, as shown in Tables 4 and 5. A thicker velocity boundary layer, created by blowing, reduces the velocity gradient close to the surface, which is why this happens. As the porosity parameter A grows, the surface temperature $\theta(0)$ somewhat rises, the rate of heat transfer $-\theta'(0)$ slightly falls, and the radial and tangential skin-friction coefficients $F'(0)$ and $G'(0)$ greatly fall, as shown in Tables 6 and 7. For various values of Rd, Tables 8 and 9 show the Nusselt number $-\theta'(0)$ (in the PST example) and the surface temperature $\theta(0)$ (in the PHF case). Raising Rd causes a drop in surface temperature (PHF instance) and a rise in the Nusselt number (PST case). As the heat generation parameter L increases in the PHF scenario, the surface temperature $\theta(0)$ rises, whereas in the PST example, the Nusselt number Nu declines. Both Table 10 and Table 11 demonstrate this. These are inevitable results of the heat generation mechanism, which causes a layer of fluid to form close to the surface, which becomes hotter as time goes on. For various values of Pr, Tables 12 and 13 display the differences between the surface temperature $\theta(0)$ in the PHF instance and the Nusselt number $-\theta'(0)$ in the PST example. In the PHF case, surface temperature measurements drop significantly because the rate of heat transfer at the disc surface drops with increasing Prandtl number. The inverse trend holds true for the rate of heat transmission.

The boundary layer radial velocity profiles $F(\eta)$ for different values of the magnetic parameter M, suction parameter Ws, and porous permeability parameter A are shown in Figures 1-3. As seen in Figure 1, a stronger z-direction (normal to the disc surface) applied magnetic field, as a result of an increase in M, reduces the radial velocity of the region due to an increase in hydromagnetic drag. Thus, radial velocity is demonstrated to reach its maximum close to the disc's surface and then quickly decay to zero. The radial velocity is quite low for large suction. Figure 2 also clearly shows that suction stabilizes the boundary layer. As shown in Figure 3, the radial velocity distribution becomes less as A increases. The reason behind this is that fluid velocity is reduced when a porous substance is present because flow resistance increases. Various values of M, Ws, and A are shown in Figures 4-6, which show the tangential velocity profiles $G(\eta)$. The boundary layer thickness for an enforced suctioned porous medium decrease with increasing M. When a tangential flow velocity G is opposed to a magnetic field B, a tangential magnetic force is produced. As the result, the boundary layer thickness drops and tangential velocities drop across the board (Fig. 4). When the Lorentz force acts against the flow, it causes the azimuthal velocity to decelerate even more. The tangential velocity profile is illustrated by the effect of suction in Figure 5. At strong suction, the tangential velocity sinks off the surface at a quick pace. Along with that, as shown in Figure 6, the tangential velocity and boundary layer thickness also drop as A increases. Figures 7–9 display the steady state axial velocity profiles $-H(\eta)$ for different values of M, Ws , and A. As Fig. 7 illustrates, the axial component of velocity obviously decreases as the magnetic parameter M rises. Let us now examine the application of a suction at the disk's surface $Ws< 0$. In addition to the pumping of the revolving disc caused by the fan, there is also additional pumping because of the suction. The amount of fluid extracted from the environment so rises. Two possible routes are now open to the inflowing fluid. The inflow can either continue through the disk's suction holes or reroute in a radial direction. Naturally, the least

difficult route will be selected. It gets easier and simpler to get out of the wall as the suction grows. Consequently, a greater and greater portion of the input enters the porous disc directly as Ws becomes more negative. Fig. 8 shows that H tends to be almost constant as a result. As illustrated in Figure 9, the axial velocity and raising the porosity parameter causes the boundary layer to thicken. Figures 10-21 display the results of the temperature changes under different M, Ws, A, Rd, L, and Pr values. Figures 10 and 11 illustrate the effects of the magnetic variable M on the temperature profiles of the boundary layers in the PST and PHF cases, respectively. It is interesting to observe that M improves the boundary layer temperature distribution, and the effect of the increasing magnetic variable is more noticeable near the wall. Both Figure 12 and Figure 13 show how the suction parameter affects the temperature profiles of the boundary layer. As soon as wall suction is applied (Ws< 0,) both the heat profiles and the thickness of the thermal boundary layer diminish. The effects of the porosity parameter A on the temperature θ, caused by the fluid's near-ambient temperature not reaching the disc surface, are shown in Figures 14 and 15, respectively, in the PST and PHF scenarios. The thickness and temperature of the thermal boundary layer do, therefore, grow in relation to M. Absence of fluid improves heat transmission at surfaces heated to around ambient temperature. For the PST scenario, Figure 16 shows the impact of the radiation parameter Rd on the temperature profile, and for the PHF case, Figure 17. Of course, Rd impacts the whole border layer. The fact that Rd minimizes the temperature distribution at the thermal boundary layer is curious. In the thermal boundary layer, a lower temperature profile value is indicated by an increase in Rd, since an increase in Rd reduces radiation. Fluid temperature drops when thermal boundary layer thickness decreases due to release of heat energy from the flow zone caused by an increase in the radiation parameter. Figure 18 showed how the boundary-layer temperature profiles for the PST case were affected by the heat source/sink parameter, L, and Figure 19 showed the same thing for the PHF case. It slows down the rate of heat transfer from the disk's surface and generates a heated layer adjacent to it, which is a heat source ($L > 0$). To the contrary, the presence of a heat sink ($L < 0$), sometimes called heat absorption, causes a chilly layer of fluid to form next to the disc surface, speeding up the removal of heat from the surface. For $L = 0.1, 0.2$, increasing the amount of thermal energy present in the flow regime leads to an increase in the temperature θ in the porosity regime. Thanks to the lower temperatures produced by $L = -0.1, -0.2$, both the PST and PHF scenarios demonstrate heat absorption. No temperature profile deviates from zero as one gets closer to the boundary-layer domain's edge. For different Pr values, the temperature profiles vary with η, as shown in Figure 20 (PST instance) and Figure 21 (PHF case). A drop in temperature is observed with increasing Pr. As Pr increases, the thermal boundary layer gets thinner, which is consistent with the physical fact.

CONCLUSION

In the presence of radiation and heat generation/absorption, mathematical analysis has been used to study the thermodynamic boundary layer flow and heat transfer properties in an incompressible electrically conducting fluid across a porous rotating disc. Two possible scenarios for heat transfer are firstly the Prescribed Surface Temperature (PST) scenario and secondly the Prescribed Heat Flux (PHF) scenario. Using von Karman similarity transformations, an extremely non-linear second-order momentum boundary layer equation can be transformed into an ordinary differential equation. Numerical solutions for the momentum, continuity, and heat transfer equations are achieved by utilizing the fourth-order Runge-Kutta method in conjunction with firing approach. Temperature and velocity profiles are derived by studying the impact of several physical parameters, such as the prandtl number, radiation, magnetic, permeability, and heat generation/absorption characteristics. Key findings from the current study are as follows: While the PST instance shows an increase in the rate of heat transfer, the PHF scenario shows a drop in surface temperature, skin friction of tangential and radial as the 17 parameters of the suction and magnetic field increase. An increase in the porosity parameter (in this case, PST) reduces the rate of heat transmission and the radial and tangential skin friction. as well as a small rise in surface temperature (PHF instance). When the radiation parameter and Prandtl number are increased in the PST scenario, the Nusselt number is raised; conversely, in the PHF scenario, the surface temperature is lowered. In the context of PST, the Nusselt number increases with the escalation of the heat source/sink parameter values. The radial velocity diminishes with an increase in the magnetic field, suction, and porosity factors. As the suction parameter, magnetic field, and porosity parameter increase, the

tangential velocity diminishes. While suction parameter accelerates the axial velocity, the magnetic interaction and porosity parameters have the opposite effect. Suction, radiation, Prandtl number, and heat sink parameters ($L < 0$) have the effect of decreasing the temperature distribution, whereas magnetic interaction, porosity, and heat generation parameters ($L > 0$) have the effect of increasing it for situations involving PST and PHF. With increasing radiation parameter Rd and Prandtl number Pr, the heat transfer coefficient rises in the PST scenario, while the heat generation/absorption parameter falls. By comparing the data trend for both cases, with the same values for the influencing parameters, we find that at every place inside the border, the temperature is lower in the PST case compared to the PHF scenario. Accordingly, PST is the better option when comparing the two because of its superior cooling activity.

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	Present			Kelson and Desseaux		
W_s	$F'(0)$	$-G'(0)$	$-\theta'(0)$	$F'(0)$	$-G'(0)$	$-\theta'(0)$
4	0.243043	0.289210e-1	0.150101e-4	0.243044	0.289211e-1	0.107326e-4
3	0.309185	0.602989e-1	0.126771e-2	0.309147	0.602893e-1	0.576744e-3
2	0.398941	0.135959	0.116090e-1	0.398934	0.135952	0.110135e-1
1	0.489481	0.302173	0.850176e-1	0.489481	0.302173	0.848848e-1
0	0.510214	0.615926	0.326831	0.510233	0.615922	0.325856
-1	0.389564	1.175221	0.793069	0.389569	1.175222	0.793048
-2	0.242416	2.038527	1.437784	0.242421	2.038527	1.437782
-3	0.165576	3.012142	2.135586	0.165582	3.012142	2.135585
-4	0.124738	4.220518	2.842382	0.124742	4.005180	2.842381

Table 1. Comparison of, $F'(0), G'(0)$ & $-\theta'(0)$ for different values of W_s with $(Pr = 0.71, A = 0.0, M = 0.0, R_d = 10^9, L = 0.0)$

M	$F'(0)$	$-G'(0)$	$-\theta'(0)$
1	0.2195945	1.848522	0.3955877
2	0.1810917	2.172436	0.4014100
3	0.1577187	2.445736	0.4061409
4	0.1416300	2.686105	0.4070684

Table 2. (PST case)

M	$F'(0)$	$-G'(0)$	$\theta(0)$
1	0.2195945	1.848522	2.542044
2	0.1810917	2.172436	2.527882
3	0.1577187	2.445736	2.517240
4	0.1416300	2.686105	2.490987

Table 3. (PHF case)

Results of $F'(0)$, $-G'(0)$ & $-\theta'(0)$ (For PST case) and $F'(0)$, $-G'(0)$ & $\theta(0)$ (For PST case) for different values of M with $(A = 0.5, W_s = -1, R_d = 1, L = -0.1, Pr = 0.71)$.

W_s	$F'(0)$	$-G'(0)$	$-\theta'(0)$
-1	0.2195945	1.848522	0.3955877
-2	0.1728272	2.594124	0.6600636
-3	0.1364101	3.443018	0.9473602
-4	0.1105327	4.348722	1.242827

Table 4. (PST case)

W_s	$F'(0)$	$-G'(0)$	$\theta(0)$
-1	0.2195945	1.848522	2.542044
-2	0.1728273	2.594124	1.514691
-3	0.1364101	3.443017	1.055564
-4	0.1105327	4.348722	0.804617

Table 5. (PHF case)

Results of $F'(0)$, $-G'(0)$ & $-\theta'(0)$ (For PST case) and $F'(0)$, $-G'(0)$ & $\theta(0)$ (For PST case) for different values of W_s with $(A = 0.5, M = 1, R_d = 1, L = -0.1, Pr = 0.71)$.

A	$F'(0)$	$-G'(0)$	$-\theta'(0)$
0	0.2510440	1.657076	0.4005608
0.5	0.2195945	1.848522	0.3975877
1	0.1975679	2.018473	0.3950058
1.5	0.1810914	2.172436	0.3943752

Table 6. (PST case)

A	$F'(0)$	$-G'(0)$	$\theta(0)$
0	0.2510440	1.657076	2.501996
0.5	0.2195943	1.848522	2.527882
1	0.1975679	2.018473	2.538024
1.5	0.1810914	2.172436	2.516337

Table 7. (PHF case)

Results of $F'(0)$, $-G'(0)$ & $-\theta'(0)$ (For PST case) and $F'(0)$, $-G'(0)$ & $\theta(0)$ (For PST case) for different values of A with $(W_s = -1, M = 1, R_d = 1, L = -0.1, Pr = 0.71)$.

R_d	$F'(0)$	$-G'(0)$	$-\theta'(0)$
1	0.2195945	1.848522	0.3955877
5	0.2195945	1.848522	0.6658165
10	0.2195945	1.848522	0.7343752
15	0.2195945	1.848522	0.7609000

Table 8. (PST case)

R_d	$F'(0)$	$-G'(0)$	$\theta(0)$
1	0.2195943	1.848522	2.527882
5	0.2195943	1.848522	1.501915
10	0.2195943	1.848522	1.361701
15	0.2195943	1.848522	1.314267

Table 9. (PHF case)

Results of $F'(0)$, $-G'(0)$ & $-\theta'(0)$ (For PST case) and $F'(0)$, $-G'(0)$ & $\theta(0)$ (For PST case) for different values of R_d with $(W_s = -1, M = 1, A = 0.5, L = -0.1, Pr = 0.71)$.

L	$F'(0)$	$-G'(0)$	$-\theta'(0)$
-0.2	0.2195945	1.848522	0.4518507
-0.1	0.2195945	1.848522	0.3955877
0.1	0.2195945	1.848522	0.2547453
0.2	0.2195945	1.848522	0.0964136

Table 10. (PST case)

L	$F'(0)$	$-G'(0)$	$\theta(0)$
-0.2	0.2195943	1.848522	2.211595
-0.1	0.2195943	1.848522	2.527882
0.1	0.2195943	1.848522	4.078546
0.2	0.2195943	1.848522	6.519483

Table 11. (PHF case)

Results of $F'(0)$, $-G'(0)$ & $-\theta'(0)$ (For PST case) and $F'(0)$, $-G'(0)$ & $\theta(0)$ (For PST case) for different values of L with ($W_s = -1, M = 1, A = 0.5, R_d = 1, Pr = 0.71$).

Pr	$F'(0)$	$-G'(0)$	$-\theta'(0)$
0.71	0.2195945	1.848522	0.3955877
1.0	0.2195945	1.848522	0.5275478
2.0	0.2195945	1.848522	0.9722018
7.03	0.2195945	1.848522	3.145561

Table 12. (PST case)

Pr	$F'(0)$	$-G'(0)$	$\theta(0)$
0.71	0.2195943	1.848522	2.527882
1.0	0.2195943	1.848522	1.895563
2.0	0.2195943	1.848522	1.028592
7.03	0.2195943	1.848522	0.317908

Table 13. (PHF case)

Results of $F'(0)$, $-G'(0)$ & $-\theta'(0)$ (For PST case) and $F'(0)$, $-G'(0)$ & $\theta(0)$ (For PST case) for different values of Pr with ($W_s = -1, M = 1, A = 0.5, L = -0.1, R_d = 1$).

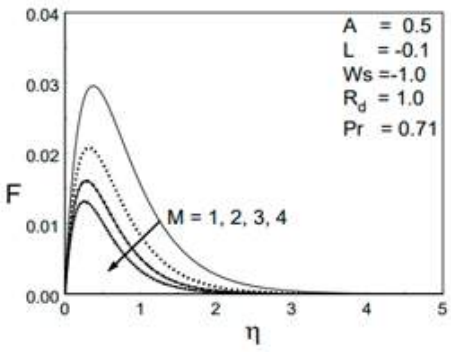


Fig.1 Impact of M on profiles of radial velocity

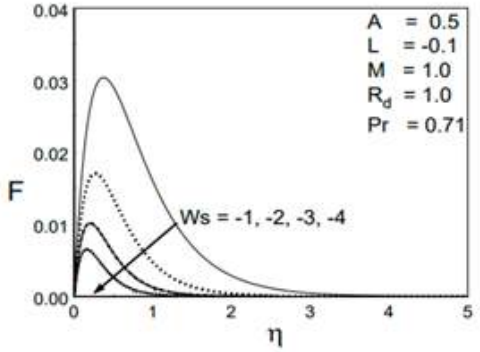


Fig.2 Impact of Ws on profiles of radial velocity

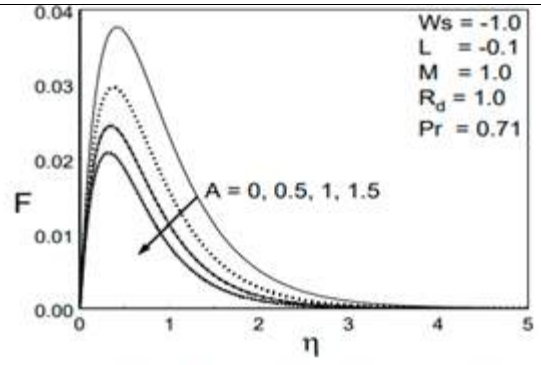


Fig.3 Impact of A on profiles of radial velocity

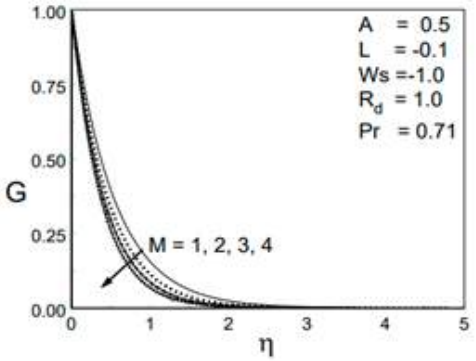


Fig.4 Impact of M on tangential velocity distributions

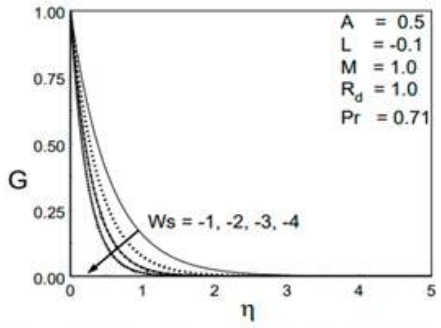


Fig.5 Impact of *Ws* on tangential velocity distributions

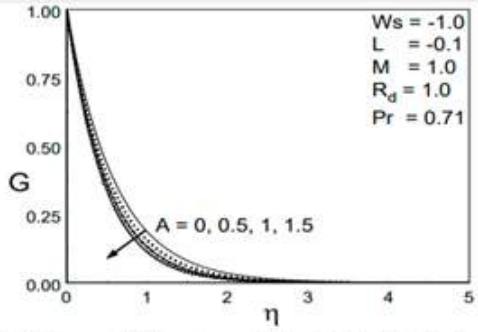


Fig.6 Impact of *A* on tangential velocity distributions

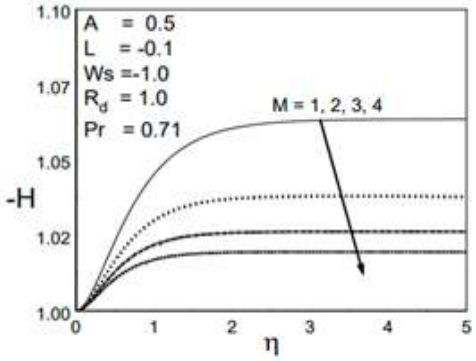


Fig.7 Impact of *M* on axial velocity distributions

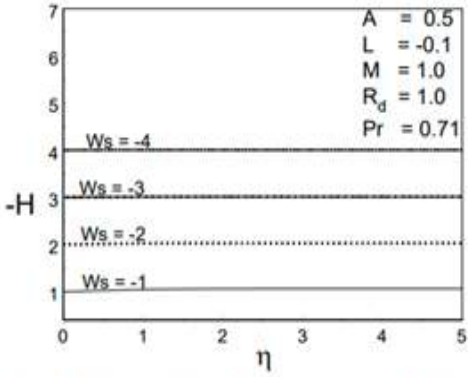


Fig.8 Impact of *Ws* on axial velocity distributions

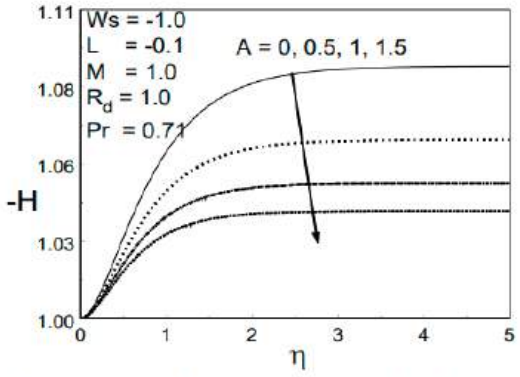


Fig.9 Impact of *A* on axial velocity distributions

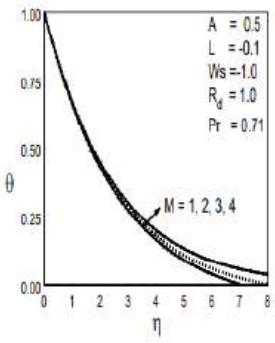


Fig.10 (PST Case) Impact of *M* on the distribution of temperatures

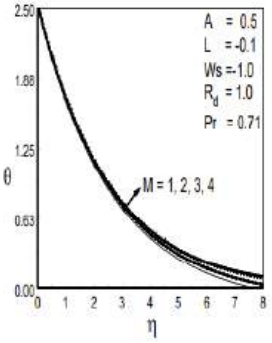


Fig.11 (PHF Case)

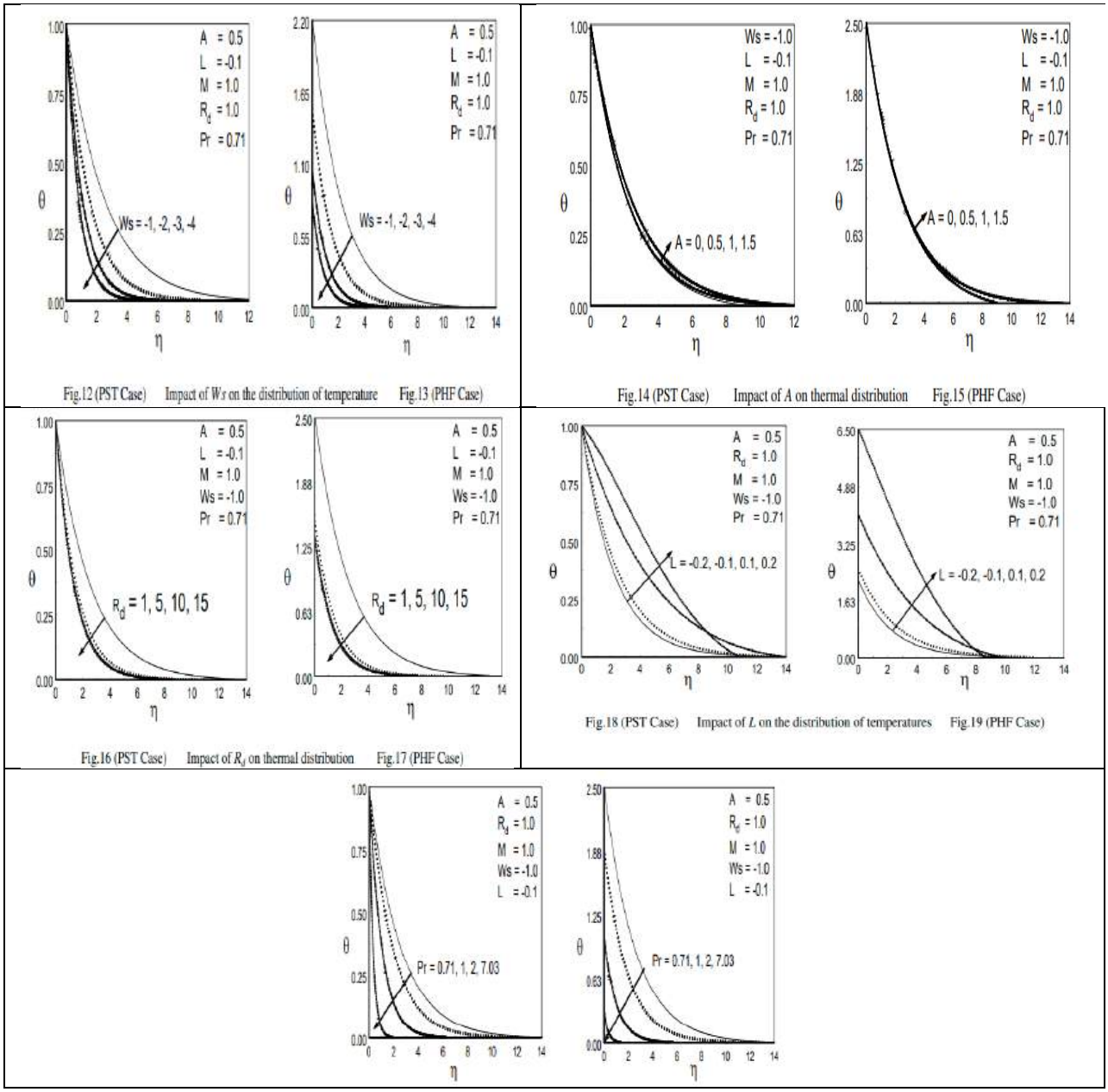


Fig.12 (PST Case) Impact of *Ws* on the distribution of temperature Fig.13 (PHF Case)

Fig.14 (PST Case) Impact of *A* on thermal distribution Fig.15 (PHF Case)

Fig.16 (PST Case) Impact of R_d on thermal distribution Fig.17 (PHF Case)

Fig.18 (PST Case) Impact of *L* on the distribution of temperatures Fig.19 (PHF Case)

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RESEARCH ARTICLE

Real-Time Weed Detection in Agriculture using CNNs and Edge Computing

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ABSTRACT

A major problem in contemporary agriculture, weed control has a big influence on crop yields and production costs. This paper presents a real-time weed detection system leveraging Convolutional Neural Networks (CNNs) and edge computing. The proposed system achieves high detection accuracy while maintaining low latency, making it suitable for deployment in resource-constrained environments. The methodology includes training a CNN on a diverse dataset of crop and weed images, deploying the model on edge devices, and optimizing it for real-time inference. Experimental results demonstrate the system's efficacy, achieving a detection accuracy of 95.6% with an inference time of less than 100 ms per frame. One of the first sources of human subsistence in the world is agriculture. Nowadays due to the immediate increase in people, the increased capacity for agriculture production is required to meet the demands. To boost the production of crops, farmers need to detect the weed plants in the crop so that they can easily remove them from the crop. So, Farmers' circumstances and agricultural decision-making can be improved by new technologies. To address the issue of weed detection in the agricultural sector, this work employed deep learning and image processing techniques. Bounding boxes containing varied image samples from the numerous resources that will detect the weed are used in this work to collect data on crop and weed detection. The data set contains hundreds of photographs. The user selects which of the images are crop plants and which are weed plants. Using deep learning algorithms like CNN, SVM, and others based on the data sets, this article primarily focuses on the analysis of agricultural data and identifying the best farms to maximize crop production. To attain effective accuracy, we first take into account pictures of the data set that are sent into the algorithm. This paper's output is to identify weed plants in the crop. This paper reduces the risk management for the farmers based on the algorithm.

Keywords: Bounding boxes containing varied image samples from the numerous resources that will detect the weed are used in this work to collect data on crop and weed detection

INTRODUCTION

The spread of weeds, which compete with crops for resources like water, nutrients, and sunlight, frequently reduces agricultural production. Chemical pesticides and hand weeding are two labor-intensive traditional weed control techniques. Environmentally harmful, and economically unsustainable. Technological advancements in artificial intelligence (AI) and edge computing offer promising solutions for automating weed detection and management. This paper focuses on developing a real-time weed detection system that combines the power of CNNs with the efficiency of edge computing. In the past, weed identification was accomplished by hiring men specifically for that purpose. This article describes how to use image processing to identify weed plants. By inspecting every area of the field, they will find the weed. They will then use their hands to carefully pull them out. Later, when technology advanced, they began removing the weeds with herbicides. However, in many places of the world, manual labor is still used to detect weeds. A few automated weed-detection techniques were later developed, but their inaccuracies prevented them from reaching the general public. After that, they began to use image processing for this. Our primary goal in this suggested research is to use image processing to identify weeds in the crop. In India, agriculture is significant. It is essential to the survival and expansion of the Indian economy. Approximately 80% of urban households and 15% of the total population rely on agriculture as their primary source of income. India produces a wide range of agricultural goods. India's soil types and agroclimates vary greatly. Numerous weed concerns plague the extremely varied fanning and agriculture systems. Weeds are plants that grow in inappropriate locations and compete with crops for resources like light, water, nutrients, and space. This reduces agricultural productivity and makes it harder to use machinery efficiently and can disrupt agriculture. Additionally, weeds can harbor illnesses and pests that can infect farmed crops. Weed management costs farmers a lot of money and time. Weeds reduce crop yields by 15–85%, degrade product quality, and pose health and environmental risks. Problematic weeds that are peculiar to a given crop are becoming a threat to cultivation, impacting crop yield, product quality, and farmer income. In India, manual weeding has historically been the main method of weed control.

Later, as technology advanced, people began using pesticides to eradicate weeds. Since weeds compete with crops for vital resources like sunshine, water, and nutrients, resulting in large yield reductions, weed detection is a crucial component of contemporary precision agriculture. Traditional methods of weed control, such as manual weeding or blanket application of herbicides, are labour-intensive, environmentally detrimental, and economically unsustainable. As the demand for efficient and sustainable agricultural practices increases, technological solutions that integrate real-time monitoring and intelligent decision-making are becoming imperative. Recent advancements in computer vision and machine learning, particularly Convolutional Neural Networks (CNNs), have shown remarkable potential in automating weed detection tasks. CNNs can accurately classify and localize weeds in complex field environments, leveraging their ability to extract and process hierarchical features from images. However, implementing such models in real-world scenarios poses challenges, particularly in terms of computational demands, latency, and energy efficiency, when relying on centralized cloud-based systems. Edge computing offers a promising solution to these challenges by enabling data processing closer to the source of data generation—on-edge devices like drones, robots, or IoT sensors. This approach minimizes latency, reduces dependency on internet connectivity, and ensures real-time operation, making it particularly suited for agricultural applications where timeliness is crucial. Integrating CNN-based weed detection with edge computing has the potential to transform weed management practices, enhancing efficiency while reducing the environmental footprint. This paper explores the integration of CNNs and edge computing for real-time weed detection in agriculture, providing a detailed analysis of system design, implementation challenges, and performance evaluation. By leveraging these technologies, we aim to contribute to the development of sustainable, data-driven agricultural systems that align with global goals for food security and environmental conservation.

RELATED WORK

Several studies have explored the application of deep learning for weed detection. CNNs have shown remarkable success in image classification and object detection tasks, including distinguishing between crops and weeds. However, most existing systems rely on cloud computing, leading to latency issues and high energy consumption. Recent advancements in edge computing provide a decentralized approach, enabling real-time processing directly on the device. This paper builds on prior work by integrating CNNs with edge devices to achieve real-time weed detection. The rapid growth of the global population necessitates sustainable and efficient agricultural practices. Weed management is a critical component, as weeds compete with crops for resources, leading to significant yield losses. Chemical pesticides and hand weeding are two labor-intensive and environmentally harmful traditional weed control techniques. Convolutional neural networks (CNNs), a recent development in artificial intelligence (AI), and edge computing have enabled real-time, automated weed detection systems that promise higher efficiency and reduced environmental impact.

Convolutional Neural Networks for Weed Detection

CNNs have emerged as a powerful tool for image-based weed detection due to their ability to learn spatial hierarchies of features. Early works utilized pre-trained models such as AlexNet and VGG16 to classify crop and weed species. For instance, Milić et al. (2020) demonstrated the use of a CNN-based system for distinguishing between maize and weed species, achieving over 90% accuracy. More recent studies focus on custom architectures tailored to agricultural settings. According to Dos Santos Ferreira *et al.* (2019), a lightweight CNN optimized for mobile platforms, significantly reducing computational costs while maintaining high detection accuracy. Transfer learning has also been widely adopted to leverage large datasets from general domains and fine-tune models for specific agricultural applications (Zhou et al., 2021).

Edge Computing in Agricultural Applications

The drawbacks of cloud-based systems, like latency and reliance on internet connectivity, are addressed by combining edge computing with AI models. By processing data locally, edge devices lower the bandwidth needed for data transmission and allow for real-time decision-making. This is particularly advantageous in remote agricultural fields with limited connectivity. A notable implementation is presented by Ramachandran *et al.* (2020), where an edge-based weed detection system employed NVIDIA Jetson devices to run real-time CNN inference. The system achieved a latency of less than 50 ms per frame, making it suitable for deployment on autonomous farming equipment.

Challenges and Opportunities

Despite significant advancements, several challenges remain. First, variability in lighting conditions, soil types, and weed species can degrade model performance. Second, computational constraints on edge devices necessitate highly optimized models, often at the expense of accuracy. Addressing these issues requires:

1. **Robust Data Augmentation:** Models can more effectively generalize to a variety of settings with the aid of techniques like random cropping, rotation, and brightness adjustment.
2. **Model Compression:** By lowering CNNs' computational footprint, methods like quantization and pruning make them appropriate for edge deployment (Han *et al*., 2016).
3. **Integration with IoT:** Combining edge computing with Internet of Things (IoT) devices can enable seamless data collection and system scalability (Koirala *et al.,* 2021).

METHODOLOGY

Data Collection and Pre-processing

From various agricultural fields, a collection of 50,000 labeled images of weeds and crops was gathered. To guarantee resilience, images were taken from several perspectives and under different lighting circumstances. Rotation, flipping, scaling, and other data augmentation techniques were used to increase the dataset's diversity.

Model Architecture

The CNN model was based on the EfficientNet-B0 architecture, chosen for its strike a compromise between computing efficiency and precision. Convolutional layers are used in the model to extract features, while fully linked layers are used for classification. Transfer learning was employed to accelerate training and improve performance.

Edge Deployment

The trained model was deployed on an NVIDIA Jetson Nano, a popular edge device for AI applications. TensorRT optimization was applied to reduce model size and enhance inference speed. The system was integrated with a camera module for real-time image capture and processing.

Performance Metrics

The system's performance was evaluated using accuracy, precision, recall, F1-score, and inference time. Energy consumption was also measured to assess the feasibility of edge deployment.

Accuracy

The percentage of weeds that were accurately detected in relation to all samples. Shows how accurate the model's predictions are overall.

$$\text{Accuracy} = \frac{\text{TP} + \text{TN}}{\text{TP} + \text{TN} + \text{FP} + \text{FN}}$$

Precision

The proportion of correctly identified weeds out of all samples classified as weeds. Measures the reliability of positive predictions.

$$\text{Precision} = \frac{\text{TP}}{\text{TP} + \text{FP}}$$

Recall

The percentage of real weeds that were accurately recognized. Shows how well the system can identify weeds.

$$\text{Recall} = \frac{\text{TP}}{\text{TP} + \text{FN}}$$

F1- Score

Harmonic methods for memory and accuracy. Balances recall and precision, which is particularly helpful in cases where class distributions are unbalanced.

$$\text{F1 Score} = 2 \times \frac{\text{Precision} \times \text{Recall}}{\text{Precision} + \text{Recall}}$$

EXPERIMENTAL RESULTS

The system's F1-score was 95.5%, its recall was 96.2%, its precision was 94.8%, and its detection accuracy was 95.6%. These findings demonstrate the model's ability to distinguish between crops and weeds effectively. Inference time was measured at an average of 92 ms per frame, meeting the requirements for real-time applications. The optimized model size was 15 MB, suitable for deployment on edge devices with limited storage. The system consumed an average of 10 W during operation, making it energy-efficient and practical for use in remote agricultural fields.

DISCUSSION

The proposed system demonstrates that combining CNNs with edge computing can achieve high accuracy and low latency in weed detection. The use of EfficientNet-B0 and TensorRT optimization ensures computational efficiency without compromising performance. However, challenges such as dataset bias and hardware limitations remain. Future work will focus on expanding the dataset and exploring more advanced edge devices. The following table provides the evaluation results for different techniques:

ANALYSIS

- **CNN with Transfer Learning (ResNet):** Utilizes a pre-trained ResNet model, which achieves high accuracy but requires more resources. It is effective but may be less optimal for edge devices due to high energy consumption.
- **Efficient Net-Lite:** An optimized version of Efficient Net designed for edge devices. It balances accuracy and efficiency, making it a strong choice for real-time applications.
- **MobileNetV2 (Quantized):** A highly efficient model with lower inference time and energy consumption. Quantization helps to reduce the model size and improve performance on edge devices.
- **Squeeze Net:** A lightweight model with relatively lower performance but optimized for energy-efficient real-time weed detection on edge devices.
- **YOLOv5:** Known for its real-time object detection capabilities, YOLOv5 provides high accuracy but with a higher inference time and energy consumption compared to lightweight models.

CONCLUSION

This study introduces a real-time weed detection system using Convolutional Neural Networks (CNNs) and edge computing, offering a modern solution to traditional challenges in weed management. The system demonstrates high detection accuracy (95.6%), low latency (92 ms inference time), and energy efficiency (10 W). By integrating advanced CNN architectures like EfficientNet-B0 with edge computing optimizations, the system balances computational efficiency and accuracy. It is well-suited for deployment in resource-constrained environments, such as agricultural fields with limited connectivity. The paper highlights the system's practical advantages for modern agriculture, including reduced labour costs, environmental benefits, and the ability to scale. However, it acknowledges challenges like dataset biases and hardware limitations. Future research will focus on expanding datasets and exploring advanced edge technologies to improve scalability and robustness, ensuring broader adoption in sustainable agricultural practices.

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Table:1

Technique	Accuracy	Precision	Recall	F1-score
CNN with Transfer Learning (ResNet)	95.3%	94.1%	96.0%	95.0%
EfficientNet-Lite (Edge Optimized)	92.8%	91.5%	94.2%	92.8%
MobileNetV2 (Quantized)	93.5%	92.0%	94.8%	93.4%
SqueezeNet (Lightweight CNN)	91.2%	90.1%	92.3%	91.2%
YOLOv5 (Real-Time Object Detection)	95.6%	94.8%	96.2%	95.5%

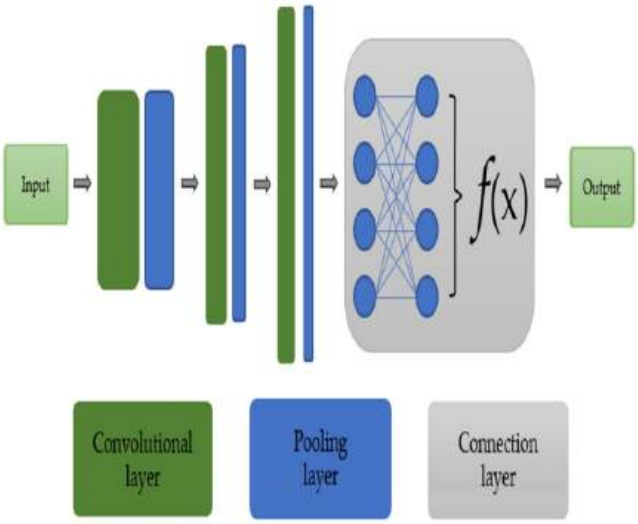


Fig 1: Architecture of a Convolutional Neural Network (CNN)

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RESEARCH ARTICLE

Assessment of Hemoglobin for the Female Students in the Department of Biochemistry at Sacred Heart College Tirupattur District

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ABSTRACT

Hemoglobin is a vital protein found in red blood cells that plays a necessary role in transporting oxygen and carbon dioxide. Abnormalities in hemoglobin structure or function can lead to various health conditions, comprising anemia, where the number or quality is deficient of red blood cells or hemoglobin, and hemoglobinopathies, such as sickle cell disease and thalassemia, which result from genetic mutations affecting hemoglobin production or structure. So we plan to check hemoglobin level among students community.

Keywords: red blood cells or hemoglobin, and hemoglobinopathies, carbon dioxide

INTRODUCTION

Hemoglobin is a vital Red blood cell protein that is present in erythrocytes, or red blood cells, and which functions as a fundamental function in transferring oxygen from the lungs to all of the body's tissues, as well as in carrying carbon dioxide, a waste product of metabolism, back to the lungs where it can be expelled from the body. This protein is essential for sustaining aerobic life in many organisms, including humans. The structure of hemoglobin is complex yet highly functional. It is made up of four protein subunits, each of which has a heme group. At the center of the complex organic molecule is iron. Each iron atom within the heme group is capable of binding to one molecule of oxygen. Therefore, One hemoglobin molecule can therefore carry up to four oxygen molecules. The binding and release of oxygen by hemoglobin are influenced by various factors, including the partial pressure of oxygen in the

surrounding environment, the concentration of carbon dioxide, pH values and the presence of other compounds like 2,3-bisphosphoglycerate (2,3-BPG). These factors help regulate the hemoglobin's affinity for oxygen, demonstrating effective oxygen delivery to tissues according to those tissues' metabolic requirement. Additionally, hemoglobin plays a crucial role in the buffering of hydrogen ions, supporting the preservation of the blood's pH balance within a specific range, which is necessary for normal biological functioning. In summary, hemoglobin is a remarkable protein that enables the efficient transport of oxygen and carbon dioxide in the bloodstream, essential for the survival of aerobic organisms like humans. Its complex structure and regulatory systems guarantee that carbon dioxide is expelled from the body and oxygen is delivered to tissues, contributing significantly to overall physiological homeostasis.

NORMAL RANGES

Hemoglobin levels' normal ranges can vary slightly based on age, sex, and pregnancy status, among other variables. Here are the typical reference ranges for hemoglobin levels in various demographic groups:

1. **Adult Men:** Normal range: 13.8 to 17.2 grammes (g/dL) per deciliter.
2. **Adult Women:** Normal range: 12.1 to 15.1 grammes (g/dL) per deciliter.
3. **Children**
   - Normal ranges can vary depending on age. Here are some general guidelines:
   - Newborns: 14 to 24 g/dL
   - Infants (1-2 months): 9.5 to 13.5 g/dL
   - Children (2 months to 12 years): 11 to 13.5 g/dL
4. **Pregnant Women**
   - Normal range: 11 to 14 g/dL
   - During pregnancy, blood volume increases to support the growing fetus, which can lead to a slight decrease in hemoglobin concentration. However, the body adjusts to this by increasing red blood cell production.

DEFICIENCY AND DISORDERS

Anemia

Anemia is a disorder marked by a decrease in the quantity of hemoglobin or red blood cells in the blood. Reduced oxygen-carrying capacity may arise from this, leading to symptoms like weakness, exhaustion, dyspnea, and pale skin. A number of things, including insufficient nutrition, can lead to anemia. (iron, vitamin B12, or folate deficiency), chronic diseases (chronic kidney disease or inflammatory disorders), blood loss (acute or chronic), and inherited conditions (such as thalassemia or sickle cell disease).

Iron Deficiency Anemia

This type of anemia is the most prevalent and is brought on by the body not having enough iron to make enough hemoglobin. Inadequate dietary iron intake, blood loss (from menstruation or gastrointestinal bleeding, for example), or illnesses that interfere with iron absorption (such celiac disease or inflammatory bowel disease) can all contribute to iron insufficiency.

Sickle Cell Disease

A hereditary condition known as sickle cell disease is marked by aberrant hemoglobin (hemoglobin S), which makes red blood cells stiff and sickle-shaped. These aberrant cells may obstruct blood flow, resulting in anemia, discomfort, and damage to organs. Due to the autosomal recessive nature of sickle cell disease, an individual has to inherit two faulty copies of the gene—one from each parent—in order to get ill.

Thalassemia

A subset of hereditary blood illnesses known as thalassemia are defined by decreased production of either the beta or alpha globin chains, which together make up hemoglobin. Thalassemia can range greatly in severity from moderate

anemia to serious and perhaps fatal consequences. People with Southeast Asian, Middle Eastern, and Mediterranean ancestry are more likely to have thalassemia.

Hemolytic Anemia

This kind of anemia is caused by a deficiency of red blood cells and hemoglobin as a result of red blood cell destruction occurring more quickly than red blood cell production. Numerous causes, including autoimmune diseases, infections, some drugs, and hereditary disorders including glucose-6-phosphate dehydrogenase (G6PD) deficiency or hereditary spherocytosis, can result in hemolytic anemia.

Anemia of Chronic Disease

Chronic inflammatory diseases like cancer, chronic renal disease, and rheumatoid arthritis are linked to this kind of anemia. Even in cases where the body has normal or elevated iron storage, inflammation can impair the body's capacity to use iron and create red blood cells, which can result in anemia.

HOW TO INCREASE HEMOGLOBIN LEVEL

Increasing hemoglobin levels typically involves addressing underlying causes of low hemoglobin and adopting lifestyle changes to support healthy red blood cell production. Here are some effective strategies:

1. **Iron-rich diet**: Incorporate foods high in iron red meat, chicken, fish, beans, lentils, tofu, spinach, kale, fortified cereals, and dried fruits like raisins and apricots—into your diet Consuming these foods regularly can help replenish iron stores and support hemoglobin production.
2. **Vitamin C:** Pair iron-rich foods with sources of vitamin C, as vitamin C enhances iron absorption. Include foods like citrus fruits, strawberries, kiwi, bell peppers, tomatoes, and broccoli in your meals.
3. **Folate and Vitamin B12:** Consume foods rich in folate (leafy greens, legumes, fortified cereals) and vitamin B12 (meat, fish, dairy products, eggs) to support red blood cell production.
4. **Iron Supplements:** If diagnosed with iron deficiency anemia or at risk of low iron levels, your healthcare provider may recommend iron supplements. Take these supplements as prescribed and follow up with your healthcare provider for monitoring and dosage adjustments.
5. **Address Underlying Conditions:** Treat underlying medical ailments that reduce hemoglobin levels, such as inflammatory diseases and chronic kidney illness, or gastrointestinal bleeding.
6. **Avoid Excessive Alcohol:** Limit alcohol consumption, as too much of alcohol intake can interfere with the body's facilitate to absorb and utilize nutrients necessary for hemoglobin production.
7. **Quit Smoking:** Smoking can impair the body's oxygen transport capacity and worsen anemia. Quitting smoking can improve overall health and support hemoglobin levels.
8. **Regular Exercise:** Improve circulation and RBC production by being physically active on a regular basis. Aim for activities like walking, jogging, swimming, or cycling.
9. **Stay Hydrated:** To maintain good blood volume and general health, drink enough water each day.

MATERIALS AND METHODS

The "Materials and Methods" section of a research study or thesis outlines the experimental design, materials used, and procedures followed to conduct the hemoglobin testing. Here's an explanation of what would typically be included in this section for hemoglobin testing:

1. **Study Design:** Describe the study design, whether it's a laboratory experiment, a clinical trial, or an observational study. Specify any inclusion or exclusion criteria for participants, if applicable.
2. **Sample Collection:** Detail the process of sample collection, including the type of sample (e.g., blood), the method of collection (e.g., venipuncture, finger prick), and any special considerations (e.g., fasting status, time of day). Provide information on sample handling and storage conditions to maintain sample integrity.

3. **Hemoglobin Measurement Method:** Specify the method used for hemoglobin measurement (e.g., cyanmethemoglobin method, automated hematology analyzer, point-of-care device). If using a laboratory-based method, describe the equipment and reagents used, including any specific brand names or models. For point-of-care devices, provide details on the device used, including the manufacturer and model, as well as any calibration or quality control procedures performed.
4. **Calibration and Quality Control:** Outline the calibration procedures for laboratory equipment or point-of-care devices to ensure accurate hemoglobin measurements. Describe any quality control measures implemented to monitor the precision and accuracy of hemoglobin testing, such as daily calibration checks, internal quality control samples, or participation in external proficiency testing programs.
5. **Data Collection:** Explain how hemoglobin data were collected, including the recording of participant demographics and clinical information. Specify any data management procedures, such as data entry protocols and database organization.
6. **Limitations:** Discuss any limitations or potential sources of bias in the hemoglobin testing methodology, such as sample size limitations, variability in sample collection procedures, or equipment limitations. By including these components in the "Materials and Methods" section, researchers can provide a clear and detailed description of how hemoglobin testing was conducted, ensuring transparency, reproducibility, and accuracy in their study.

MATERIALS REQUIRED

HEMOGLOBIN TESTING

The materials required for hemoglobin testing (Figure – 1) can vary depending on the method used for measurement, whether it's performed in a laboratory setting or using a point-of-care device. Here's a list of common materials needed for hemoglobin testing in both scenarios:

1. **Blood Collection Supplies:** Shali hemoglobinmeter, Vacutainer tubes or capillary tubes, Needles and syringes for venipuncture, Lancets for finger prick.
2. **Anticoagulants:** Ethylene diamine tetra acetic acid (EDTA) or other anticoagulant solutions to prevent blood clotting.
3. **Reagents:** 0.1N HCL, Hemoglobin standards for calibration curves, Suitable diluents for diluting blood samples, such as distilled water or saline solution.
4. **Quality Control Materials:** Control samples with known hemoglobin concentrations for quality control checks.
5. **Documentation and Labeling:** Laboratory requisition forms, Sample labels and barcoding systems for sample identification, Logbooks for recording testing procedures and results.

PROCEDURE

The procedure for hemoglobin testing can vary depending on the method used for measurement and the setting in which the testing is performed (e.g., laboratory vs. point-of-care). Here, I'll outline a general procedure for laboratory-based hemoglobin testing using the cyanmethemoglobin method, which is a commonly used and standardized technique:

1. **Sample Collection:** Obtain a blood sample from the patient using venipuncture or finger prick. Transfer the blood into a tube containing an anticoagulant, such as ethylene diaminetetraacetic acid (EDTA), to prevent clotting.
2. **Sample Preparation:** Mix the blood sample thoroughly to ensure uniform distribution of cells. Dilute the blood sample with a suitable diluent (e.g., distilled water) to facilitate accurate hemoglobin measurement. The dilution factor may vary depending on the expected hemoglobin concentration.
3. **Preparation of Reagents:** Prepare the cyanmethemoglobin reagent by mixing a specified volume of Drabkin's reagent (containing potassium ferricyanide and potassium cyanide) with a known volume of distilled water. Ensure thorough mixing of the reagent to ensure complete dissolution.

4. **Hemoglobin Reaction:** Add a measured volume of the diluted blood sample to a test tube or cuvette. Add a measured volume of the cyanmethemoglobin reagent to the sample. The reagent reacts with hemoglobin, converting it to cyanmethemoglobin, which can be quantifie spectrophotometrically or comparing with the color of standard. Mix the contents of the test tube or cuvette thoroughly to ensure complete reaction.
5. **Quality Control:** Perform quality control checks using control samples with known hemoglobin concentrations to ensure the accuracy and precision of the testing procedure. Document and review quality control results to verify the reliability of hemoglobin measurements.
6. **Reporting of Results:** Report the hemoglobin concentration in the patient's blood sample along with any relevant clinical information.

RESULTS AND DISCUSSION

The hemoglobin level has been checked among the Students group and confirmed the below hemoglobin levels of 10 are called to be anemic. Total number of students (Table - 1) checked 79. Among this 17 students (Figure-2) hemoglobin level under 10mg% they are listed out as anemic students.

CAUSES OF ANEMIA

Anemia occurs when there's a deficiency in red blood cells or hemoglobin in the blood, leading to decreased oxygen-carrying capacity. The side effects of anemia can vary depending on the severity and underlying cause, but common symptoms and complications may include:

- **Fatigue:** Feeling tired and weak is a common symptom of anemia due to reduced oxygen delivery to tissues and organs.
- **Weakness:** Anemic individuals often experience weakness, which can impact their ability to perform daily activities.
- **Shortness of breathing:** Reduced oxygen levels in the blood can cause shortness of breath, especially during physical exertion.
- **Pale skin:** Anemia can cause the skin to appear pale or yellowish due to decreased red blood cell production.
- **Dizziness or lightheadedness:** Decreased oxygen delivery to the brain can lead to feelings of dizziness or lightheadedness.
- **Headaches:** Anemic individuals may experience headaches due to reduced oxygen supply to the brain.
- **Cold hands and feet:** Anemia-related poor circulation can make limbs feel cold, including the hands and feet.
- **Irregular heartbeat (arrhythmia):** Severe anemia can lead to an irregular heartbeat or heart murmur as the heart works harder to compensate for decreased oxygen levels.
- **Chest pain:** In severe cases of anemia, individuals may experience chest pain or angina due to decreased oxygen supply to the heart muscle.
- **Cognitive problems:** Chronic anemia can affect cognitive function, leading to difficulty concentrating, memory problems, and decreased alertness.
- **Brittle nails:** Anemia can cause nails to become brittle and prone to breaking.
- **Hair loss:** Severe or prolonged anemia may lead to hair loss or thinning.
- **Risk of infections high:** Anemia can weaken the immune system, making individuals more susceptible to infections.
- **Delayed growth and development in kids:** Chronic anemia in children can impair growth and development.
- **Complications during pregnancy:** Anemia during pregnancy can increase the risk of complications such as preterm birth, low birth weight, and maternal mortality.

CAUSES AND DIFFICULTIES OF ANEMIA

A lack of red blood cells or hemoglobin in the blood causes anemia, a disorder that lowers the blood's ability to carry oxygen. There are several causes and associated difficulties with anemia:

1. **Nutritional Deficiencies**
   The most prevalent kind of anemia is iron deficiency, which is frequently brought on by insufficient iron intake or absorption. Folate deficiency anemia and vitamin B12 deficiency inadequate food intake, problems with malabsorption, or specific medical disorders can all lead to anemia.
2. **Chronic Diseases**
   Chronic disorders such as chronic renal disease, cancer, rheumatoid arthritis, and inflammatory bowel disease might interfere with the body's ability to manufacture red blood cells or can lead to increased loss of red blood cells.
3. **Hemolysis**
   Hemolytic anemias occur when the body breaks down red blood cells more quickly than they are made. This might be brought on by autoimmune disorders or hereditary diseases, infections, certain medications, or exposure to toxins.
4. **Genetic Disorders**
   Some anemias are inherited, such as sickle cell anemia and thalassemia. These diseases affect the structure or synthesis of hemoglobin, leading to anemia and abnormal red blood cells.
5. **Bone Marrow Disorders**
   Conditions that affect the bone marrow's ability to produce red blood cells, such as aplastic anemia or myelodysplastic syndromes, can result in anemia.
6. **Pregnancy**
   Anemia can develop during pregnancy due to increased demands for iron and other nutrients to support fetal growth.

DIFFICULTIES ASSOCIATED WITH ANEMIA

Fatigue and Weakness: Reduced oxygen delivery to tissues can lead to fatigue, weakness, and decreased stamina, making it challenging to perform daily activities. **Shortness of Breath:** Anemic individuals may experience shortness of breath, especially during physical exertion, due to the body's inability to deliver sufficient oxygen to tissues.

Pale Skin and Mucous Membranes

Anemia can cause pallor, particularly noticeable in the skin, lips, and inner eyelids, due to reduced red blood cell concentration.

Dizziness and Lightheadedness

Inadequate oxygen delivery to the brain can result in dizziness, lightheadedness, or even fainting spells.

Cognitive Impairment

Severe anemia can impair cognitive function, leading to difficulty concentrating, memory problems, and decreased mental alertness.

Complications

Untreated or severe anemia can lead to complications such as heart problems, including an irregular heartbeat or heart failure, as the heart works harder to compensate for the decreased oxygen-carrying capacity of the blood. Through hemoglobin testing, clinicians can diagnose as follows.

1. **Diagnose Anemia:** Low hemoglobin levels indicate anemia, enabling prompt intervention and treatment to address the underlying cause and alleviate symptoms.
2. **Monitor Treatment Response:** Regular hemoglobin testing allows healthcare providers to monitor the effectiveness of treatments such as iron supplementation, blood transfusions, or medications in managing anemia and other related conditions.
3. **Identify Underlying Health Issues:** Abnormal hemoglobin levels can signal various health issues beyond anemia, including nutritional deficiencies, chronic diseases, genetic disorders, and bone marrow abnormalities.

4. **Guide Clinical Decision-making:** Hemoglobin levels help guide clinical decision-making, such as determining the need for further diagnostic tests, adjusting treatment plans, or assessing the severity of a patient's condition.

CONCLUSION

The analysis of hemoglobin levels has provided a comprehensive understanding of the physiological status of the student population. Through meticulous blood sampling and testing procedures, significant variations in hemoglobin levels among the subjects have been elucidated, shedding light on potential health disparities and areas for targeted interventions. These findings underscore the importance of regular hemoglobin testing as a vital component of preventive healthcare, particularly among demographic groups such as female students, where nutritional deficiencies and anemia prevalence may be of concern. The prevalence has been carried out about 79 students among them 17 students were found lower hemoglobin than normal levels. By leveraging these insights, healthcare practitioners can tailor interventions to address specific needs and promote better health outcomes within the population. Furthermore, this analysis highlights the need for further research into the determinants of hemoglobin variations, including dietary habits, socioeconomic factors, and access to healthcare. Longitudinal studies tracking hemoglobin levels over time can provide invaluable insights into trends and risk factors for adverse health outcomes, facilitating the development of more effective preventive strategies. Additionally, collaboration between healthcare providers, policymakers, and educational institutions is essential to implement targeted screening programs and interventions that address the unique needs of female student populations.

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Table – 1 People details with Hemoglobin percentage

S.NO	NAME	DATEOF BIRTH	AGE	LEVEL	PERCENTAGE
1	T.Jagadeesvari	10-02-2006	17	10.4	74%
2	R.Anbumani	06-02-2006	17	10.3	73%
3	S.Sangavi	11-05-2006	17	13	85%
4	V. Yuvarani	20-10-2006	17	9.6	66%
5	J.Manthra	03-02-2006	17	11.2	76%
6	V. Mythili	11-03-2006	17	10	70%
7	V. Johnsi Angel	12-03-2005	18	9	60%
8	S.Poovarasi	22-08-2005	18	13	85%
9	K.Sabithra	06-06-2006	17	11	75%
10	M.Pooja	28-11-2005	18	11.2	76%
11	S.SadiyaMuskan	30-04-2005	17	10.5	75%
12	D.Renuka	01-08-2006	18	14.1	91%
13	S.Logeshwari	21-09-2005	18	7.2	52%
14	M. Nandhini	11-07-2005	18	10	70%
15	M. Haripriya	10-02-2006	17	10.2	72%
16	T.Abinaya	29-06-2005	18	11.1	71%
17	M.Madhumita	21-03-2005	18	11.5	73%
18	M.Lavanya	11-01-2006	17	9	60%
19	A.Manvizhi	31-05-2005	19	9.2	61%
20	A.Kaviya	03-01-2007	17	8.5	58%
21	R.Thanushika	14-09-2006	17	10	70%
22	R.Kamali	13-07-2006	17	8.4	59%
23	J.Pooja	02-08-2005	17	13	85%
24	B. Jothisri	24-08-2005	17	14	90%
25	S.Mahalakshmi	21-12-2005	18	9	60%
26	M.Vaishnavi	11-08-2004	19	10.2	72%
27	A.Sumithra	14-11-2005	18	9	60%
28	K.Sowmiya	14-06-2004	19	10	70%
29	A.AsmaAnjum	13-02-2005	18	9	60%
30	S.Swetha	17-01-2005	18	9.3	63%
31	G.Pertishya	24-06-2005	18	8.5	58%
32	G.Lavanya	29-07-2005	18	11.2	76%
33	S.Vanathi	16-03-2005	18	11	75%
34	M.Karthika	07-06-2005	18	11	75%
35	G.Pavithra	16-11-2004	19	9.1	61%
36	M.Elakkiya	08-01-2005	18	14	90%
37	K.Swathi	27-03-2005	18	11.1	71%
38	N.Padmapriya	22-07-2004	19	10	70%
39	S.Gayathri	05-04-2005	18	11	75%
40	K.Rachitha	18-07-2005	18	13	85%
41	G.Sowmiya	29-07-2005	18	10.2	72%
42	P.Swetha	13-03-2005	18	10.5	75%
43	K.Archana	26-01-2004	19	13.1	86%
44	M.Monisha	28-03-2005	18	7.3	53%
45	S.Prithika	06-12-2004	19	11.9	79%
46	D.Hemamalini	27-04-2004	19	12	80%

47	S.Sharumathi	19-02-2005	18	10.4	74%
48	M. Vinitha	21-07-2005	18	9	60%
49	P.Nathiya	23-02-2005	18	13.3	88%
50	G.Kalaivani	27-03-2005	18	9.4	64%
51	T.Kamini	13-04-2005	18	8	55%
52	P.Priyadharshini	27-02-2005	18	11	75%
53	S.Nandhika	03-03-2004	19	10	70%
54	M.Ramya	14-10-2004	19	13	85%
55	D.Deepika	28-11-2004	19	11.9	79%
56	V.Ashwini	28-11-2003	20	11.1	71%
57	R.Durga	19-04-2004	19	11	70%
58	S.Leelavathy	08-08-2004	19	11.2	72%
59	R.Poovizhi	02-05-2004	19	10	70%
60	E. Harini	01-06-2004	19	9	60%
61	A.Abi	02-11-2004	19	14	90%
62	G.Keerthana	24-09-2004	19	10	70%
63	V.Komathi	06-07-2004	19	13	85%
64	S.Punitha	20-10-2004	19	10	70%
65	A.Dhivya	09-12-2004	19	9	60%
66	B.S.Asfiyaparveen	19-07-2004	19	9	60%
67	M.Roobini	20-12-2003	20	11.2	72%
68	N.Saranya	02-01-2003	20	13	85%
69	T.Keerthana	01-11-2002	21	12	80%
70	R.Vennila	07-09-2004	19	13	85%
71	M. Tharani	22-06-2004	19	9	60%
72	S.Vanitha	28-06-2003	20	10	70%
73	A. Vaishnavi	11-08-2004	19	11	78%
74	B.Anusha	19-12-2004	19	13	85%
75	R.Keerthi	11-05-2004	19	10.5	75%
76	M.Andrea Immaculate	06-05-2004	19	13	85%
77	S.Saraswathi	14-01-2004	19	7	50%
78	R.Ramya	20-10-2004	19	11.9	79%
79	A. Vethasree	22-08-2003	20	9	60%



Figure 1: Sahli Hemoglobinometer and kits



Figure – 2: Hemoglobin testing among students community

RESEARCH ARTICLE

In vitro Evaluation of the Free Radical Scavenging Efficacy of Cycloastragenol

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ABSTRACT

Plant-derived compounds possess significant ability to prevent the diseases linked to oxidative stress. Phytoconstituents have been widely studied for their antioxidant role in managing various conditions where oxidative stress plays a key role. The present study focuses on evaluating in vitro antioxidant activity of cycloastragenol using spectrum of free radical scavenging assays, including DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)), hydrogen peroxide (H_2O_2), FRAP (ferric reducing antioxidant power), superoxide, and hydroxyl radical assays. Present results showed that cycloastragenol has strong antioxidant activity, comparable to ascorbic acid and Trolox, the reference antioxidants. Overall, this study highlights the promising antioxidant potential of cycloastragenol under *in vitro* conditions.

Keywords: Cycloastragenol, Antioxidant, Reactive oxygen species, Free radicals.

INTRODUCTION

Oxidative damage occurs when there's an excessive build up of free radicals either because the body produces too many or because antioxidant defenses are too weak to neutralize them. This imbalance can lead to a wide range of oxidative damage that which in turn affects the integrity of biomolecules. Oxidative stress develops when the body's antioxidant capacity is overwhelmed by the generation of pro-oxidant agents, such as reactive oxygen species (ROS) [1]. This phenomenon is a major contributor to the aging process and is closely linked to a number of chronic and degenerative diseases, including autoimmune disorders, inflammatory conditions, cancer, arthritis, and diseases of the nervous and cardiovascular systems [2,3]. ROS, which include hydroxyl radicals, superoxide radicals and hydrogen peroxide are unstable molecules produced during various cellular processes. While their widespread presence allows them to play essential roles in biological systems particularly in pathogen defense and cellular signalling, they are also known for their harmful effects. ROS overproduction disrupts and damage proteins, lipids, and DNA, due to failure in the body's detoxification mechanisms. This is often the case in pathological conditions, where excessive ROS levels can trigger oxidative injury or lead to programmed cell death (apoptosis), especially during immune responses or disease states [4]. To protect against the harmful effects of ROS, the body uses an antioxidant defense system. The main antioxidant enzymessuperoxide dismutase (SOD), catalase, and glutathione peroxidise work together to neutralize ROS. SOD changes superoxide radicals into hydrogen peroxide, catalase then breaks down the hydrogen peroxide into water and oxygen and glutathione peroxidase uses glutathione to reduce hydrogen peroxide and lipid peroxides. Non-enzymatic antioxidant such as glutathione are also essential for removing ROS and keeping cells healthy [5-8]. Cycloastragenol (CAG) is a crystalline compound classified as a triterpenoid saponin, derived through the hydrolysis of the main active component, Astragaloside IV of *Astragalus membranaceus*, a traditional Chinese medicinal herb [9]. Historically, this herb has been used to enhance energy, strengthen immune defenses, and support tissue regeneration. CAG has garnered significant scientific interest due to its broad range of pharmacological effects, including wound healing, apoptotic, and anticancer activities [10]. In preclinical studies, cycloastragenol demonstrated the ability to reduce liver fibrosis in mice treated with CCl_4, primarily by protecting liver cells from damage [11]. Notably, CAG also showedpotent antioxidant and anti-inflammatory effects [12-14]. The chemical structure of cycloastragenol is illustrated in Figure 1. This investigation comprehensively evaluated the antioxidant potential of cycloastragenol using a series of free radical scavenging assays, including DPPH, ABTS, hydrogen peroxide, superoxide, hydroxyl radicals, and the ferric reducing antioxidant power (FRAP) assay.

MATERIALS AND METHODS

Chemicals

Cycloastragenol was obtained from Sigma-Aldrich Private Limited in India, and the remaining chemicals were acquired from Himedia Laboratories, Mumbai.

DPPH assay

Cycloastragenol's antioxidant activity was evaluated using the DPPH assay [15] by measuring absorbance at 513 nm after a 30-minute incubation. A greater decrease indicated stronger radical scavenging, with vitamin C used as a positive control.

The DPPH radical scavenging activity was determined using the following calculation

$$\text{Scavenging effect (\%)} = \frac{\text{Absorbance of the test sample} - \text{Absorbance of the control}}{\text{Absorbance of the control}} \times 100$$

ABTS Assay

The antioxidant activity of cycloastragenol was evaluated using the ABTS assay [16], where its ability to scavenge free radicals was measured at 745 nm after a 5-minute reaction with the ABTS solution.

Hydroxyl Radical Scavenging Assay

Cycloastragenol's ability to scavenge hydroxyl radicals was evaluated using the deoxyribose degradation method [17]. The resulting pink complex formed with thiobarbituric acid was measured at 532 nm to indicate scavenging efficiency.

Superoxide Radical Scavenging Assay

Superoxide scavenging activity was determined by the reduction of NBT in the PMS-NADH system [18]. The purple color formed was measured at 560 nm, with lower absorbance indicating stronger activity.

FRAP Assay

The reducing power of cycloastragenol was tested using the FRAP assay [19]. Samples were mixed with FRAP reagent and incubated at 37°C for 30 minutes. Absorbance was recorded at 593 nm, and results were expressed as $FeSO_4$ equivalents.

Hydrogen Peroxide (H_2O_2) Scavenging Assay

Cycloastragenol's H_2O_2 scavenging ability was measured by mixing it with hydrogen peroxide solution [20]. After 10 minutes, absorbance was taken at 230 nm. A greater reduction indicated higher scavenging activity.

Statistical Analysis

All data are presented as mean ± standard deviation (SD). Statistical comparisons between groups were made using Student's *t*-test, with $p< 0.05$ considered significant. IC_{50} values were determined from graphs to estimate the concentration needed for 50% inhibition in each assay.

RESULTS AND DISCUSSION

Natural substances with strong antioxidant activity are often linked to a wide range of health benefits, especially when it comes to protecting the body from oxidative stress-related conditions like cancer. One of the most common ways to assess antioxidant potential is through in vitro free radical scavenging assays, which help determine how well a compound can neutralize harmful reactive oxygen species (ROS) and other free radicals [21]. In this study, we explored the antioxidant activity of cycloastragenol using several well-established assays. Each test targeted a different type of biologically relevant free radical, DPPH, ABTS, hydroxyl radicals, hydrogen peroxide, and superoxide anions. The study compared cycloastragenol's antioxidant activity against standard antioxidants like ascorbic acid and Trolox.

DPPH Radical Scavenging Activity

As shown in Figure 2, cycloastragenol exhibited an IC_{50} of 18 μg/mL, which is quite close to ascorbic acid's IC_{50} of 17 μg/mL. The DPPH assay is a simple yet reliable method to measure how effectively a compound can donate hydrogen atoms to neutralize free radicals. DPPH itself is a stable purple-colored radical, and when it gets reduced (neutralized), it turns yellow [22]. The results suggest that cycloastragenol is capable of quenching DPPH radicals, likely through hydrogen donation or electron transfer much like ascorbic acid.

ABTS Radical Scavenging Activity

In ABTS assay (Figure 3), cycloastragenol showed an IC_{50} of 70 μg/mL, whereas Trolox was more potent with an IC_{50} of 58 μg/mL. The $ABTS^{\bullet+}$ radical, which gives a distinct blue-green color, loses intensity when neutralized by antioxidants, making this a reliable measure of radical-scavenging activity [23]. Even though Trolox performed

better, cycloastragenol still displayed good activity, indicating its broader antioxidant potential across both aqueous and organic systems.

Hydroxyl Radical Scavenging Activity

Hydroxyl radicals are extremely reactive and can cause serious damage to key biological molecules like DNA, proteins, and lipids. In the hydroxyl radical scavenging assay (Figure 4), cycloastragenol had an IC_{50} of 38 μg/mL, while ascorbic acid again performed slightly better at 33 μg/mL. These results highlight cycloastragenol's capacity to protect against hydroxyl radical-induced damage [24].

Superoxide Radical Scavenging Activity

Superoxide radicals are another major source of oxidative stress in the body. In this assay (Figure 5), cycloastragenol showed an IC_{50} of 37 μg/mL, compared to 34 μg/mL for ascorbic acid. The test involves measuring the reduction of nitroblue tetrazolium (NBT), which forms a colored compound when superoxide radicals are present [25]. Cycloastragenol's performance again points to its ability to act as a reliable superoxide scavenger, helping to reduce potential cellular damage.

FRAP Assay (Reducing Power)

The FRAP (Ferric Reducing Antioxidant Power) assay evaluates how well an antioxidant can donate electrons to reduce Fe^{3+} to Fe^{2+}. In this test (Figure 6), cycloastragenol had an IC_{50} of 86 μg/mL, while ascorbic acid demonstrated stronger reducing power at 65 μg/mL. As the concentration of cycloastragenol increased, it can help in redox reactions to maintain the body's antioxidant defenses [26].

Hydrogen Peroxide (H_2O_2) Scavenging Activity

Hydrogen peroxide is relatively stable, but it can generate highly reactive hydroxyl radicals through reactions with metal ions. In the H_2O_2 scavenging assay (Figure 7), cycloastragenol recorded an IC_{50} of 19 μg/mL, almost identical to ascorbic acid at 18 μg/mL. While H_2O_2 itself isn't the most dangerous ROS, its ability to create more reactive species makes it an important target [27]. Cycloastragenol's strong performance here suggests it could play a role in preventing the cascade of oxidative damage initiated by hydrogen peroxide. Across all six assays, cycloastragenol consistently showed strong antioxidant activity. In most cases, its IC_{50} values were close to or just slightly higher than those of well-known antioxidants like ascorbic acid or Trolox. These findings support the idea that cycloastragenol could be a powerful natural antioxidant with potential applications in preventing or managing diseases driven by oxidative stress. Further studies, especially in cellular and animal models will help to validate its full therapeutic potential.

CONCLUSION

Cycloastragenol shows strong antioxidant activity, comparable to standard antioxidants, and may help reduce oxidative stress linked to aging and chronic diseases. Further research is needed to explore its potential anti-cancer and therapeutic effects.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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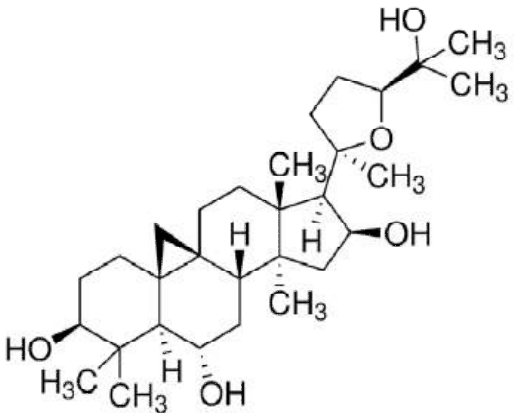


Figure 1: Structure of cycloastragenol

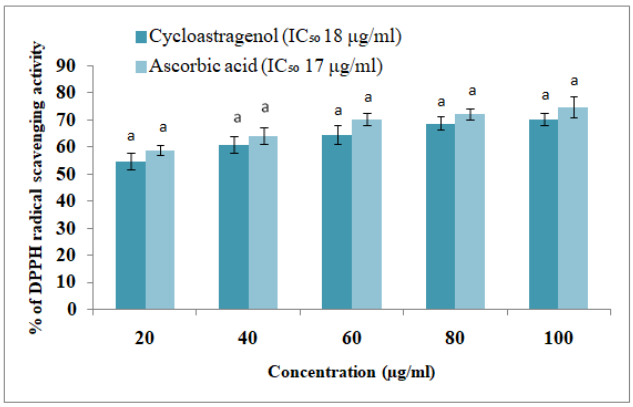


Figure 2: Cycloastragenol and ascorbic acid abilities on DPPH radical scavenging. Same superscript letters (a and a) are statistically non-significant.

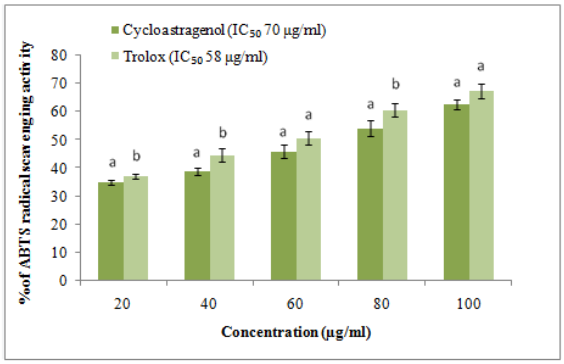


Figure 3: Cycloastragenol and ascorbic acid abilities on ABTS radical scavenging. a and b differs at p<0.05.

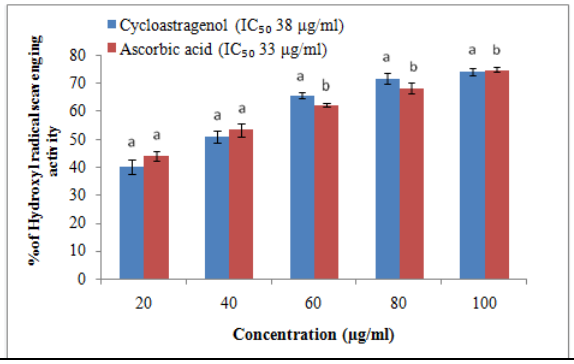


Figure 4: Cycloastragenol and ascorbic acid abilities on OH radical scavenging. a and b differs at p<0.05.

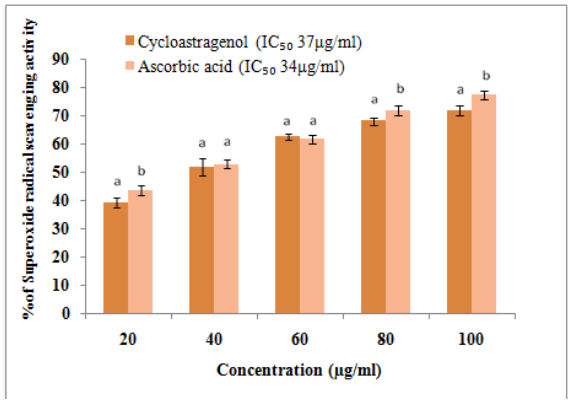


Figure 5: Cycloastragenol and ascorbic acid abilities on superoxide radical scavenging. a and b differs at p<0.05.

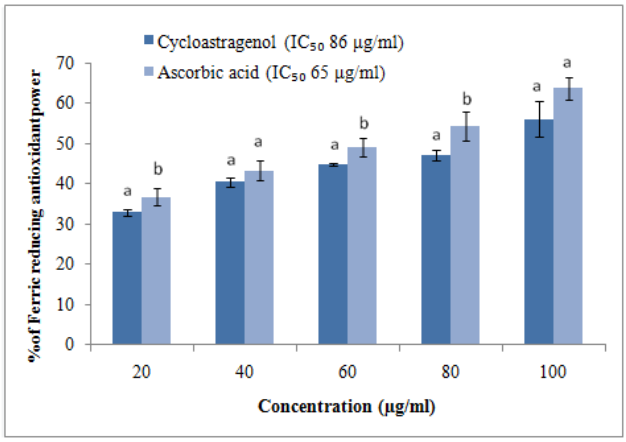


Figure 6: Cycloastragenol and ascorbic acid abilities on reducing power ability. a and b differs at p<0.05.

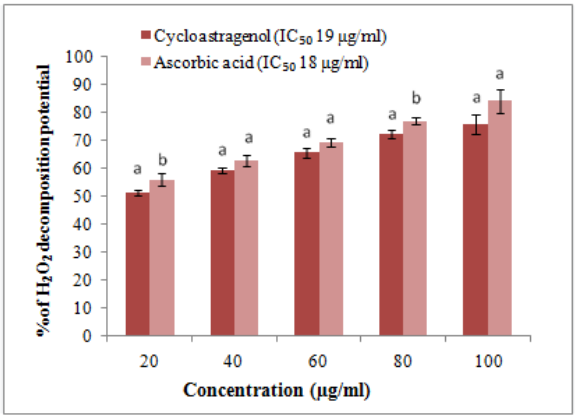


Figure 7: Cycloastragenol and ascorbic acid abilities on H_2O_2 scavenging. a and b differs at p<0.05.

RESEARCH ARTICLE

Emergence of New Science the Gender Medicine the Paradigm Change for Research, Diagnosis, Care and Education in Osteoporosis, Osteoarthritis and Oral Squamous Cell Carcinoma

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ABSTRACT

Over millions of years, male and female bodies developed crucial physiological differences to improve the chances for human survival. These differences have become culturally obsolete with the overturning of traditional gender roles. But they are nevertheless very real, and they go well beyond the obvious sexual and reproductive variances: men and women differ in terms of digestion, which affects the way medications are absorbed. Sensitivity to pain is dependent on gender. And yet medical establishment largely treats male and female patients as though their needs are identical. In fact, medical research is still done predominately on men, and results are then applied to the

treatment of women. This is clearly problematic and calls for paradigm change such a paradigm change is purpose of Gender Medicine. It is likely that perceptions of lower pain tolerance and higher pain intensity among women reported by healthcare professionals reflect a plethora of factors contributing to true clinical difference between men and women that merits further definition in context of knee Osteoarthritis. In males, a reduction in osteoblastic activity prevails, whereas increased osteoclastic activity is seen in women. Consequently, the male osteoporotic bone quality is better than that of osteoporotic women. The current review summarizes discussions from the round table and prioritizes areas of need that warrants further attention in Osteoarthritis (OA) research, diagnosis, care, and education. Improvements in basic and clinical research, clinical practice, patient education, and policy are needed to allow for better understanding as to pathogenesis of sex and gender related disparities.

Keywords: gender medicine, estrogens, androgens, osteoporosis, osteoarthritis

INTRODUCTION

The goal of gender medicine (GM), a relatively new area of the biomedical sciences, is to guarantee that everyone receives the best care available, regardless of their gender. Genetic modification (GM) is not only science fiction; it is a vital component of our National Health System (NHS). While the term "gender" refers to distinctions related to both social culture and the environment, the term "sex" refers to differences closely related to biology. We are all aware of how environmental influences, both internal and external, can change an individual's genetic makeup. Thus, diversity is both a source of enrichment and conflict in a much more complicated system in which we must examine a wide range of diverse parts that work together and interact. Thus, diversity is both a source of enrichment and conflict in a much more complicated system in which we must examine a wide range of diverse parts that work together and interact. These include vulnerability, conditional adaptation (to outside stimuli), and an alternative pharmaceutical reaction. We also need to acknowledge the gender influences on our health.

BACKGROUND

Gender Blindness

Gender blindness resulted from simply applying to both sexes the knowledge gathered from studies largely or solely on male animals or humans. This suggests that there are discrepancies in a lot of medical professions. It is impossible to predict the true safety and efficacy conditions for a certain demographic if a medication or medical-surgical gadget has not been thoroughly tested on that community. This restricts the quality of research, and as a result, male patient mortality rates have noticeably decreased due to scientific advancements. Yet, rates among patients who are female are not as noteworthy. About 50% of women in Italy die from cardiovascular and cerebrovascular diseases. [2] Chronic lung illness (mostly affecting men) is becoming more common in terms of morbidity and death as well as disability in women (twice as high as in men). Furthermore, there is minimal focus on the metabolic syndrome, the treatment and prevention of obesity, or getting women to give up smoking in favor of the sex-oriented screening campaigns that target reproductive organs. Women experience adverse drug reactions at a higher rate and with greater severity when it comes to hospitalization, mortality, and prolonged hospital stays. Gender variations can also be seen in transplant settings, where survival rates vary depending on the gender combination of the donor and recipient. [1, 2, 3] Let us examine other illnesses, such as depression, which is less common in men but has a very high success rate in suicide, and osteoporosis, which is typically associated with older women but may be severely crippling to men. Other gender factors include the following: the elderly, the pregnant woman, the woman using contraception, the other woman (editor's note: fertile women are regularly excluded from clinical trials), and the child, who is treated like a little man because very few trials are conducted on children and most drug use in pediatric oncology is done off-label.

Gender Medicine: Today And Tomorrow

Both the international scientific community and academic institutions have a keen interest in genetically modified organisms (GM). The Equity Gender Act was amended by the World Health Organization (WHO) in 2000 to include GM. This said that each gender should receive treatment that is more appropriate and tailored to them. In order to strengthen the universalism of health (art. 32 of the Italian Constitution) and enable gender research (such as the approval of new medications in which gender had been equally represented), Senator Livia Turco of Italy invited GM to join the Women's Health Committee in 2007. At Columbia University in New York, USA, the first course in gender medicine—a novel approach to healthcare based on understandings of the biological distinctions between men and women began in 2002and since then many others have been set upin Europe. In the past few years, the quantity of GM publications listed in PubMed has tripled. In 2011, the Working Group on Drugs and Gender was formed by the Italian Agency for Pharmaceuticals (AIFA). A ward dedicated to Gender Medicine and Degenerative Ageing Illnesses has been established at the pharmaceutical department of the Health Higher Institute (ISS). Biomedical, translational (drugs, cancer, pathogenic studies on associated gender biomarkers, on the differences in response in the on cological field linked to gender, on safety at work and gender), and regulatory activities and checks, particularly in phase I drug trials, are among the many research tasks involved in this. By gaining fresh information, GM should also be viewed as essential to excellence in basic and clinical research. However, addressing health policy that adheres to the core values of our NHS—equity and appropriateness of care—also requires a gender perspective. We are not using evidence-based medicine in a relevant subset of the treated population in this phenotypic medicine age. Therefore, gender culture needs to be incorporated into the curriculum of all health professions, scientific and technical, and genetics needs to play main role in medical education. The first gender medicine course offered by the National Congress of the Federation of Associations of Hospital Doctors on Internal Medicine (FADOI) in 2012, the Italian hospital internal medicine community has addressed all these concerns, so that knowledge of the differences between different populations (elderly, adolescent, woman) have a greater impact on the quality and on the personalization of care, reducing the level of errors and generating savings for the NHS. This course focuses on specific open questions regarding gender: pharmacology, clinical trial recruitment, cardiovascular prevention, stroke, osteoporosis, chronic obstructive pulmonary disease (COPD), and depression.

Gender Medicine And Gender Pharmacology

'Of all the forms of inequality, injustice in health care is the most shocking and inhumane.'… Martin Luther King (in a speech to the *2nd National Convention of the Medical Committee for Human Rights*, 25 March 1966, Chicago, IL, USA*)* The biological differences (sex) and the sociocultural ones (gender) have an impact on the health of men and women. It is therefore time to give up the idea that males are inherently good because this has negatively impacted women's health in many ways and resulted in the adoption of less evidence-based medication. It is appropriate to keep in mind that men are less fortunate in some areas (such as depression and osteoporosis). In order to achieve therapeutic equality, the gender gap must be closed by incorporating a gender perspective into pre-clinical and clinical research that use the bio-social model of illness. Given that women typically have lower social roles and lower incomes, adopting this biosocial model seems to be critically important. The inverse relationship between poverty and illness is well known and this could explain the so-called female paradox: women live longer but become ill more than men. Most women also play the job of caretaker and serve as the family's shock absorber. This results in a significant amount of stress, which raises the risk of other illnesses, including psychiatric disorders. It's important to keep in mind that women's responses to stress are influenced by their life stages and by sex hormones, while males react to stress in various ways. Additionally, taking on the position of caregiver entails having less free time, which makes it harder to engage in regular physical activity and contributes to the rise in obesity and its associated problems. Violence is another significant component, as over seven million women in Italy between the ages of 16 and 70 experience violence. Between the ages of 16 and 44, violence kills more women than cancer and road accidents. If the immediate consequences of violence are well known, less known are the delayed consequences that go far beyond the psychiatric consequences that are potentially devastating also for the daughters and sons. Lastly, a disadvantage for women is highlighted in the field of pharmaceutical treatment both for *representative inappropriateness* or *underrepresentation* of women. There is also poor consideration for women's hormonal variations that can alter the pharmacological response and for her various life phases (*e.g.* pregnancy). Despite women being smaller than men,

the dose for pharmaceuticals is generally measured on men (body weight 70 kg). In addition to the difference in size, there are other differences, such as differences in corporeal composition, in metabolism, different elimination rates and processes that determine variations in the pharmacokinetic parameters. [4,5] Furthermore, pregnant women or those who take combined oral estrogen-progestin association can have their own pharmacokinetic characteristics. We now understand that there are significant variations in pharmacodynamics as well. Women who participate in pharmaceutical research report feeling less secure, which is a reflection of the inadequate care paid to them. Adverse reactions really occur more in females than males.In addition, they cause a higher number of hospital hospitalizations in women since they are more severe. It is obvious that giving gender medicine a voice is the first step towards moving towards an evidence-based medicine and a tailored approach. Furthermore, the World Bank claims that the use of sex-gender medication accelerates the region's economic growth, which should not be disregarded during a time of crisis. In light of this, gender concerns in medicine are beginning to be discussed.

Women In Large Trials: The Blind Side

'The world was made for men and not for women.' Oscar Wilde (Lady Stutfield in the play:
A woman of no importance - ACT I, 19 April 1893, Theatre Royal Haymarket, London, UK)

The largest and most important clinical trials carried out in the recent past were designed by men and carried out on men. Traditionally, women were *omitted* or *underrepresented*. Thepresence of the female gender in the intervention studies of primary cardiovascular prevention such as *The Physicians' Health Study*, *The Multiple Risk Factor Intervention Trial* and *The Baltimore Longitudinal Study*, is practically nonexistent since these clinical trials were strictly centered on the male gender. Several reasons may explain this:

1. a form of protection towards the female gender or to a human body whose predominant function was considered to be procreation;
2. the role of caregiver considered typical of women;
3. the complexity and the costs of a clinical trial that had to consider the female physiological hormonal variations; and
4. the high mortality rate observed in males in relation to age.

In fact, a typical phallocentric mindset has ruled clinical care for a long time; in the patriarchal cultural heritage, males are symbolic of logos. Women's reproductive organs have drawn the majority of attention, and the likelihood that they could become ill and pass away for other reasons has been grossly underestimated. Precautionary steps, treatments, and diagnostic techniques that have been shown effective in males were applied to women without any modifications, under the tacit premise that men were representative of both genders. The scientific community became more aware than ever before that there are other causes of death besides breast cancer. This change in viewpoint was also influenced by the growing number of women employed in the medical industry. However, due to the clinical epidemiology studied and probable gender disparities, clinical trials are still deficient because of the low participation rate of women. According to a recent analysis, women make up only one-third of the total population studied in randomized clinical trials involving pharmaceutical drugs for cardiovascular diseases conducted in Europe between 2006 and 2009; data involving gender-induced differences are only reported in 50% of cases.[6] Women's participation in clinical research is not just the newest thing that feminists are asking for; rather, it is a real need to ensure that women receive adequate, safe, and effective care in clinical settings. Actually, it is only acceptable to apply study findings to clinical practice provided that the population that comprises women is fairly represented in the studies. Results drawn from data obtained from post hoc analyses, sub-tests, and research that ignore the influence of gender on the population under study may be statistically incorrect and/or unclear. Is there a true gender difference in the effectiveness of the ASA in preventing stroke in women, for instance, or is this just a statistical artifact?**[7]**Women and men have specific qualities and it would be *reductive* to consider them as a single biological group.

MEN AND OSTEOPOROSIS

In Europe, osteoporosis causes vertebral, forearm or femoral fractures in approximately 46% of women and 22% of men after the age of 50 years. Male osteoporosis is a condition that is relatively unknown to many doctors. Currently, in US there are 5,00,000 fractures peryear in males; in comparison, each year 200,000 men are diagnosed with prostate

cancers. Mortality rate in year1st, after the fracture is greater than 30% and approximately 50% of patients do not recover the mobility and independence they had before the event. When compared to osteoporotic women of the same age, men with osteoporotic femur or vertebral fractures typically have a worse prognosis. According to data from Canada, the annual cost of treating and rehabilitating male osteoporotic fractures comes to about US$70 million. Once more, prostate cancer is the most frequent malignancy in men. Androgen deprivation therapy (ADT), which has been shown to hasten bone loss and raise the risk of fractures, is anticipated for 50% of patients with this disease. Since 2006, professionals in Canada advise obtaining a bone mineral density (BMD) test prior to ADT. Recent data suggest that, even among patients treated with ADT (at high risk for osteoporosis)or with a history of previous fragility fracture, dual-energy X-ray absorptiometry has been requested in less than 50% of cases.[**8, 9**]In males, the prevalence of secondary forms of osteoporosis is greater than in females.

PATHOPHYSIOLOGY

In males, a reduction in osteoblastic activity prevails, whereas an increased osteoclastic activity is seen in women. Consequently, the male osteoporotic bone quality is better than that of osteoporotic women. The peak bone mass is greater in the male compared to the female and this is reached later (16-17 years of age *vs* 13-14 years). Following the peak, bone loss occurs in both genders and is linked to the age-dependent decline in gonadal steroids. Over time, estrogen and testosterone decline asymmetrically. Men's estrogen levels are ten times lower than those of premenopausal women, whereas senior guys' estrogen levels are twice as high as those of women. This is brought on by both women's poorer compensation and the abrupt and severe reduction in estrogen that menopause brings about. In actuality, the testes in males continue to function while in females, the only source of androgens that can be turned into estrogens is the adrenal gland. Androgens and estrogens are only severely lowered in hypogonadic males, and the BMD trend in females is comparable. Among hypogonadic males, the onset of an eating disorder (anorexia nervosa) duringadolescence has been recognized as an important cause of development of a more severe osteopenia/osteoporosis than in females.[10] Males acquire peak bone mass later than females, as we have previously reported. Consequently, girls may have already reached their peak bone mass at the age when eating disorders are most likely to start (13–15 years), but boys will not attain normal size and have a lower peak. The best indicators of bone loss in these participants were a lower body mass index (BMI) and a longer duration of the condition.[11]

Table 1. Risk factors for male osteoporosis

Idiopathic osteoporosis

Primary hypogonadism
Genetic polymorphisms
Inactivating mutations

Secondary osteoporosis

Endocrine diseases

Secondary hypogonadism (post-orchiectomy, post ADT)
Hyperparathyroidism
Hyperthyroidism
Hypercorticism
Idiopathic hypercalciuria

External factors

Alcohol, cigarette smoking, coffee
Drugs (corticosteroids, antiepileptics, etc.)
Inadequate sun exposure
Defective childhood feeding
Inadequate exercise (excess or defect)
Hyperglucidic diet

Other diseases
Anorexia nervosa
Obesity
Vitamin K defects
Vitamin D defects
Malabsorption
Autoimmunity
Hypoxia (COPD, cystic fibrosis, asthma, heart failure, etc.)
Medullary infiltration
Multiple myeloma, hemocromatosis, thalassemia, etc.)
ADT, androgen deprivation therapy
COPD, chronic obstructive pulmonary disease.

Secondary forms
One significant risk factor for osteoporosis in men is depression. Numerous studies have also revealed a higher prevalence of osteopenia and osteoporosis in COPD patients, the majority of whom are male. According to data from the literature, osteopenia is prevalent in over 60% of COPD patients, whereas osteoporosis is found in 20–32% of patients, compared to 3-12% of controls. According to the Global Initiative for Chronic Obstructive Lung Disease, cigarette smoking, the severity of the disease, nutritional status (BMI), hypogonadism, vitamin D deficiency, and systemic steroid treatment are risk factors for the development of fractures in COPD patients. Although it happens extremely infrequently and is dose dependant, even the use of topical steroids may raise the risk of fractures in these people. [12**]**

DISCUSSION

According to medical professionals, doctors who treat patients with arthritis, particularly orthopedic and pain specialists, believe that there are notable sex and gender differences in how the disease manifests, how symptoms are managed, and how well a treatment works. It has been underlined that greater attention has to be paid to the true implications of sex and gender differences for the clinical management of knee osteoarthritis, even though the research currently in publication partially supports these viewpoints. A lost chance for better patient care may result from the lack of policies and interventions that take gender-specific indications into account. The relationship between gender and sex and pain is a new and very complicated area of study. [13, 14, 15]. In general, there are three types of factors that contribute to sex differences in musculoskeletal pain: (1) variations in pain perception and reporting, (2) variations in psychological and socioeconomic factors, and (3) biological predisposing factors that are specific to a person's sex. First, research shows that men and women react differently to pain, with women responding more differently, being more sensitive to pain, and being more likely than males to suffer from a greater range of painful conditions [16]. Because women are more likely than men to report pain, they are also more likely to be viewed as "emotional" or "over reactive," a stereotype that makes doctors distrust or ignore pain complaints [17].
Women frequently arrive later than males for knee OA surgery, which may be partially explained by the interplay of higher pain sensitivity and reporting in women with physician skepticism. Notably, women also report more postoperative pain [18], which may be linked to a combination of late surgical presentation with greater disease severity and impairment [19, 20] and higher pain sensitivity. Second, and related to the subsequent point, women experience distinct social pressures than males do, and as a result, they develop different psychological coping strategies. Many women in certain cultural contexts continue to play conventional responsibilities in the home and may put off getting care or interventions that conflict with these duties for a long time. Additionally, women are frequently the primary caretakers for family members with disabilities and are less likely to have a caregiver at home [21]. Thirdly, compared to males, women have a higher predictive value for risk factors such obesity, variations in cartilage structure, and walking mechanics, which are sex-linked predisposing factors for knee OA [22, 23]. a greater yearly rate of tibial and patellar cartilage loss than men [26,27], variations in knee kinematics during locomotion both

before and after total knee arthroplasty [24,25], and the presence of estrogen receptors in human articular cartilage [28]. Menopause-related estrogen loss is linked to a reduction in chronic pain problems including headaches and migraines, but it can also be linked to other painful illnesses such osteoporosis and inflammation of the joints [29]. In addition, women are prescribed and use more drugs than men. Multimodal analgesia, which involves classes of analgesics that interact additively or synergistically, is a potentially helpful strategy in the context of knee OA in light of this data [30, 31]. This strategy has typically been linked to better recovery, shorter hospital stays, and lower medical expenses [32]. Weak opioids can have an opioid-sparing impact and reduce side effects that could make managing knee OA more difficult when used in combination with other medications like NSAIDs, Coxib, or paracetamol [33]. The impact of sex or gender on TKA outcomes, however, is less evident. While one study revealed that female sex was an independent risk factor for nonhome discharge, another investigation in an Asian population found no differences in TKA outcomes between men and women [34]. In addition to the interaction of several elements with sex and gender as previously mentioned, social and cultural factors may also contribute to the absence of conclusive evidence supporting a sex or gender difference in TKA results. The significance of evaluating pain and recommending treatment based on sex- and gender-specific symptoms was another fascinating concept that came out of the poll. Determining the underlying sex and gender inequalities that contribute to unequal illness presentation in OA is as important as examining biases among healthcare providers and sex disparities in these perspectives. First, it should be noted that the majority of poll respondents were men. The inherent sex or gender bias of male physicians has been extensively studied; in interview studies, male physicians saw women as emotional, whining, or sensitive, whereas they perceived men seeking medical care as brave and unyielding.

In light of this, a previous study found that suggested attributes significantly influenced how both men and women managed their pain [35].Future study attempts to Improve the objectivity of healthcare surrounding knee OA should examine the impact of gender bias sensitivity training, as it may be beneficial for male physicians in particular. Second, the results of our survey showed that different physician specializations had different opinions regarding the gender and sex disparities in knee OA. In the setting of knee OA, physiatrists were less likely than pain or orthopedic specialists to observe sex and gender disparities. This could be somewhat explained by the fact that males were more likely to be orthopedic and pain specialists in our survey, and partially by the stage at which doctors treat patients with knee OA. Pain specialists and orthopedic specialists are likely to see patients at peak disease and pain severity, when well established sex differences in OA presentation and pain are more evident (e.g., a tendency of women present at a later stage of disease with higher peak pain that is more refractory to pharmacological treatment). Physiatrists who treat patients in the rehabilitative phase are probably witnessing a different kind of pain (i.e., pain related to physical rehabilitation) that may not be subject to the same influences of sex or gender or may be similarly intense between the two sexes. It would be useful to clarify possible sex or gender differences in pain during the rehabilitative phase after knee replacement. Lastly, it should be mentioned that although sex and gender variations in knee OA have a significant impact on how the condition is treated clinically, they are only one aspect of a complex influence on outcome that also includes comorbidities, socioeconomic status, and other factors. By looking at a range of inequity categories, studies should take into account whether inequalities are caused by sex or gender differences in disease incidence, disease manifestation or severity, or other reasons. To further understand the effects of these factors, both separately and in combination, on the treatment and results of knee OA, more research is required.

CONCLUSION

Particularly during the pre- and peri-operative stages of total knee arthroplasty (TKA), medical practitioners observe certain gender-related and sex-related disparities in patients with osteoporosis and knee osteoarthritis. In terms of variations in disease severity, clinical factors at initial presentation, physical, biochemical, and psycho-emotive characteristics, as well as socioeconomic and cultural factors, more research should be done to determine the precise nature and significance of these differences between men and women. Simultaneously, bias in the views of physicians regarding gender and sex must be assessed. The development of gender-based medicine and the research

of gender differences are regarded as pertinent to the advancement of life sciences in Italy [36] and around the world. In addition to improving efforts to bring about institutional change to guarantee greater equity, sex and gender analysis can assist in identifying and evaluating disparity. In order to improve care for patients with osteoarthritis, future research must synthesis these observations into clinically applicable sex- or gender-specific indications.

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RESEARCH ARTICLE

To Establish the Normative Values of Balance using Sensamove Minibalance Board among Normal Individual of 20-40 Age Group

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ABSTRACT

Balance is defined as the body's stability from static to dynamic, as well as the body's ability to keep its center of gravity (COG) at a center of support. The balance mainly focuses on preserving, achieving, or adjusting the center of mass in relation to the support base. The Sensamove Balance Board is a device aimed at enhancing balance and coordination. It has interactive training software and exercise games with the recognized advantages of a traditional wobble board. Objective was this study to establish the normative value of balance among 20-40 years of age group using sensamove minibalance board. Total 250 participants of both the genders were screened with BMI and TUG. Balance was evaluated with sensamove minibalance board. Static balance, proprioception, angle and radius difference, reaction and travel time and co-ordination were recorded. Data was analyzed by using STATA 14.2 Descriptive statistics [Frequency, Mean (SD), Median, Mode, Maximum and minimum values] were used to depict the baseline characteristics and analysis for other variables. The contribution of the current study was to establish normative values of balance among 20-40 years using sensamove minibalance board.

Keywords: Balance, Sensamove Minibalance board, Healthy individuals, Normative data, Balance assessment

INTRODUCTION

Balance refers to the body's ability to maintain stability in both static and dynamic states while keeping its center of gravity (COG) aligned with its base of support [1]. Balance is achieved and maintained through a sophisticated interplay of sensory motor control mechanisms. Balance is regulated by the vestibular nuclei located in the brain stem. An object's ability to stay balanced while stationary depends on the position of its center of mass (also known as the center of gravity) and the size of its base of support [2]. When the line of gravity falls within this base, the object remains stable. The farther the line of gravity can move before the object tips, the greater its stability. Balance primarily involves maintaining, achieving, or adjusting the body's center of mass relative to its base of support [3]. It plays a vital role in both movement and stability, depending on the coordinated function of multiple systems. Maki and McIlroy described balance control as the ability to regulate the relationship between the body's center of gravity and its base of support (BOS) during daily activities [4]. The Sensamove Balance MiniBoard combines interactive training software and exercise games with the well-known benefits of a traditional wobble board, resulting in a ground breaking and highly efficient addition to Sensamove's interactive balance product lineup [5]. Balance can be assessed through various methods, including laboratory studies and field assessments that have been validated for reliability. The aim of this study was to establish balance norms for individuals aged 20 to 40 years, which could serve as reference values when evaluating balance abilities. Since balance sway tends to increase linearly with age after 50, these normative values could be helpful in assessing balance in individuals with neurological conditions, such as multiple sclerosis, stroke, Parkinson's disease, and traumatic brain injuries, all of which commonly impair balance. These disorders can significantly increase the risk of falls by affecting the brain's ability to control posture, coordinate muscle movement, and maintain equilibrium. Additionally, orthopaedic conditions like osteoarthritis, hip or knee replacements, and ankle sprains can also impact balance by causing pain, joint instability, or limited range of motion. Such impairments hinder proper movement and alignment, making it more difficult to maintain stability. Normative balance values can help identify individuals at higher risk of falling and track their progress during rehabilitation. The objective of this study was to establish normal values among 20-40 years of both genders using sensamove minibalance board.

METHODOLOGY

Prior commencing the study, the study proposal was prepared and submitted to the Institutional Ethics Committee (IEC) of Bhaikaka University, Karamsad for approval and permission for conducting study. IEC approval **no** IEC/BU/151/Faculty/19/264/2024. Participants who were normal healthy individuals aging between 20-40 years were selected from constituent institutes of Bhaikaka University. After the consent participants were screened with height(cm), weight(kg) and body mass index (BMI) was calculated the Time Up and Go (TUG) test were assessed. Participants with a BMI within the normal range (As per Asian Pacific criteria) were included for additional assessment. Participants included who were normal healthy individuals of age group between 20-40 years, both males and females, Body Mass Index (BMI)- 18.5-22.9 kg/m2.[6,] Time Up and Go test (TUG) - < 10 seconds. Participants excluded who had history of diabetes, hypertension or any other neurological disorder which may affect balance, Body Mass Index (BMI)- > 22.9 kg/m2.[6,] History of any neurological, orthopaedic and cardiovascular disorders, surgery or injury which could affect balance (self-reported/medical records), Time Up and Go test (TUG)- >10 seconds and addictions like smoking, alcohol abuse etc.

Procedure

394 participants were screened with BMI and TUG
Eligible (n=250)
Informed consent was taken and assessed with sensamove minibalance board Enrollment
Not Eligible (n=144)
BMI=>22.9 kg/m2

Flowchart of participants recruitment

Then participants were assessed on sensamove minibalance board for static balance (Time and Degree), proprioception, angle difference, radius difference, reaction time, travel time and co-ordination. All these components were evaluated for center, front, back, left, right, front-back, front-right, back-right, front-left, and left-right.

Statistical analysis

Data was analyzed by using STATA 14.2 Descriptive statistics [Frequency, Mean(SD), Median, Mode, Maximum and minimum values] were used to depict the baseline characteristics and analysis for other variables.

RESULTS

Table 1 shows baseline characteristics of age group and gender distribution of 250 participants. Table 2 shows descriptive analysis of age, weight, height, BMI and TUG. Table 3 shows descriptive analysis for static balance time (seconds) for 1-2 seconds, 3-4 seconds and 5-6 seconds for both genders. Table 4 shows descriptive analysis for static balance degree of both genders. Ranges for all directions: - Centre [Male: 0.30-0.80, Female: 0.30-0.91], Front [Male: 0.10-0.70, Female: 0.10-1.21], Back [Male: 0.10-0.73, Female: 0.10-2.00], Left [Male: 0.10-0.86, Female: 0.10-0.90], Right [Male: 0.10-1.10, Female: 0.10-0.90], Front-Right [Male: 0.10-0.46, Female: 0.10-0.81], Back-Right [Male: 0.10-0.60, Female: 0.10-1.10], Back-Left [Male: 0.10-0.70, Female: 0.10-1.10], Front-Left [Male: 0.10-0.53, Female: 0.10-0.63]. Table 5 shows descriptive analysis for angle difference (degree) of both genders. Ranges for all directions: - Front [Male: 0.49-145.43, Female: 0.89-159.88], Back [Male: 0.33-47.40, Female: 0.50-46.01], Left [Male: 0.50-32.34, Female: 0.59-43.54], Right [Male: 1.23-34.48, Female: 0.49-38.41], Front-Right [Male: 0.33-36.81, Female: 0.29-122.13], Back-Right [Male: 0.13-60.13, Female: 0.20-60.69], Back-Left [Male: 0.32-28.75, Female: 0.49-31.80], Front-Left [Male: 0.43-27.81, Female: 0.30-58.04]. Table 6 shows descriptive analysis for radius difference (degree) of both genders. Ranges for all directions: - Front [Male: 0.00-1.96, Female: 0.00-4.30], Back [Male: 0.00-1.10, Female: 0.00-1.60], Left [Male: 0.00-1.46, Female: 0.00-1.80], Right [Male: 0.00-1.80, Female: 0.00-1.60], Front-Right [Male: 0.00-3.05, Female: 0.00-1.80], Back-Right [Male: 0.00-1.26, Female: 0.00-2.00], Back-Left [Male: 0.00-1.26 Female: 0.00-1.51], Front-Left [Male: 0.00-1.26, Female: 0.00-1.80]. Table 7 shows descriptive analysis for reaction time (seconds) of both genders. Ranges for all directions: - Front [Male: 0.43-2.06, Female: 0.40-1.81], Back [Male: 0.23-1.40, Female: 0.49-1.70], Left [Male: 0.40-1.73, Female: 0.50-1.70], Right [Male: 0.50-1.66, Female: 0.49-1.60], Front-Right [Male: 0.40-1.80, Female: 0.40-1.90], Back-Right [Male: 0.50-2.10, Female: 0.29-1.80], Back-Left [Male: 0.50-1.73, Female: 0.49-1.70], Front-Left [Male: 0.40-1.70, Female: 0.50-1.70]. Table 8 shows descriptive analysis for travel time (seconds) of both genders. Ranges for all directions: - Front [Male: 0.80-2.97, Female: 0.69-3.01], Back [Male: 0.66-2.36, Female: 0.80-2.70], Left [Male: 0.90-2.66, Female: 0.99-2.80], Right [Male: 0.80-3.36, Female: 1.00-3.20], Front-Right [Male: 0.73-2.70, Female: 0.70-2.62], Back-Right [Male: 0.70-3.67, Female: 0.70-2.70], Back-Left [Male: 0.73-2.63, Female: 0.80-2.60], Front-Left [Male: 0.56-2.60, Female: 0.19-2.40]. Table 9 shows descriptive analysis for co-ordination of both genders. Ranges for all directions: - Front-Back [Male: 0.00-1.13, Female: 0.00-0.41], Left-Right [Male: 0.00-1.20, Female: 0.00-0.30], Diagonal-Right [Male: 0.00-0.46, Female: 0.00-0.40], Diagonal-Left [Male: 0.00-0.40, Female: 0.00-0.40]. Table 10 shows normative values of each parameter of sensamove minibalance board.

DISCUSSION

The aim of this research was to establish the normative value of balance among 20-40 years of age group using sensamove minibalance board. The Sensamove minibalance tool gives a complete balance assessment, including time and degree deviations for static balance, proprioception, reaction time, travel time, and coordination [7-9]. By creating a normative value, the sensamove minibalance board can also be used as a diagnostic and therapeutic tool. Siraj et al (2022) reported that cut off value for balance sway increases linearly with age between 50-70 years [10-12]. In this study, there was result carried out for both the genders in each component, which showed approximately minimal difference in ranges. Simon et al (2019) reported for age and sex differences in human balance performance

from 6-18 years of age: systematic review and meta-analysis that sex-related differences in balance performance in youth were greatest for measures of static steady-state balance in favor of girls and for measures of proactive balance in favor of boys [13].

CONCLUSION

The contribution of the current study was that to establish normative values of balance using Sensamove mini balance board among normal individuals between 20-40 years of age group. It assesses various components like static balance (seconds), static balance(degree), angle difference and radius difference(degree), reaction time and travel time (seconds) and coordination (degree). These results demonstrated consistent balance performance across this age group, providing a reference for what can be considered normal balance. These normative values can be useful for health and fitness professional to assess balance abilities of individuals in this age group. These findings contribute to the existing literature on balance in healthy adults and can help for the balance training purpose.

Limitation
Lack of equal distribution for age group and gender.

Future Projections
- Normative values for different age groups in children and old age group.
- Normative values according to BMI categories.
- Training for therapeutic and diagnostic purpose for different neurological and orthopaedic conditions.
- Can be done with larger sample size.

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Conflict of interest
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Table 1: Baseline characteristics

Sr. No	Categorial age	Total	
	Age Group	Frequency (%)	
1	20-25	202(80.8%)	250(100%)
2	26-30	11(4.4%)	
3	31-40	37(14.8%)	
	Gender	Frequency (%)	Total
1	Male	92(36.8%)	250(100%)
2	Female	158(63.2%)	

Table 2: shows descriptive analysis of age, weight, height, BMI and TUG.

Sr. No	Variables	Mean (SD)	Median	Mode	Minimum Value	Maximum Value
1	Age	24.01(5.06)	22	20	20	39
2	Weight	52.69(6.17)	52	52	40.5	72
3	Height	159.62(8.08)	160	160	138	183
4	BMI	20.66(1.23)	20.60	19.8	18.6	22.8
5	TUG	7.51(1.07)	7.43	7.14	5	8.3

*BMI= Body Mass Index, *TUG= Time up and go

Table 3: shows descriptive analysis for static balance time (seconds) for 1-2 seconds, 3-4 seconds and 5-6 seconds for both genders.

Sr. No	Static Balance (Time)	Time(seconds)	Male Frequency (%)	Female Frequency (%)	Total
1	Centre	1-2	27(29.3%)	70(44.3%)	97(38.8%)
		3-4	38(41.3%)	42(26.6%)	80(32%)
		5-6	27(29.3%)	46(29.1%)	73(29.2%)
2	Front	1-2	61(66.3%)	106(67.1%)	167(66.8%)
		3-4	21(22.8%)	33(20.9%)	54(21.6%)

		5-6	10(10.9%)	19(12%)	29(11.6%)
3	Back	1-2	57(62%)	99(62.7%)	156(62.4%)
		3-4	27(29.3%)	39(24.7%)	66(26.4%)
		5-6	8(8.7%)	20(12.7%)	28(11.2%)
4	Left	1-2	67(72.8%)	112(70.9%)	179(71.6%)
4	Left	3-4	10(10.9%)	23(14.6%)	33(13.2%)
		5-6	15(16.3%)	23(14.6%)	38(15.2%)
5	Right	1-2	66(71.7%)	111(70.3%)	177(70.8%)
		3-4	14(15.2%)	18(11.4%)	32(12.8%)
		5-6	12(13%)	29(18.4%)	41(16.4%)
6	Front-Right	1-2	69(75%)	108(68.4%)	177(70.8%)
		3-4	19(20.7%)	32(20.3%)	51(20.4%)
		5-6	4(4.3%)	18(11.4%)	22(8.8%)
7	Back-Right	1-2	66(71.7%)	107(67.7%)	173(69.2%)
		3-4	3(3.3%)	26(16.5%)	29(11.6%)
		5-6	23(25%)	25(15.8%)	48(19.2%)
8	Back-Left	1-2	71(77.2%)	109(69%)	180(72%)
		3-4	9(9.8%)	29(18.4%)	38(15.2%)
		5-6	12(13%)	20(12.7%)	32(12.8%)
9	Front-Left	1-2	64(69.6%)	117(74.1%)	181(72.4%)
		3-4	21(22.8%)	26(16.5%)	47(18.8%)
		5-6	7(7.6%)	15(9.5%)	22(8.8%)

Table 4: shows descriptive analysis for static balance in degree of both genders.

*P 2.5= calculated values at 2.5%, *P 97.5= calculated values at 97.5%

Sr. No	Static Balance (Degree)	Gender	Mean (SD)	Median	Mode	Minimum Value	Maximum Value	Percentile 2.5	Percentile 97.5
1	Centre	Male	0.48(0.13)	0.50	0	0	1.00	0.30	0.80
		Female	0.49(0.23)	0.40	0	0	3.00	0.30	0.91
2	Front	Male	0.28(0.16)	0.20	0.20	0.10	1.30	0.10	0.70
		Female	0.32(0.27)	0.20	0.20	0.10	2.00	0.10	1.21
3	Back	Male	0.28(0.16)	0.20	0.20	0.10	1.30	0.10	0.73
		Female	0.35(0.36)	0.30	0.20	0.10	3.10	0.10	2.00
4	Left	Male	0.30(0.33)	0.30	0.20	0.10	2.90	0.10	0.86
		Female	0.29(0.24)	0.20	0.20	0.10	2.00	0.10	0.90
5	Right	Male	0.32(0.21)	0.30	0.30	0.10	1.20	0.10	1.10
		Female	0.30(0.21)	0.25	0.20	0.10	2.10	0.10	0.90
6	Front-Right	Male	0.22(0.08)	0.20	0.20	0.10	0.50	0.10	0.46
		Female	0.26(0.20)	0.20	0.20	0.10	1.90	0.10	0.81
7	Back-Right	Male	0.26(0.11)	0.20	0.20	0.10	0.60	0.10	0.60
		Female	0.31(0.35)	0.20	0.20	0.10	4.00	0.10	1.10
8	Back-Left	Male	0.31(0.51)	0.20	0.20	0.10	5.00	0.10	0.70
		Female	0.30(0.28)	0.20	0.20	0.10	2.30	0.10	1.10
9	Front-Left	Male	0.25(0.09)	0.20	0.20	0.10	0.70	0.10	0.53
		Female	0.29(0.28)	0.30	0.20	0.10	2.30	0.10	0.63

Table 5: shows descriptive analysis for angle difference (degree) of both genders.
*P 2.5= calculated values at 2.5%, *P 97.5= calculated values at 97.5%

Sr. No	Angle Difference (Degree)	Gender	Mean (SD)	Median	Mode	Minimum Value	Maximum Value	Percentile 2.5	Percentile 97.5
1	Front	Male	24.14(35.21)	10.15	5.50	0.10	170.40	0.49	145.43
		Female	21.75(37.81)	10.40	5.50	0.10	177.00	0.89	159.88
2	Back	Male	9.34(11.13)	7.05	5.00	0.20	81.50	0.33	47.40
		Female	11.06(11.86)	7.90	1.20	0.30	86.40	0.50	46.01
3	Left	Male	10.55(15.06)	8.00	3.70	0.30	135.50	0.50	32.34
		Female	12.57(14.00)	9.30	4.30	0.30	134.50	0.59	43.54
4	Right	Male	12.33(13.24)	9.00	13.60	0.10	114.60	1.23	34.48
		Female	11.59(12.66)	8.75	0.90	0.10	109.70	0.49	38.41
5	Front-Right	Male	10.65(7.95)	9.40	5.10	0.30	38.40	0.33	36.81
		Female	16.15(25.87)	10.30	1.50	0.00	156.10	0.29	122.13
6	Back-Right	Male	9.41(16.75)	5.55	0.20	0.00	137.10	0.13	60.13
		Female	12.63(17.04)	9.00	6.20	0.10	147.10	0.20	60.69
7	Back-Left	Male	9.80(7.68)	7.40	2.80	0.00	41.30	0.32	28.75
		Female	11.01(10.43)	8.65	3.20	0.20	89.50	0.49	31.80
8	Front-Left	Male	9.97(7.00)	9.60	6.30	0.20	41.20	0.43	27.81
		Female	11.26(18.33)	7.35	6.90	0.00	167.20	0.30	58.04

Table 6: shows descriptive analysis for radius difference (degree) of both genders.
*P 2.5= calculated values at 2.5%, *P 97.5= calculated values at 97.5%

Sr. No	Radius Difference (Degree)	Gender	Mean (SD)	Median	Mode	Minimum Value	Maximum Value	Percentile 2.5	Percentile 97.5
1	Front	Male	0.71(0.68)	0.50	0.20	0.00	4.80	0.00	1.96
		Female	1.13(1.24)	0.80	0.50	0.00	9.90	0.00	4.30
2	Back	Male	0.50(0.34)	0.50	0.40	0.00	1.70	0.00	1.10
		Female	0.62(0.46)	0.60	0.60	0.00	3.00	0.00	1.60
3	Left	Male	0.53(0.36)	0.60	0.60	0.00	1.80	0.00	1.46
		Female	0.58(0.46)	0.50	0.20	0.00	2.60	0.00	1.80
4	Right	Male	0.54(0.43)	0.50	0.10	0.00	2.00	0.00	1.80
		Female	0.53()0.40	0.50	0.10	0.00	1.90	0.00	1.60
5	Front-Right	Male	0.51(0.59)	0.50	0.60	0.00	4.30	0.00	3.05
		Female	0.50(0.41)	0.40	0.20	0.00	2.20	0.00	1.80
6	Back-Right	Male	0.45(0.34)	0.35	0.30	0.00	1.90	0.00	1.26
		Female	0.50(0.55)	0.40	0.10	0.00	5.30	0.00	2.00
7	Back-Left	Male	0.50(0.74)	0.35	0.30	0.00	7.00	0.00	1.26
		Female	0.47(0.38)	0.40	0.50	0.00	2.50	0.00	1.51
8	Front-Left	Male	0.40(0.33)	0.40	0.10	0.00	1.30	0.00	1.26
		Female	0.52(0.51)	0.40	0.30	0.00	4.40	0.00	1.80

Table 7: shows descriptive analysis for reaction time (seconds) of both genders.
*P 2.5= calculated values at 2.5%, *P 97.5= calculated values at 97.5%

Sr. No	Reaction Time (Seconds)	Gender	Mean (SD)	Median	Mode	Minimum Value	Maximum Value	Percentile 2.5	Percentile 97.5
1	Front	Male	0.92(0.34)	0.90	0.70	0.40	2.20	0.43	2.06
		Female	0.89(0.52)	0.80	0.60	0.40	5.60	0.40	1.81
2	Back	Male	0.79(0.22)	0.80	0.60	0.06	1.40	0.23	1.40
		Female	0.81(0.27)	0.80	0.80	0.00	2.30	0.49	1.70
3	Left	Male	0.91(0.41)	0.90	1.00	0.00	3.60	0.40	1.73
		Female	0.94(0.29)	0.90	1.00	0.40	1.80	0.50	1.70
4	Right	Male	0.90(0.32)	0.80	0.80	0.40	1.80	0.50	1.66
		Female	0.87(0.30)	0.80	0.60	0.40	1.90	0.49	1.60
5	Front-Right	Male	0.82(0.32)	0.70	0.60	0.40	2.40	0.40	1.80
		Female	0.80(0.37)	0.70	0.60	0.30	3.40	0.40	1.90
6	Back-Right	Male	0.90(0.65)	0.80	0.80	0.40	6.50	0.50	2.10
		Female	0.86(0.80)	0.80	0.80	0.00	3.20	0.29	1.80
7	Back-Left	Male	0.89(0.27)	0.80	0.80	0.50	2.00	0.50	1.73
		Female	0.86(0.27)	0.80	0.90	0.00	2.00	0.49	1.70
8	Front-Left	Male	0.81(0.28)	0.80	0.70	0.00	1.90	0.40	1.70
		Female	0.83(0.29)	0.80	0.80	0.00	2.00	0.50	1.70

Table 8 : shows descriptive analysis for travel time (seconds) of both genders.
*P 2.5= calculated values at 2.5%, *P 97.5= calculated values at 97.5%

Sr. No	Travel Time (Seconds)	Gender	Mean (SD)	Median	Mode	Minimum Value	Maximum Value	Percentile 2.5	Percentile 97.5
1	Front	Male	1.40(0.57)	1.20	1.00	0.50	4.20	0.80	2.97
		Female	1.42(0.66)	1.20	1.20	0.50	5.80	0.69	3.01
2	Back	Male	1.21(0.37)	1.20	1.20	0.10	2.40	0.66	2.36
		Female	1.29(0.42)	1.20	1.20	0.00	3.40	0.80	2.70
3	Left	Male	1.53(0.53)	1.40	1.40	0.90	5.10	0.90	2.66
		Female	1.55(0.54)	1.40	1.40	0.70	5.60	0.99	2.80
4	Right	Male	1.48(0.57)	1.40	1.20	0.70	4.40	0.80	3.36
		Female	1.47(0.55)	1.35	1.20	0.80	5.40	1.00	3.20
5	Front-Right	Male	1.37(0.46)	1.30	1.40	0.70	3.40	0.73	2.70
		Female	1.35(0.52)	1.20	1.20	0.60	4.90	0.70	2.62
6	Back-Right	Male	1.48(0.75)	1.35	1.40	0.70	6.40	0.70	3.67
		Female	1.42(0.48)	1.30	1.30	0.00	3.70	0.70	2.70
7	Back-Left	Male	1.38(0.48)	1.40	1.40	0.10	2.80	0.73	2.63
		Female	1.50(1.43)	1.30	1.20	0.00	18.70	0.80	2.60
8	Front-Left	Male	1.38(0.67)	1.20	1.10	0.00	5.60	0.56	2.60
		Female	1.33(0.47)	1.30	1.00	0.00	2.60	0.19	2.40

Table 9: shows descriptive analysis for co-ordination of both genders.

*P 2.5= calculated values at 2.5%, *P 97.5= calculated values at 97.5%

Sr. No	Co-ordination	Gender	Mean (SD)	Median	Mode	Minimum Value	Maximum Value	Percentile 2.5	Percentile 97.5
1	Front-Back	Male	0.18(0.59)	0.10	0.00	0.00	5.50	0.00	1.13
		Female	0.09(0.15)	0.10	0.00	0.00	1.20	0.00	0.41
2	Left-Right	Male	0.12(0.22)	0.10	0.10	0.00	1.30	0.00	1.20
		Female	0.09(0.16)	0.10	0.10	0.00	1.80	0.00	0.30
3	Diagonal-Right	Male	0.12(0.15)	0.10	0.10	0.00	1.20	0.00	0.46
		Female	0.12(0.13)	0.10	0.10	0.00	1.20	0.00	0.40
4	Diagonal-Left	Male	0.14(0.11)	0.10	0.10	0.00	0.50	0.00	0.40
		Female	0.14(0.12)	0.10	0.10	0.00	0.80	0.00	0.40

Table 10: shows normative values of each parameter of sensamove minibalance board.

Direction	Degree changes in static balance	
	Male	Female
Centre	0.30-0.80	0.30-0.91
Front	0.10-0.70	0.10-1.21
Back	0.10-0.73	0.10-2.00
Left	0.10-0.86	0.10-0.90
Right	0.10-1.10	0.10-0.90
Front-right	0.10-0.46	0.10-0.81
Back-right	0.10-0.60	0.10-1.10
Back-left	0.10-0.70	0.10-1.10
Front-left	0.10-0.53	0.10-0.63
	Angle difference in degree	
Front	0.49-145.43	0.89-159.88
Back	0.33-47.40	0.50-46.01
Left	0.50-32.34	0.59-43.54
Right	1.23-34.48	0.49-38.41
Front-right	0.33-36.81	0.29-122.13
Back-right	0.13-60.13	0.20-60.69
Back-left	0.32-28.75	0.49-31.80
Front-left	0.43-27.81	0.43-27.81
	Radius difference in degree	
Front	0.00-1.96	0.00-4.30
Back	0.00-1.10	0.00-1.60
Left	0.00-1.46	0.00-1.80
Right	0.00-1.80	0.00-1.60
Front-right	0.00-3.05	0.00-1.80
Back-right	0.00-1.26	0.00-2.00
Back-left	0.00-1.26	0.00-1.51
Front-left	0.00-1.26	0.00-1.80
	Reaction time in seconds	
Front	0.43-2.06	0.40-1.81
Back	0.23-1.40	0.49-1.70

Left	0.40-1.73	0.50-1.70
Right	0.50-1.66	0.49-1.60
Front-right	0.40-1.80	0.40-1.90
Back-right	0.50-2.10	0.29-1.80
Back-left	0.50-1.73	0.49-1.70
Front-left	0.40-1.70	0.50-1.70
	Travel time in seconds	
Front	0.80-2.97	0.69-3.01
Back	0.66-2.36	0.80-2.70
Left	0.90-2.66	0.99-2.80
Right	0.80-3.36	1.00-3.20
Front-right	0.73-2.70	0.70-2.62
Back-right	0.70-3.67	0.70-2.70
Back-left	0.73-2.63	0.80-2.60
Front-left	0.56-2.60	0.19-2.40
	Co-ordination in degree	
Front-back	0.00-1.13	0.00-0.41
Left-right	0.00-1.20	0.00-0.30
Diagonal-right	0.00-0.46	0.00-0.40
Diagonal-left	0.00-0.40	0.00-0.40



Figure 1: **wooden wobble board connected via cable to laptop showing software screen**



Figure 2: Participants enrol for height, weight, and on sensamove minibalance board

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RESEARCH ARTICLE

Automatic Image Segmentation using CNN-Based Panoptic Segmentation in Deep Learning

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ABSTRACT

Deep learning techniques are used in this research to present automatic image segmentation. Simultaneous sematic and instance segmentation is achieved through the use of dual-stream neural networks. Although the instance segmentation stream uses instance- aware networks to precisely delineate object borders, the semantic segmentation stream uses a fully convolutional network to provide category labels to pixels, capturing scene context. The model is trained on several datasets containing a variety of scenarios, objects, and environmental conditions in an effort to enhance generalization. Transfer learning improves flexibility in the face of panoptic segmentation problems. It is initialized with pre-trained weights and fine-tuned using domain-specific datasets.

Keywords: Mechanization; picture; panoptic division; deep learning; identifying; grouping

INTRODUCTION

Deep learning techniques have proliferated, leading to tremendous gains in computer vision tasks. Of these, image segmentation is particularly important as a first step toward visual content interpretation. Semantic segmentation, which gives a category label to each pixel, and instance segmentation, which locates specific item instances within a picture, have traditionally been the main emphasis of segmentation techniques. These techniques, however, frequently function in isolation, ignoring the holistic comprehension of images necessary for thorough scene analysis. A single system that combines semantic and occurrence division is utilized by panoptic division to overcome this limitation. By concurrently relegating a category name for objects (such as streets, skies) to each pixel and identifying particular events of objects (such as automobiles and people on foot), it looks for to supply a pixel-level information

of pictures. More comprehensive scene representation is given by this bound together strategy, which makes errands like protest discovery, independent route, and scene understanding simpler to do. By empowering end-to-end learning of complicated highlight representations from information, profound learning has totally changed panoptic division. With its remarkable execution in a extend of computer vision applications, Convolutional Neural Systems (CNNs) have ended up a

IMAGE SEGMENTATION

Introduction

Fig. 1 illustrates how picture segmentation, one of the components of computer vision, is an important step in image Processing in the context of industrial automation. Objects, backgrounds, individual constituent bits of interest can be extracted from pictures for the purpose of further analysis and perhaps categorization. This process is known as segmentation, and it is made possible by a collection of processing techniques. Image segmentation has become crucial in the context of the increasingly common capture of pictures using video cameras and their processing for decision-making in various autonomous processes. After the picture has been segmented, it is then erased to expose homogenous areas with contours, distinct objects, or homogeneous areas that adhere to strict uniformity standards. Here is the caption for a figure. Right underneath the figure, it appears.

Segmentation methods

Semantic segmentation: this technique entails assigning a preset class or category to each pixel in an image. The end product is a pixel-by-pixel labeling of the image that indicates the category every single one is in. This kind of segmentation is commonly utilized in applications like autonomous driving, item recognition, and scene interpretation. It is essential for comprehending the overall information of a picture.

Instance segmentation

Semantic segmentation is extended by instance segmentation, which distinguishes between distinct instances of the same class in addition to giving each pixel a class label. It is useful for tasks like item counting, tracking, and fine-grained analysis because it makes a picture more understandable by distinguishing between distinct objects or instances.

Panoptic segmentation

The computer vision task of panoptic segmentation combines semantic and instance segmentation. This assignment to give each pixel in a picture a unique name, distinguishing between "stuff" classes (such as road, sky) and "thing" classes(such as vehicles, people), as well as recognizing specific occurrences of the "thing" classes. Panoptic refers to a wide or comprehensive perspective, and panoptic segmentation in computer vision aims to give a comprehensive knowledge of a picture by concurrently addressing the semantic and instance aspects. Numerous industries, such as robots, augmented reality, and autonomous cars, can benefit from this work.

SEMANTIC SEGMENTATION USING DEEP LEARNING

With the progression of manufactured vision, a few pictures division calculated have been created. But in an exertion to urge comes about that are superior and more exact, manufactured insights methods have as late been developed. To rearrange the method of using these approaches to counterfeit vision applications as fast and simple as conceivable, common picture division databases exist. The most important ones are MS COCO, Pascal VOC, and Cityscapes, which focuses on comprehending urban road scenes. The YouTube channel Video-Objects, which focuses on question placement, has ADE20K recordings with ten topic classes. KITTI is applied in Berkeley division, SUN database, LabelMe, portable robots, independent cars, and other applications.

Convolutional Neural Networks Based on Regions

An artificial neural network specifically designed to handle pixel input is called a CNN. CNNs are utilized for image processing and recognition. Consequently, CNN serves as the Basic foundation for image segmentation in the field of artificial visual (CNN segmentation). CNN convolutional neural networks are constructed using three layers.

a) The convolutional layer, which creates a feature map from the source picture by using filters and kernels.
b) Using a pooling level, the feature maps are subsampled by counting the characteristics that are present within the feature map regions.
c) Every neuron on a single layer is linked to each of the other neurons in the layer that is above it through the entire layer of connections. It is possible to teach the CNN inherent neural network to recognize and locate the object of interest in a picture. The most basic CNNs are designed to recognize items in single- object photos and classify images.

B.R-CNN

When a picture contains many objects, a new architecture called R-CNN mask— it is grounded in RCNN—is used. By employing neural net boundary areas of this kind, which specify areas, assess neural net independently for each Area of Concern, regions from different photographs are categorized into a number of theoretical classes. CNN systems are used to identify items autonomously by identifying their intrinsic properties. Consequently, a CNN is examining hundreds of instruction images and pick up the traits that set several groups within a same type apart so that it can differentiate between them. Most Deep Learning applications use the transferable education technique, it involves enhancing a previously trained function we must first add fresh data comprising unexplored classifications to an already-existing network. The R-CNN network is divided into two tiers. In order to anticipate the limit of the square that item under study, At first degree, known as the Region Proposal Network(RPN), employs anchor boxes. The intended features are refined, classified, and the segmentation of these projections at the pixel layer is resolved by the R-CNN detector, which is the second level.

PANOPTIC SEGMENTATION USING DEEP LEARNING

Combining the difficulties of Panoptic segmentation, along with semantics and case segmentation, is an electronic vision problem. Panoptic segmentation, which is semantically similar to segmenting instances, tries to identify unique instances of objects and also provide A type of designation assigned to every picture frame.

Data preparation

Obtain a labelled dataset for both semantic and instance segmentation, which consists of photos with pixel- by-pixel annotations. Many scenarios and object instances should be included in the collection. The COCO (Common Objects in Context) and Maxillary Vistas databases are frequently used for panoptic segmentation

Architecture

For a comparative work like question location or semantic division, pre train the show on a sizable dataset. Optimize for both semantic and occurrence division execution by fine- tuning the demonstrate utilizing the Panoptic Division dataset. For each errand, utilize the correct misfortune work. The Cover R-CNN, for case, regularly combines classification misfortune, bounding box relapse misfortune, and veil division misfortune for division.

Training

For a similar job like object detection or semantic segmentation, pre train the model on a sizable dataset. Optimize for both semantic and instance segmentation performance by fine-tuning the model using the Panoptic Segmentation dataset. For every task, use the proper loss function. The Mask R- CNN, for example, often blends masks, bounding box regression loss, and classifier loss. segmentation loss for segmentation. The data training shown figure (4-21).

Inference

Apply the panoptic segmentation training model on fresh, unviewed pictures. Semantic segmentation and instance segmentation refer to the model's ability to provide class labels for each pixel and differentiate between distinct instances of an item.

Post processing

Post-processing methods, such as segmenting away tiny or unnecessary segments, to improve the outcomes of segmentation. Additionally, other techniques divide or combine segments according to their properties using heuristic.

Evaluation

Standard measures, such as mean Semantic segmentation using IoU and segmentation of instances utilizing AP can be used to assess the model's performance.

Semantic Evaluation

Evaluation of a confusion matrix is done for every single pixel. for semantic segmentation tasks. Pixel accuracy (pAcc) is theeasiest to understand statistic.

SQ =∑ IoU(pred, GT)| (6)

$pAcc$ = TP + TN

TP + TN + FP + FN (1)

TP^{RQ} = |TP| + ½|FP| + ½|FN| (7)

Nevertheless, there are frequently imbalances in the classes, which lead to inaccurate outcomes. A weighted average is calculated using the average pixel precision, which accounts for the quantity of each class's pixel. In several research on semantic segmentation he main metric, other from PA, is intersect over union (IoU), which penalizes the algorithm for FP and FN mistakes.

RESULT

The present study showcases a strong panoptic segmentation model that utilizes deep learning approaches to tackle the intricate problems of concurrently executing semantic and instance segmentation. Our model was tested and trained on a broad range of scenes and object instances found in a selected dataset from many sources. The dataset contains thorough pixel-by-pixel annotations for specific item instances as well as semantic categories. The suggested deep learning architecture has shown

IoU =TP + TN

TP + TN + FP + FN

Remarkable performance in obtaining precise and(2) comprehensive scene perception, and it is modelled most recent developments in computer vision. Our model is able to identify object categories and differentiate between specific instances within each Where A union of B is the intersection area and A union of B is the union area. We may Utilize the amount of every balanced IoU (fwIoU), that is the average weighted of each an IoU that accounts for the frequency of every class. or the mean IoU, the mean IoU or total IoU across every category, for a more comprehensive comprehension of this statistic.

Instance Evaluation

Metrics for instance segmentation involve both the mask quality and the bounding box predictions. Conventional COCO metrics are the most often used method for solving instance segmentation issues. The average accuracy is the region within the accuracy-recall slope, is the main parameter used in evaluations. category by combining the tasks of semantic and instance segmentation.

We found that the model performs competitively across a range of criteria after conducting thorough trials and evaluations, demonstrating its ability to handle complex situations with many overlapping objects. The training method produced a well-generalized model that could capture the subtleties of many scenarios. It was conducted over a predetermined number of epochs with careful consideration of batch size. The panoptic segmentation output shown fig 22.

TP Precision = TP + FP TP

Recall = TP + FN (3)(4)

Panoptic Evaluation

As of right now, the COCO panoptic task challenge uses the Panoptic Quality (PQ) measure as its major means of evaluation. PQ is defined as follows:

PQ = ∑ IoU(pred, GT)

|TP| + ½|FP| + ½|FN| (5)

CONCLUSION

Our work has developed and evaluated a panoptic where g represents the actual reality and p represents the prediction made by DL. The aforementioned statement is the product of two measures, the Qualities of Segment (SQ) and Identification (RQ), which are represented as follows: segmentation model based on deep learning, which represents a major breakthrough in the field of computer vision. Our model effectively addresses the dual problems o semantic and instance segmentation through careful design and training, offering a comprehensive comprehension of intricate visual situations.

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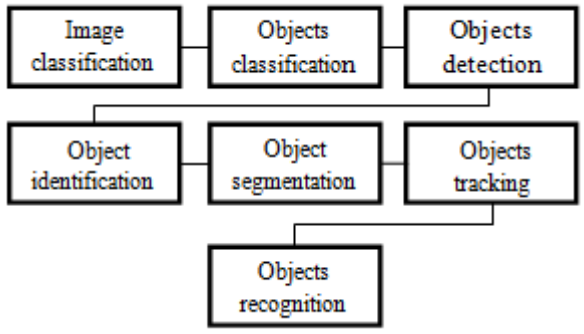


Figure. 1. Computer vision components



Fig 2 data preparation

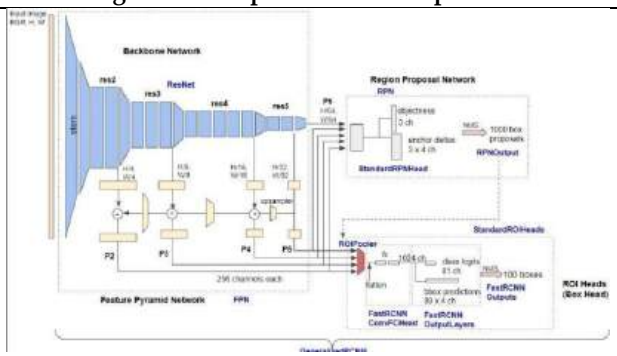


Figure 3 architecture

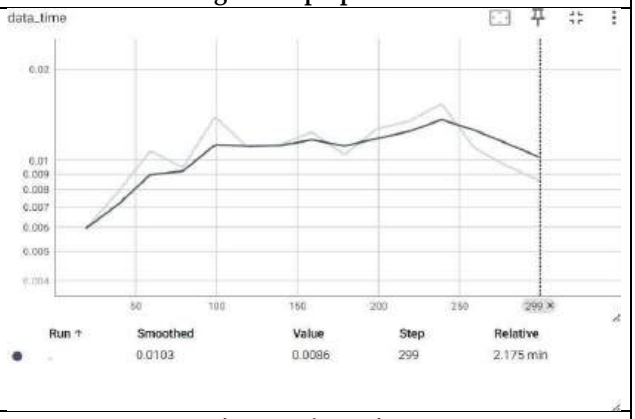


Figure 4 data _time

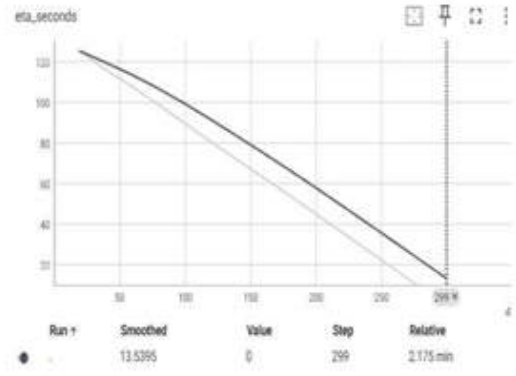


Figure 5 eta_seconds

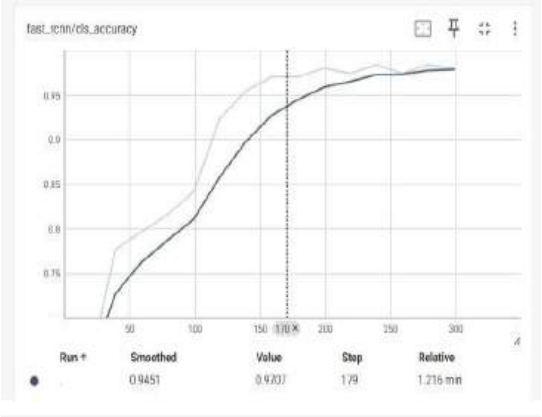


Figure 6 fast_rcnn/cls_accuracy

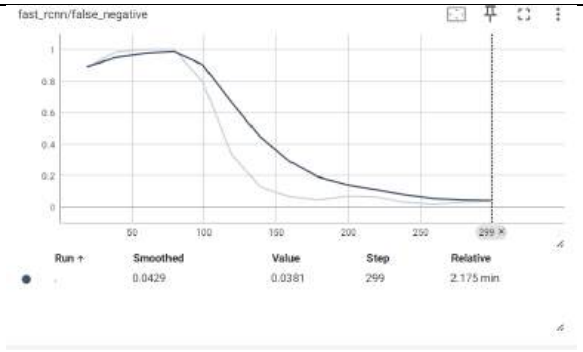


Figure 7 fast_rcnn/fast_negative

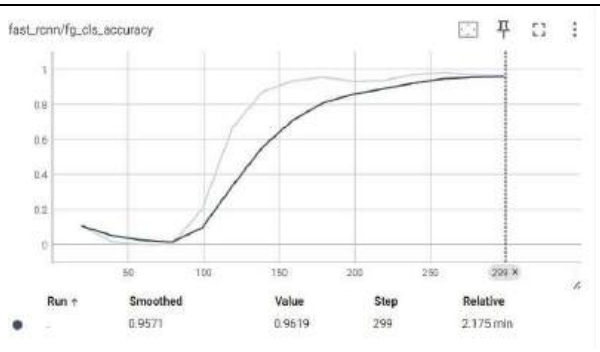


Figure 8 fast_rcnn/fg_cls-accuracy

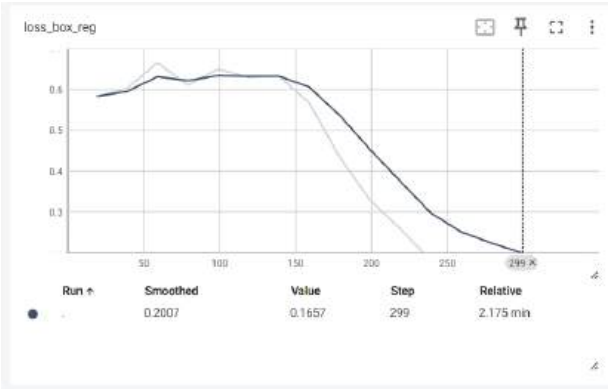


Figure 9 loss_box_reg

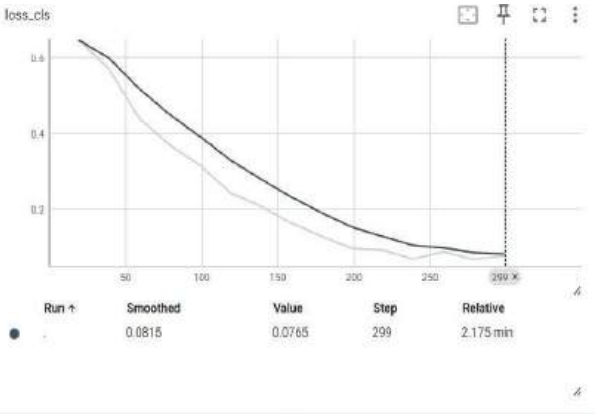


Figure 10 loss _cls

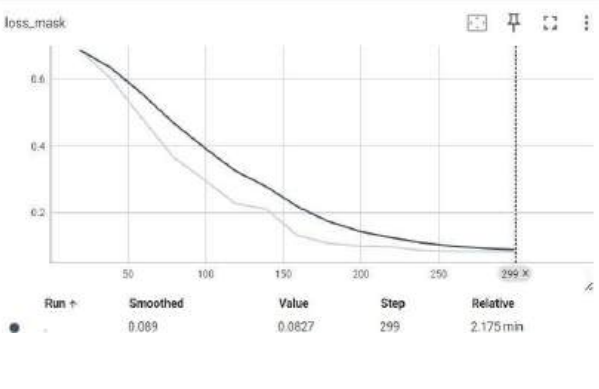


Figure 11 loss _mask

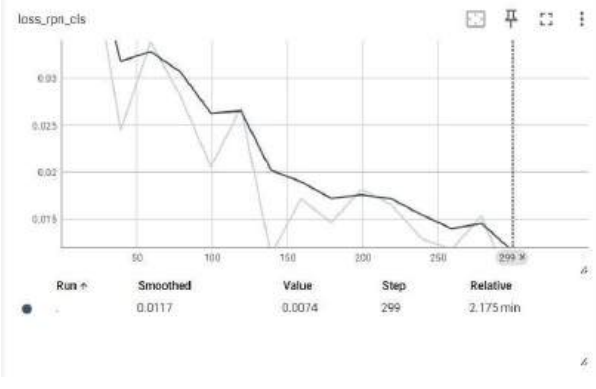


Figure 12 loss_rpn_cls

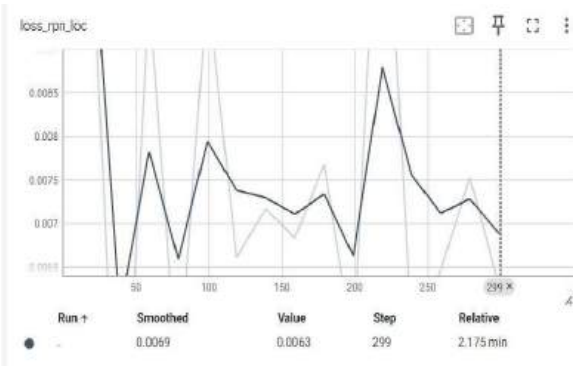


Figure 13 loss_rpn_loc

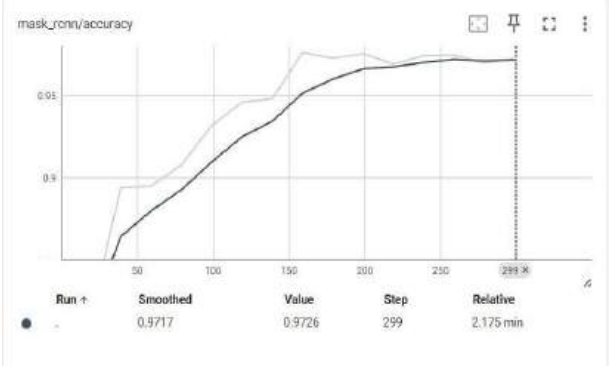


Figure 14 mask_rcnn/accuracy

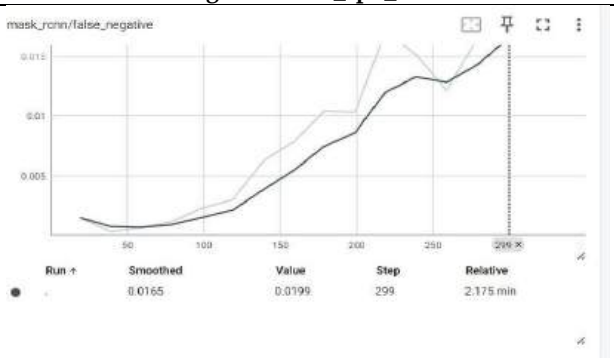


Figure 15 mask_rcnn/false negative

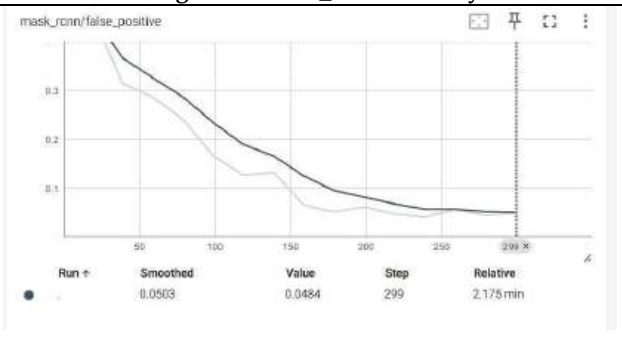


Figure 16 mask_rcnn/false positive

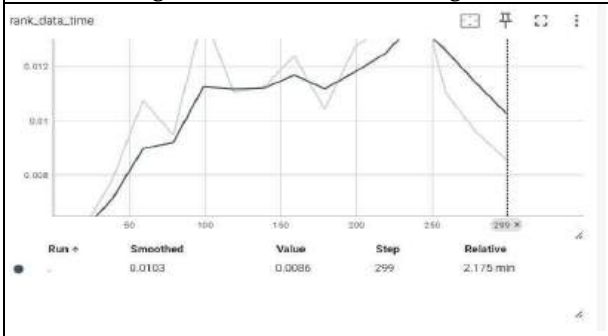


Figure 17 rank_data_time_

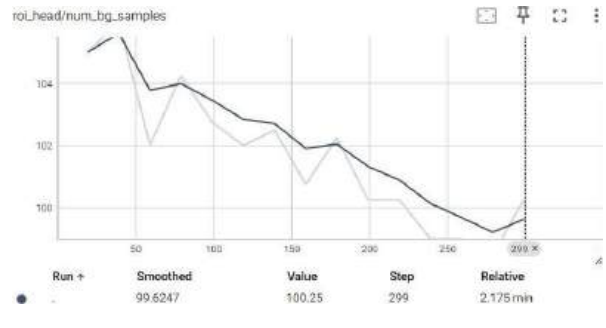


Figure 18 rci_head/num_bg_samples

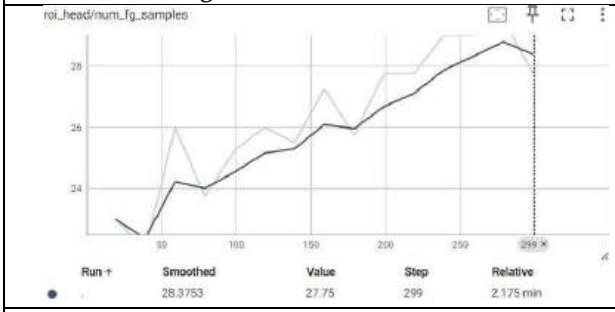


Figure 19 rci_head_fg_samples

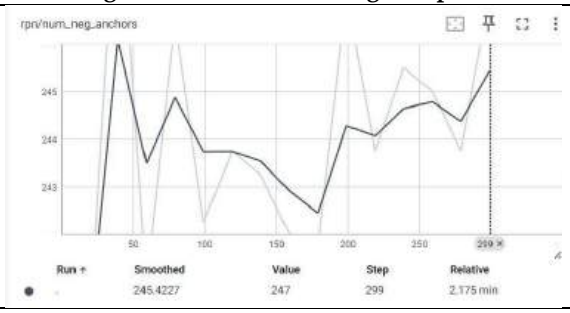


Figure 20 rpn/num_neg_anchors

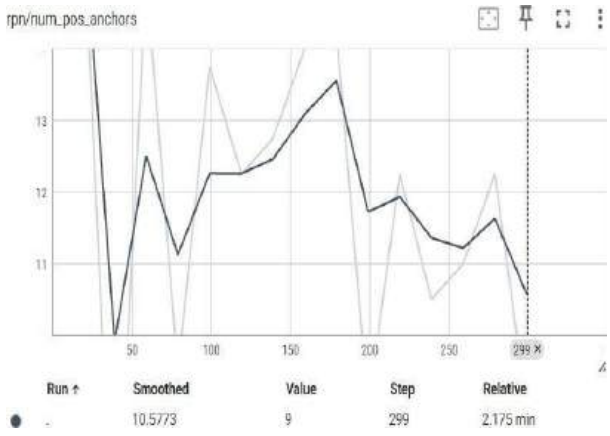


Figure 21 rpn/num_pos_anchr

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RESEARCH ARTICLE

Formulation Development and *In vitro* Evaluation of Telmisartan Nanosuspension by QBD

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ABSTRACT

Pharmaceutical nanosuspensions are aqueous dispersions of poorly soluble drug particles stabilized by surfactant, polymer, or both. Nanosuspensions can resolve drug delivery problems associated with the API. Telmisartan, a BCS class II anti-hypertensive and for enhancing cognitive function, has low water solubility, dissolution, and absorption. This study aims to develop Telmisartan nanosuspensions and apply Quality by Design (QbD) principles to identify the optimal formulation. Telmisartan is used for the treatment of hypertension and prevents the brain damage by activation of PPAR gamma in brain. In treating CNS disorders, the intra nasal route is one of the best choice for drug administration, provides a way to directly transport the medication to the brain. Tween 80, methanol, and water were used to prepare Telmisartan loaded nanosuspension by anti-solvent precipitation procedure. With varying stabilizer concentrations and sonication cycles, total nine formulations (F1–F9) were formulated. Tween 80 concentration (0.1, 0.3, and 0.5%) and sonication cycles (4, 7 and 10 cycles) were employed as independent variables, and *in vitro* drug release, particle size, and PDI as dependent variables. Optimization was carried out by 3^2 factorial design using Design Expert 13 software by Central composite design from the methodology of response surface. The mean particle size for the formulations were in the range of 155 nm to 893 nm and PDI from 0.131 to 0.561 with zeta potential in the range of -11.8 to -16. 0mV with a drug release from 89.24 ± 0.11 to 96.150 ± 006.The optimized formulation (F9) from overly

plot was observed to have an increase drug release (96.150 ± 006), particle size (155 nm) and a PDI (0.131), which was statistically significant with a P value < 0.0500. The optimized formulation F9 showed an enhanced solubility.

Keywords: Telmisartan nanosuspension, Intranasal route, Particle size and PDI, Zeta potential, Design Expert 13.

INTRODUCTION

Drugs with low solubility and high permeability fall under BCS class II. Drugs are made into nanosuspensions to improve their solubility and bioavailability because more than 40% of medications are poorly soluble in water. The phrase "nanotechnology" comes from the Greek word "nano," which meaning "dwarf." Without the matrix material, nanosuspensions are submicron colloidal dispersions of nano-sized particles(Patravale *et al.,* 2004). They can alternatively be described as a biphasic system made up of pure drug particles dispersed in an aqueous medium for parenteral, pulmonary, oral and topical application. They are created using a suitable process, and they are stabilized using a suitable stabilizer(Kocbek *et al.,* 2006). Telmisartan is an angiotensin- II receptor antagonist used for the treatment of hypertension. Telmisartan which binds the angiotensin- II type 1 receptor with high affinity, causing inhibition of the action of angiotensin II on vascular smooth muscle, ultimately leading to a reduction in arterial blood pressure(Gill *et al.,* 2012).USFDA have approved Telmisartan for treatment of hypertension and improvement of cognitive function. Hypertension leads to dementia(Reem A Aldeeb *et al.,* 2022; BeereNagaraju *et al.,* 2021). Telmisartan is used as anti-hypertensive and for dementia which is a degenerative brain disease(NofarTorika *et al.,* 2017). Because of its high lipophilicity, telmisartan can easily cross the blood–brain barrier. Telmisartan is a special ARB with PPAR-gamma stimulating activity that protects against cognitive decline in part by activating PPAR-gamma and preventing brain cell damage(Benson *et al.,* 2004). PPAR (peroxisome proliferator activated receptor gamma) activation also activates BDNF (Brain derived neurotropic factor) protects against cell death (SanchisGomar *et al.,* 2012).To deliver the Telmisartan drug from nose to brain. The nasal fluid was restricted to 25-200µL thus nanosuspensions were selected among various approach, because of its advantage, like high drug loading capacity and increasing solubility(Bharatia *et al.,* 2021). Nose to brain drug delivery is an effective approach for poorly soluble drugs to cross the blood brain barrier(Sravanthi Reddy *et al.,* 2019). As a result, the goal of the current work is to create nanosuspensions using the anti-solvent precipitation method by applying QbD in order to compare particle size, stability, and *in vitro* drug release and to assess the effectiveness of Telmisartan nanosuspensions in targeting the brain.

MATERIALS AND METHODS

MATERIALS

Telmisartan was procured from Suraksha labs Pvt. Ltd, Hyderabad, India. Tween ®80 AR, Sodium laurel Sulphate were procured from Molychem Pvt. Ltd., Mumbai, India and Methanol from Rankem Pvt. Ltd., Hyderabad, India.

METHODS

Preformulation studies

Pre-formulation were conducted to ascertain the properties of the drug and excipients, with a focus on the physicochemical, physicochemical, and bio pharmaceutical aspects(Bachhav *et al.,* 2019).

Organoleptic studies

Organoleptic characteristics of the drug sample were examined. By examining the drug sample's look, color, and smell, the organoleptic evaluation was carried out.

Melting point

The medication melting point of was established using a micro-controlled based melting point equipment. A capillary tube with one end closed and the drug sample inside was inserted. The capillary tube was placed into a controlled-heat silicone oil bath, which was heated using an electrical heating coil. The drug sample's melting point was determined to be the temperature at which it began to melt. The average of the 3 readings were documented and the value from the literature was compared.

Scanning of λ_{max} of Telmisartan nanosuspension

Using a UV-Visible double beam spectrophotometer (Shimadzu 1800), the absorbance maxima (λ_{max}) Telmisartan was prepared by taking 25mg in 25ml of methanol, 995ml of SNF of pH 6.5 with 5ml of SLS as surfactant was prepared and scanned in between a wavelength range of 200-400 nm. The maximum absorbance (λ_{max}) was found to be 296 nm(AnuMahajan *et al.,* 2017).

Standard calibration graph of Telmisartan in SNF pH 6.5

Accurately weighed quantity of 25mg of Telmisartan was dissolved in 25ml of methanol in a 25ml volumetric flask. From this stock solution 5ml was taken, diluted to 50 ml with SNF of pH 6.5 and 5ml of SLS as surfactant. Further dilutions were prepared by using SNF of pH 6.5 so to get 1,2,4,6 and 8 µg/ml concentration of Telmisartan. The optical density of this solutions were measured by using UV-Visible spectrophotometer at 296nm.

Solubility studies

Drug solubility was evaluated in different solvents. As Telmisartan is a BCS II drug it has extremely low water solubility. When it added to methanol, ethanol, chloroform and dichloromethane it is soluble after shaking continuously for some time(Miriam Sharpe *et al.,* 2012).

Drug excipient compatibility studies:

FTIR spectroscopy was carried out using FTIR-ATR spectrophotometer (Bruker), and the spectrum was obtained in the 4000-400 cm^{-1} wavelength range. In preformulation phase of the development of dosage forms, studies of drug-excipient compatibility play a significant role. FT-IR was used, to examine the compatibility between the drug and excipients. IR spectrum peaks of Telmisartan nanosuspension formulation was compared with standard Telmisartan(Brodgen *et al.,* 1981).

Formulation of Telmisartan Nanosuspension by Anti-Solvent Precipitation Method

Nanosuspension was organized by anti-solvent precipitation technique by applying QbD. Accurately weighed 40mg of Telmisartan was dissolved in 8ml of methanol. Different concentrations of tween (0.1, 0.3 and 0.5%) was dissolved in 32ml of water to obtain various concentrations of antisolvent. Then the drug solution was introduced by using syringe with a needle directly into 32ml of antisolvent at a stirring speed of 800rpm on magnetic stirrer (REMI LMLH) at room temperature for 3 hours to allow the volatile solvent to evaporate. After formation of precipitate of antisolvent, the sample was immediately transferred in to the test tube under ice cold condition subjected to probe sonication (Bandelin. HD 2070 max power) at various cycles (4,7 and 10). The wave traveled downward and reflected upward when the 6 mm-diameter tip of the probe was submerged in the liquid (Xia D *et al.,* 2010). Formulation trials were presented in Table 1.

Central Composite Design

Factorial design for optimization of key parameters

For the purpose of optimizing the crucial variables affecting stabilizer concentration and sonication cycles, a 3^2 factorial design was used. By Central Composite Design, Telmisartan nanosuspensions with nine different compositions were created by optimizing independent variables in three levels, Tween 80 (1%, 3%, and 5%), and sonication cycles (4, 7 and 10). This was accomplished by estimating dependent variables, such as *in vitro* drug release, particle size, and PDI, using the central composite design from the surface response methodology, Design

Expert 13 software. This clarified how the independent variables in an ANOVA affected the dependent variables. The statistical model with two factors interactive terms of polynomial was applied to evaluate the responses.

$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_1 X_2 + b_4 X_1^2 + b_5 X_2^2 + b_6 X_1 X_2^2 + b_7 X_1^2 X_2 + b_8 X_1^2 X_2^2$

Where Y-dependent variable, b_0 (intercept), is the average response across nine runs, and b_1 and b_2 are the evaluated coefficients of factors X_1 and X_2. A statistical analysis via multiple regression analysis of the factorial design was passed out using Design Expert 13 as the experiment has more than one independent variable. All independent and dependent variables have been correlated and reported in terms of a correlation coefficient prior to the application of regression(Prasanthi *et al.,* 2023).

Characterization of Telmisartan nanosuspensions

Mean particle size distribution

Particle size and PDI are beneficial because they directly affect formulation stability and efficient distribution(Shid *et al.,* 2014). Z- Avg i.e., average hydrodynamic diameter and PDI for the prepared Telmisartan nanosuspensions are determined using photon correlation spectroscopy (PCS) by means of Zeta sizer Nano ZS90 (Malvern Instruments Ltd., UK). At RT, samples were diluted with triple-distilled water before testing.

Zeta potential (Particle charge)

The physical stability of colloidal systems is shown by the Zeta potential, a measurement of electric charge at the particle's surface. Long-term electrostatic stability of aqueous dispersions is indicated by zeta potential values ±30mV. Through the use of Zeta sizer, the electrophoretic mobility of the particles was determined in this study by Zeta sizer analyzer by means of Zeta sizer Nano ZS90 (Malvern Instruments Ltd., UK), that was determined by Laser Doppler Velocimetry, phase analysis light scattering method.

Drug Content

A portion of the produced nanosuspension, 1 ml, was diluted in methanol and filtered through a 0.2 m filter. By using a UV spectrophotometer at the drug's maximum concentration, the total amount of drug was determined (Ling Yuan Chin *et al.,* 2021).

Total drug content = $\frac{(Totalvolumeofnanosuspension \times Amountofdruginaliquot)}{Volumeofaliquot}$

Drug entrapment efficiency

Entrapment efficiency is suitable method for determining the unentrapped drug present in the prepared formulation.10ml of the freshly made nanosuspensions were centrifuged at 10,000 rpm for 10 min to determine the entrapment efficiency. After removing the supernatant, the percentage of drug that was not trapped was calculated by measuring the optical density at 296 nm with a UV spectrophotometer.

% Entrapment efficiency = $\frac{Massofdruginnanoparticles\ (mg)}{Massofdrugusedintheformulation} \times 100$

***In vitro* drug release studies**

Franz diffusion cell device was used to analyze the drug release of Telmisartan nanosuspensions. The donor compartment of the diffusion cell contained Telmisartan nanosuspension dispersed in 1 ml of media and 12 ml of SNF (pH 6.5) in the receptor compartment, which served as the release media. At set times (0.25, 0.5, 0.75, 1, 1.5, 2, 3, 4, 5, 6, 8, 10 and 12 hrs), a portion of the 2 ml sample was taken out and replaced with the same volume of SNF (pH 6.5) media. The samples were cleared with a 0.22 μ filter, and following the proper dilutions. The content of telmisartan was determined by means of a UV-Visible spectrophotometer with a wavelength of 296 nm. Drug release was observed as a cumulative percentage(Prasanta Kumar *et al.,* 2020).

Stability studies

The optimized Telmisartan nanosuspension was stored at different temperatures for six months. The samples were periodically taken and analyzed for zeta potential and particle size by using Malvern Instrument.

RESULTS

Melting point

Melting point of telmisartan was found using capillary method and the results were within the range of 261 – 263 °c.

Scanning of λ_{max} of Telmisartan

By using the procedure outlined in the experiment, a stock solution of Telmisartan in methanol was prepared. Then, it was detected using a UV-visible spectrophotometer between 200 and 400 nm. Telmisartan UV absorption spectra revealed a λ_{max} at 296 nm.

Calibration curve of Telmisartan

A calibration was constructed by preparing different concentration of Telmisartan in SNF of pH 6.5 in the range of 1, 2,3,4,6 and 8 µg/m by using UV visible spectrophotometer and the solutions were measured for absorbance at 296 nm. The calibration graph was plotted against absorbance and concentration in µg/ml and a regression equation was found to be Y= 0.0506x + 0.0018 with regression coefficient 0.9996 shown in Fig. 3.

Compatibility Studies

FTIR studies

Telmisartan and its physical mixture were subjected to FTIR studies and the characteristic bands shown in the Fig. 4 - 6 were similar for pure drug and physical mixture and hence incompatibility was not seen between drug and its excipients.

Preliminary analysis

Particle size is influenced by the solvent choice. Telmisartan slightly dissolves in ethanol, dichloromethane, chloroform, and soluble in methanol. A precipitate formed after a stock solution of 5ml of Telmisartan in methanol when diluted to 50ml of SNF at pH 6.5, so 0.5% SLS was added to SNF to remove precipitate. Evaluation of the impact of sonication cycles (4, 7, and 10) on particle size and PDI revealed decrease in particle size and PDI with increase in sonication cycles. Telmisartan was evaluated for stability, particle size, and PDI at various stabilizer 0.1 percent, 0.3 percent, and 0.5 percent concentrations w/v in order to create a stable nanosuspension. The mean particle size for the formulations were in the range of 155 nm to 893 nm and PDI from 0.131 to 0.561 with zeta potential in the range of -11.8 to -16. 0mV. The presence of a stabilizer that adhered to the drug particle resulted in a negative outcome. Typically, nanosuspensions are considered stable with zeta potential values of ±20mV. This negative zeta potential in nanosuspensions can be attributed to the use of Tween 80, a non-ionic surfactant that offers steric stabilization. The particle sizes of all nine formulations—F6, F7, F8, and F9—are 496 nm, 382 nm, 190 nm, and 155 nm shown in Fig. 7-10, respectively, with PDI values that fall within the range of 0.264, 0.235, 0.129, and 0.131, demonstrating the stability of the nanosuspensions, limiting the Ostwald ripening phenomena. The outcomes demonstrated that with a rise in stabilizer concentration, there is a reduction in particle size and PDI with increased stability from the preliminary analysis. It was observed that increased concentration of stabilizer and sonication cycles resulted in stable nanosuspension with size of particle, PDI and zeta potential. The entrapment efficiency for formulations was initiate to be in the range of 73% to 86.3%, and for the optimized formulations F6, F7, F8, and F9, the entrapment efficiency was 81%, 83.5%, 84.6%, and 86.3%. The *in vitro* drug release for Telmisartan nanosuspensions were found to be in the range from 89.24±0.11 and 96.15±0.006 after 12 hours. F6, F7, F8, and F9 showed maximal drug releases of 94.86±0.21, 95.32±0.17, 97.29±0.07 and 96.15±0.006. The outcomes of *in vitro* drug

release testing are displayed in Table 2. Reduced particle size and increased surface area led to a higher dissolving rate.

Optimization by Central Composite Design

To evaluate the response with two-factor interactive polynomial statistical model terms in the systems were used.

$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_1 X_2 + b_4 X_1^2 + b_5 X_2^2 + b_6 X_1 X_2^2 + b_7 X_1^2 X_2 + b_8 X_1^2 X_2^2$

Particle size

The formulation F1 with a low stabilizer content (0.1%) and four cycles of sonication was found to have the biggest particle size, 893 nm. Among all nine formulations, F9 has an observed particle size of 155 nm with Tween 80 concentration of 0.5% with sonication cycles of 10. The remarkable Model F-value of 148.79 indicates that the model holds great significance. The probability of this F-value occurring solely due to noise is merely 0.01%, emphasizing its statistical significance. Furthermore, model terms having P-values lower than 0.0500 also indicate their significance. Model terms A, B, and A^2 hold significance in this case. If the values surpass 0.1000, it implies that model terms are not significant. The Predicted R^2 of 0.9666 aligns reasonably well with the Adjusted R square of 0.9823, as the discrepancy is below 0.2. Adequate Precision evaluates the proportion of signal to noise for assessing quality. A value exceeding 4 is considered favorable. A ratio of 32.741 reveals an adequate signal. This particular model proves valuable in exploring the realm of design possibilities. Using coded factors in an equation allows for predictions to be made regarding the response based on the levels of each factor. The default coding assigns a value of +1 to high levels and -1 to low levels of the factors.Comparing the coefficients of the factor, the coded equation proves valuable in pinpointing the relative influence of the factors. Statistical significance was shown in Table 5 and 3D surface response graphs were depicted in Fig. 15.

PDI (Polydispersability index)

For the formulations F1–F9, the polydispersability index ranged from 0.56–0.131 nm.F9 had the best stability of the nine formulations, with an observed PDI of 0.131, indicating that nanosuspensions with a 0.5% Tween 80 concentration and 10 sonication cycles are stable. The remarkable Model F-value of 45.73 indicates that the model holds great significance. The probability of this F-value occurring solely due to noise is merely 0.02%, emphasizing its statistical significance. Furthermore, model terms having P-values lower than 0.0500 also indicate their significance. Model terms A, B hold significance in this case. If the values surpass 0.1000, it implies that the model terms are not significant. The Predicted R square of 0.8685 aligns reasonably well with the Adjusted R square of 0.9179, as the discrepancy is below 0.2. Adequate Precision evaluates the proportion of signal to noise for assessing quality. A value exceeding 4 is considered favorable. A ratio of 17.832 reveals an adequate signal. This particular model proves valuable in exploring the realm of design possibilities. Using coded factors in an equation allows for predictions to be made regarding the response based on the stages of each factor. The defaulting code assigns a +1 to high and -1 to low levels of the factors. Comparing the coefficients of the factor, the coded equation proves valuable in pinpointing the relative influence of the factors. Statistical significance was shown in Table 5 and 3D graphs of surface response were depicted in Fig. 16.

Cumulative % drug release

12hr was selected for cumulative percent drug release as a response in the Design Expert Software. Cumulative drug release for formulations F1- F9 exhibited 89.24±0.11 to 97.29±0.21%. The sustained drug release was found to be 96.15±0.06 in F9 with a 0.5% Tween 80 concentration and 10 sonication cycles are stable. The remarkable Model F value of 63.79 indicates that the model holds great significance. The probability of this F-value occurring solely due to noise is merely 0.01%, emphasizing its statistical significance. Furthermore, model terms having P values lower than 0.0500 also indicate their significance. Model terms A, B hold significance in this case. If the values surpass 0.1000, it implies that the model terms are not significant. The Predicted R square of 0.8884 aligns reasonably well with the Adjusted R square of 0.9401, as the discrepancy is below 0.2. Adequate Precision evaluates the proportion of signal to noise for assessing quality. A value exceeding 4 is considered favorable. A ratio of 20.123 reveals an adequate signal. This particular model proves valuable in exploring the realm of design possibilities. Using coded factors in an

equation allows for predictions to be made regarding the response based on the stages of each factor. The defaulting code gives +1 to high and -1 to low levels of the factors. Comparing the coefficients of the factor, the coded equation proves valuable in pinpointing the relative influence of the factors. Statistical significance was shown in Table 5 and 3D graphs of surface response were depicted in Fig. 17.

Stability studies

F9, the optimized formulation, underwent stability studies by placing it in bottles and storing it at 40 degree ± 2 degree Centigrade/75 ± 5% Relative humidity. The % drug release, particle size, and Zeta potential were evaluated after 30, 60, and 90 days. Table No.3 demonstrates that the optimized formulations remained stable without significant changes in any of the parameters.

DISCCUSION

By adjusting the formulation parameters (stabilizer concentration) and process parameters (sonication cycles), telmisartan-loaded nanosuspensions were created utilizing the anti-solvent precipitation method. The crucial process variables for this technique are the sonication cycles, where pressure is applied and the sonication cycles create cavitation forces that could lead to a reduction in particle size and an increase in Gibbs free energy. This improves bioavailability and increases saturation solubility and dissolving rate. Due to the large surface free energy, the Ostwald ripening phenomenon could occur. Stabilizers are incorporated to prevent the agglomeration and produce a thermodynamically stable system. Therefore, the formulation parameters, such as stabilizer type and stabilizer concentration, are key factors in this formulation. Tween 80, a non-ionic surfactant with several binding sites and a tail, lowers the van der Waal forces of attraction and boosts water solubility. The percent drug release of the formulation (F1-F9) 89.24, 91.85, 95.32, 90.19, 93.21, 97.29, 91.26, 94.86, 96.15%. The drug's compatibility with the stabilizer was validated by the FTIR spectra of improved Telmisartan nanosuspensions. When compared to the pure drug, the drug's FTIR bands in the nanosuspension formulation did not significantly change. The 3^2 factorial design at three levels with -1, 0 and +1 was chosen as an experimental design by Design Expert Software 13. *In vitro* drug release, particle size, and PDI were identified as the dependent variables, whereas stabilizer concentration and sonication cycles were identified as the independent variables. To connect each response to the variables affecting it, polynomial equations were used. A formulation that is optimum was chosen using the desirability function after counter plots and 3D-surface response plots were created. ANOVA was used to determine the significance of the influence on% Drug Release (Y1) and the following polynomial equation was discovered:

$Y1= 93.2633 + 3.01167(X1) + 0.9766(X2)$

The increased surface area helped the nanosuspensions dissolution rate. The rise in stabilizer concentration and sonication cycle is accompanied by an increase in the percentage of drug Release (Y1), as shown by the positive coefficient of X1 and X2 values. The 3D figures in Fig.15 and 17 exhibit a nearly linear ascending pattern for drug release values with decreasing particle size. Model terms are measured significant when the P value is < 0.0500. ANOVA revealed that the effect on particle size (Y2) was significant, and polynomial equation was identified as follows:

$Y2= 595.33 – 270.3(X1) – 98.8333(X2) – 82.6667(X1^2)$

The decrease in particle size with increasing tween 80 concentration and sonication cycles is indicated by the negative sign for coefficients of X1 and X2, respectively. When stabilizer concentration and sonication cycles are low, particle size tends to be higher; when concentration and sonication cycles increase, particle size tends to be lower. To effectively insulate the drug particles from aggregation, the drug particles were shrunk to nanosize ranges. P values < 0.0500 indicate that significant model terms. A reduced concentration of stabilizer causes agglomeration or aggregation, and particle size was toward a greater level. Similar to this, the polydispersity index (Y3) effect was determined to be significant by ANOVA, and the following polynomial equation was discovered:

$Y3= 0.3238 – 0.1515(X1) – 0.0668(X2)$

The concentration of the stabilizer was found to be more dependent on size homogeneity than the PI value suggested. With a P-value less than 0.0500, significant model terms are indicated by the negative sign for the

coefficient of X1, which shows that as stabilizer concentration rises, PI falls and improved homogeneity is seen.In accordance with the guidelines specified in ICH Q1A (R2), stability studies were conducted on the optimized formulations. These formulations were placed inside bottles and then kept in an atmosphere with a temperature of 40° ± 2 °C and relative humidity of 75 ± 5%. Throughout a period of 30, 60, and 90 days, the formulations were regularly assessed for any alterations in the percentage of drug release, particle size, as well as the zeta potential. Remarkably, the optimized formulation exhibited a zeta potential of -16mV accompanied by an impressive drug release rate of 97%. Notably, the particles had a small size of 147.8nm and a low polydispersity index (PDI) value of 0.124.

CONCLUSIONS

The present study aimed at developing Telmisartan loaded nanosuspensions via intranasal route. It is a BCS class II drug, insoluble in water and also has less bioavailability. The current endeavor focuses on the creation of nanosuspensions through the utilization of the anti-solvent precipitation method, employing Quality by Design (QbD) principles. A range of different mixtures, labeled F1-F9, were created by incorporating Tween 80 as a stabilizer and methanol as an organic solvent. The process of optimizing Telmisartan nanosuspensions (F1-F9) included the optimization of independent variables, specifically the concentration of Tween 80, which was varied between 0.1, 0.3, and 0.5% and probe sonication for 4, 7cycles. *In vitro* drug release, particle size, and PDI were analyzed using Central composite design from methodology of Response surface with Design Expert software 13. The dependent variables were assessed. The software proposed a blend of variables for consideration. The optimized formulation (F9) was observed to have a drug release of 96.15% *in vitro*, with a particle size of 155 nm and a poly dispersability of 0.131, which was statistically significant with a P value < 0.0500. The suggested optimized formulation demonstrated comparable outcomes to the predicted values. Analysis conducted on the optimized formulation revealed no interaction between the drug excipients. Consequently, the examination deduced that a rise in the stabilizer concentration along with multiple probe sonication cycles would cause a boost in the *in vitro* discharge of the drug, while simultaneously reducing particle size and PDI. This outcome could potentially enhance the solubility and bioavailability of Telmisartan nanosuspensions.

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Conflict of interest

The authors hereby report that there is no conflict of interest to carry out this work.

Abbreviations

BCS: Biopharmaceutical classification system; QbD: Quality by design; BBB: Blood-brain barrier; CNS: Central nervous system; ARB: Angiotensin receptor blocker; USFDA: United States Food and Drug Administration; FTIR: Fourier Transform Infrared Spectroscopy; IR: Infrared; nm: Nano meter; SNF: Stimulated nasal fluid; SLS: Sodium laurel sulphate; PDI: Polydispersity Index; mg: Milli grams; ml: Milliliter; mV: *Millivolt;* °C: Degrees centigrade; rpm: Revolutions per minute; ANOVA: Analysis of Variance; hr: hour; PPAR: Peroxisome proliferators–activated receptor; µg: Micrograms; m: meter; µ: Micro; RH: Relative humidity; µL: Microliters TEL: Telmisartan; NS: Nanosuspensions; UV: Ultraviolet.

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Table 1: Formulation trails for Telmisartan nanosuspensions

Formulation batch	Drug (% W/V)	Tween 80 (%V/V)	Methanol (% V/V)	Water (% q.s.)	Probe sonication cycles
F1	0.04	0.1	8	32	4
F2	0.04	0.1	8	32	7
F3	0.04	0.1	8	32	10
F4	0.04	0.3	8	32	4
F5	0.04	0.3	8	32	7
F6	0.04	0.3	8	32	10
F7	0.04	0.5	8	32	4
F8	0.04	0.5	8	32	7
F9	0.04	0.5	8	32	10

Table 2: Particle size, PDI, Zeta potential and In vitro studies of F1 to F9 Telmisartan nanosuspension

Formulation code	Particle size in nm	Poly Dispersity Index	Zeta potential in mV	Percent Drug release	Percent entrapment efficiency
F1	893	0.561	-11.8	89.24±0.11	73
F2	761	0.406	-12.0	91.85±0.07	75
F3	695	0.437	-13.9	95.32±0.23	78.5
F4	681	0.437	-12.1	90.19±0.003	80
F5	592	0.315	-14.6	93.21±0.09	80.5
F6	513	0.264	-14.2	97.29±0.21	81
F7	382	0.23	-13.9	91.26±0.17	83.5
F8	190	0.129	-15.7	94.86±0.07	84.6
F9	155	0.131	-16.0	96.15±0.006	86.3

Table: 3 *In vitro* dissolution studies of Telmisartan nanosuspensions F1 to F9

Time (hr)	F1	F2	F3	F4	F5	F6	F7	F8	F9
15	6.1±0.11	5.18±0.002	5.56±0.07	1.2±0.12	4.5±0.02	9±0.03	2.89±0.12	5.87±0.02	3.81±0.11
30	8.40±0.13	8.79±0.09	14.51±0.03	1.9±0.24	9.6±0.18	11.84±0.05	9.46±0.06	8.48±0.11	8.25±0.02
45	11.55±0.2	9.65±0.12	15.85±0.22	12.5±0.11	18.7±0.05	12.84±0.18	15.28±0.02	10.79±0.13	10.63±0.15
1	11.73±0.1	9.90±0.06	18.02±0.26	20.3±0.14	19.05±0.	21.27±0.08	16.32±0.16	13.18±0.03	13.02±0.03
1.5	12.14±0.07	12.82±0.15	23.70±0.13	21.8±0.06	22.14±0.21	25.46±0.13	17.81±0.22	13.36±0.06	16.18±0.05
2	12.77±0.14	16.97±0.11	23.70±0.17	26.04±0.02	24.7±0.07	27.1±0.25	21.89±0.11	26.43±0.12	18.39±0.13
3	16.69±0.08	20.97±0.04	30.53±0.21	27.69±0.21	24.9±0.2	28.3±0.04	22.17±0.14	27.73±0.22	25.59±0.21
4	17.65±0.06	27.44±0.12	35.11±0.11	39.41±0.01	26.8±0.12	29.4±0.12	23.51±0.07	29.85±0.003	34.47±0.12
5	28.21±0.18	31.32±0.16	37.07±0.13	43.7±0.05	35.07±0.15	30.9±0.24	26.3±0.03	32.35±0.18	48.34±0.24
6	48.17±0.14	40.57±0.22	45.25±0.05	47.4±0.26	58.3±0.005	48.9±0.11	28.9±0.22	47.8±0.05	54.01±0.11
8	51.28±0.21	54.27±0.05	50.68±0.07	68.5±0.28	69.5±0.07	52.5±0.14	43.5±0.26	79.3±0.1	60.67±0.26
10	78.50±0.13	80.20±0.03	67.20±0.14	76.3±0.009	82.5±0.23	79.3±0.06	64.8±0.13	82.5±0.21	87.04±0.12
12	89.24±0.11	91.85±0.07	95.32±0.23	90.19±0.003	93.21±0.09	97.29±0.21	91.26±0.17	94.86±0.07	96.15±0.006

Table: 4 Independent and dependent variables of Telmisartan nanosuspensions by using Central Composite Design

Std	Run	Independent variables		Dependent variables		
		Factor 1	Factor 2	Response 1	Response 2	Response 3
		A: Tween 80	B: Probe Sonication	*Invitro* drug release	Particle size	PDI
		%	Cycles	%	nm	%
9	1	0.3	7	93.21	592	0.315
8	2	0.3	10	94.86	513	0.264
1	3	0.1	4	89.24	893	0.561
5	4	0.1	7	90.19	761	0.406
3	5	0.1	10	91.26	695	0.437
6	6	0.5	7	97.29	190	0.129
2	7	0.5	4	95.32	382	0.235
7	8	0.3	4	91.85	681	0.437
4	9	0.5	10	96.15	155	0.131

Statistical significance (P< 0.05)

Table: 5 Coefficient table

	Intercept	A	B	AB	A^2	B^2
***In vitro* drug release**	93.2633	**3.01167**	**0.976667**			
p-values		**< 0.0001**	**0.0131**			
Particle size	595.333	**-270.333**	**-98.8333**		**-82.6667**	
p-values		**< 0.0001**	**0.0008**		**0.0181**	
PDI	0.323889	**-0.1515**	**-0.0668333**			
p-values		**0.0001**	**0.0084**			

Statistical significance (P< 0.05)



Fig. 1. Preparation of Telmisartan nanosuspension

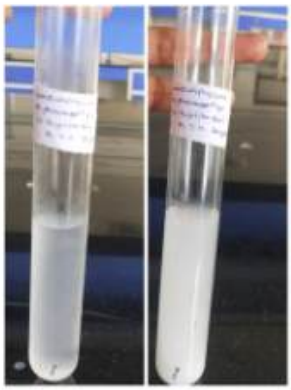


Fig. 2. Redispersion of formulated Telmisartan nanosuspension

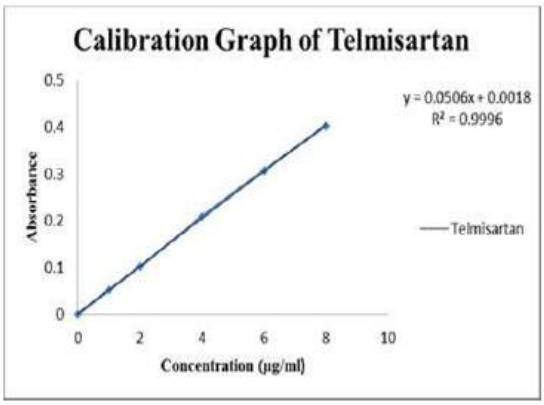


Fig. 3. Standard curve of Telmisartan in SNF pH 6.5

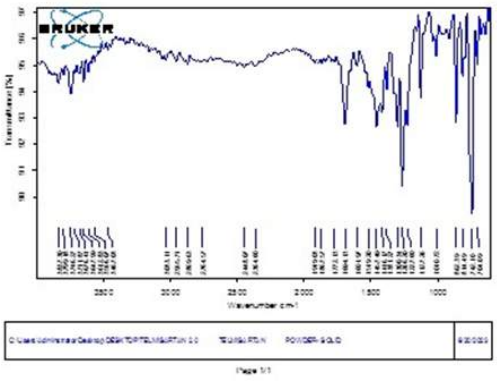


Fig. 4. FT-IR spectra of Telmisartan

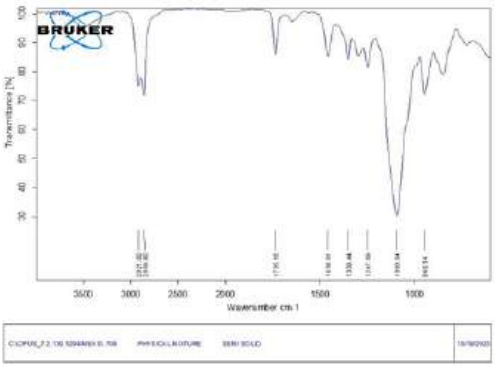


Fig. 5. FT-IR spectra of Telmisartan physical mixture

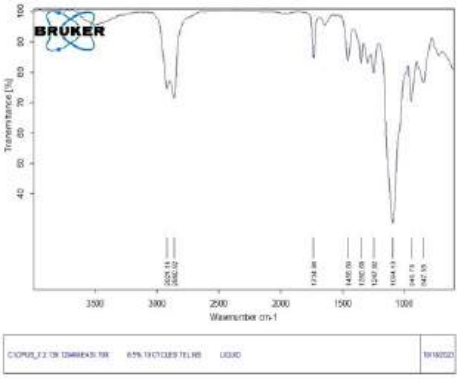


Fig. 6.Optimized formulation FT-IR spectra of Telmisartan Particle size graph for Telmisartan nanosuspension F7-F10:

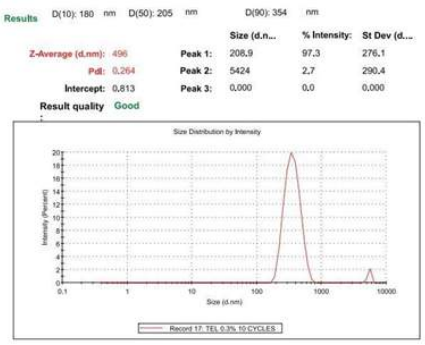


Fig. 7. Size distribution of TELNS for 0.3% 10 cycles

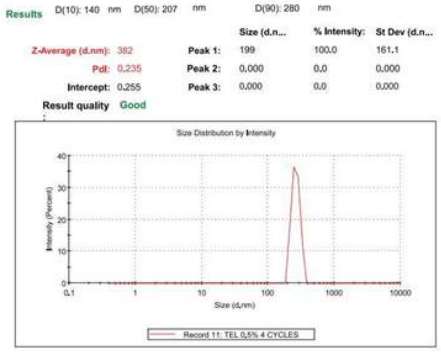


Fig. 8. Size distribution of TEL NS for 0.5% 4 cycles

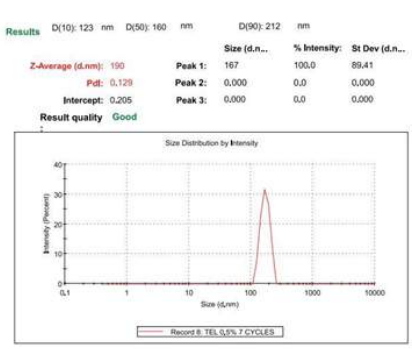


Fig. 9. Size distribution of TEL NS for 0.5% 7 cycles

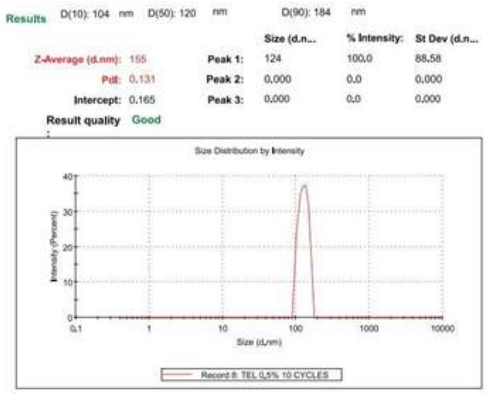


Fig. 10. Size distribution of TEL NS for 0.5% 10 cycles

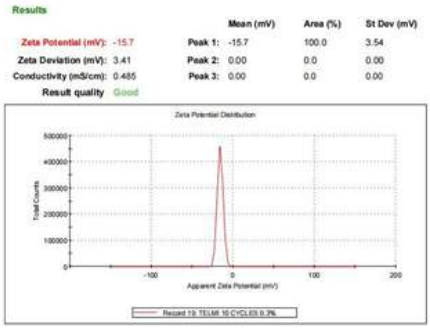


Fig. 11. TEL NS Zeta potential distribution for 0.3%, 10 cycles

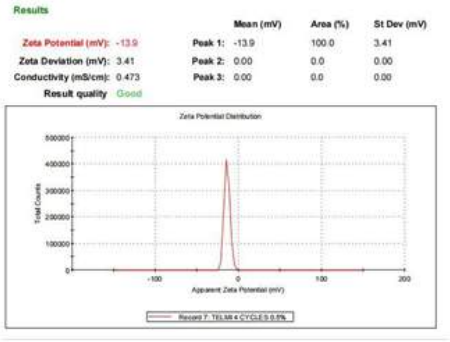


Fig. 12. TEL NS Zeta potential distribution for 0.5% 4 cycles

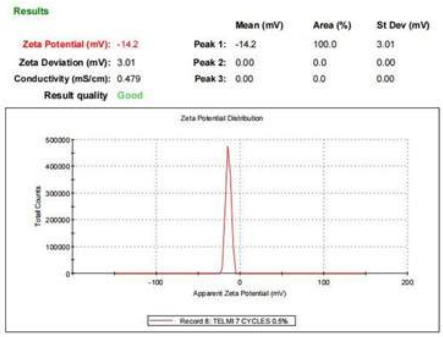


Fig. 13. TEL NS Zeta potential for 0.5% 7 cycles

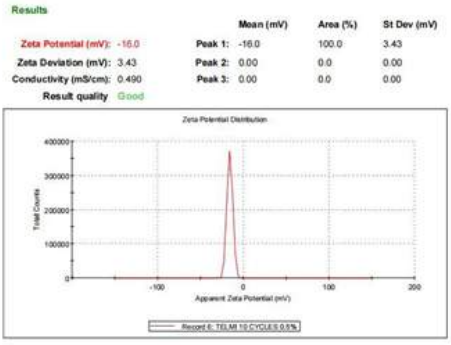


Fig. 14. TEL NS Zeta potential for 0.5% 10 cycles

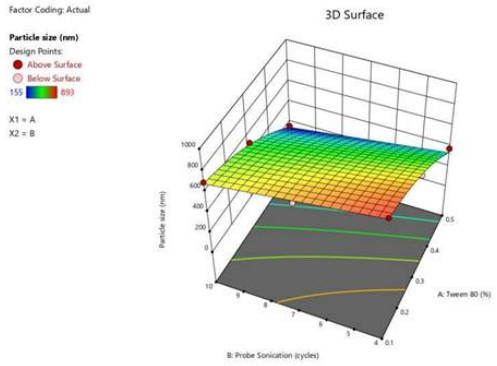


Fig. 15. ANOVA for reduced quadratic model

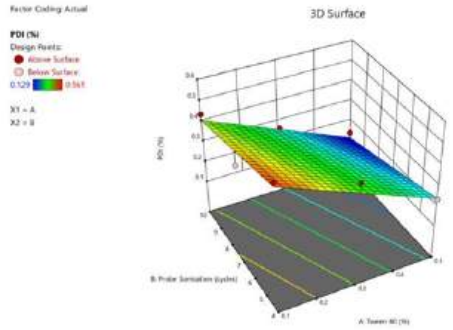


Fig. 16. ANOVA for linear model

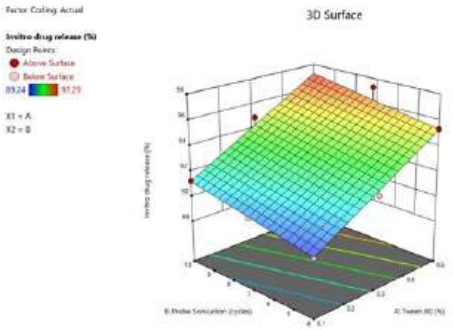


Fig. 17. ANOVA for linear model

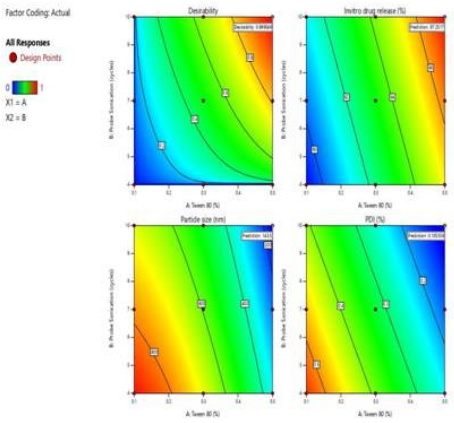


Fig. 18. Numerical counter plot with desirability and prediction

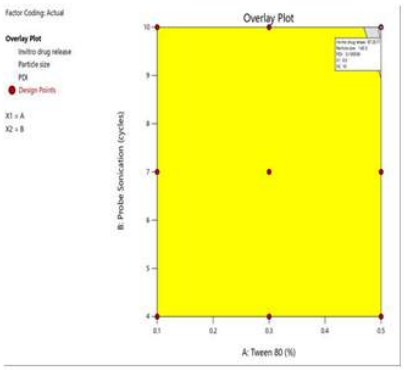


Fig. 19. Overlay plot

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RESEARCH ARTICLE

Bioactive Chitosan PVA Films with Pomegranate Peel Powder for Food Packaging Applications

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ABSTRACT

Chitosan-based edible films are gaining attention as sustainable alternatives to synthetic plastic packaging due to their biodegradability, biocompatibility, and antimicrobial properties. However, pure chitosan films often exhibit poor mechanical strength and barrier properties. To enhance their functionality, pomegranate peel extract (PPE) is incorporated into chitosan-polyvinyl alcohol (PVA) films. PPE, rich in bioactive compounds like polyphenols and flavonoids, contributes antioxidant and antimicrobial properties, improving film durability and extending food shelf life. The films were synthesized using the solvent casting method, and their structural, mechanical, and physicochemical properties were analysed. Fourier Transform Infrared Spectroscopy (FTIR) confirmed the presence of key functional groups, while X-ray Diffraction (XRD) analysis indicated a crystalline structure with a 0.263 nm particle size. Contact angle measurements showed moderate hydrophobicity (91.73°–95.39°), suggesting their suitability for food packaging and biomedical coatings. Scanning Electron Microscopy (SEM) revealed a rough, porous morphology, while Energy Dispersive X-ray Spectroscopy (EDS) confirmed a high carbon-oxygen content. The incorporation of PPE enhanced the mechanical and barrier properties of the films, making them more effective for food preservation. These findings highlight the potential of PPE-infused chitosan-PVA films as eco-friendly alternatives for packaging and biomedical applications.

Keywords: Chitosan-based films, Pomegranate peel extract (PPE), Antimicrobialproperties, Food packaging, Biodegradability

INTRODUCTION

Chitosan-based edible films have gained significant interest due to their biodegradability, biocompatibility, and antimicrobial properties. Derived from chitin, chitosan is a natural polymer widely used in food packaging as a sustainable alternative to synthetic plastics.(1) These films offer a promising solution to reduce plastic waste while maintaining food quality and safety. However, chitosan alone has limitations in mechanical strength and barrier properties, necessitating the incorporation of natural additives to enhance its performance. One such additive is pomegranate peel extract (PPE), a byproduct of the fruit industry rich in bioactive compounds such as polyphenols, flavonoids, and tannins. These compounds exhibit strong antioxidant and antimicrobial properties, making PPE a valuable ingredient for improving the functional properties of chitosan-based films. (2)When PPE is added, it enhances the film's mechanical strength, increases water vapour resistance, and provides bioactive protection against spoilage microorganisms, thereby extending the shelf life of perishable foods. (3) The incorporation of PPE into chitosan-based edible films not only improves food preservation but also contributes to environmental sustainability. This approach aligns with the principles of a circular economy by repurposing agro-industrial waste into valuable packaging materials.(4) Utilizing natural waste-derived additives reduces the dependency on synthetic chemicals, making the packaging process eco-friendlier and more cost-effective. Additionally, PPE's strong antimicrobial and antioxidant properties reduce the need for artificial preservatives in food products. Chitosan-based edible films are composed of chitosan as the primary matrix, along with plasticizers and functional additives to improve their properties. (5) Plasticizers such as glycerol and sorbitol enhance flexibility, reducing brittleness, while nanoparticles like titanium dioxide improve mechanical strength and barrier properties.

Blending chitosan with other biopolymers such as proteins or polysaccharides further enhances its water resistance and flexibility, making the films more suitable for food packaging applications. (6) Despite their advantages, chitosan films have some limitations, primarily their hydrophilic nature, which affects their resistance to moisture. However, combining chitosan with PPE and other natural reinforcements can improve moisture barrier properties while maintaining transparency and mechanical strength. (7) The films also offer moderate protection against oxygen and carbon dioxide, which helps prevent oxidation and spoilage of packaged foods. Moreover, they are soluble in acidic conditions and completely biodegradable, reinforcing their role as a sustainable alternative to conventional plastic films. The extraction of PPE is carried out using various methods such as solvent extraction, ultrasound-assisted extraction, microwave-assisted extraction, supercritical fluid extraction, and enzymatic extraction. (8) Each method influences the concentration of bioactive compounds obtained, thereby impacting the effectiveness of the resulting chitosan-based films. The choice of extraction technique plays a crucial role in optimizing the antimicrobial and antioxidant performance of PPE-enriched edible films. Chitosan edible films incorporating PPE have applications beyond food packaging, extending to pharmaceuticals and nutraceuticals. These films serve as natural biodegradable carriers for drug delivery, wound dressings, and antimicrobial coatings for biomedical use. In food packaging, they act as protective barriers for fresh produce, meat, seafood, and dairy products, significantly extending their shelf life. As global demand for sustainable and functional packaging solutions increases, chitosan-PPE films emerge as a promising alternative to synthetic materials, supporting both food safety and environmental conservation.

MATERIALS AND METHODS

Materials Used

The materials used in this study include pomegranate peel powder (PGP), a natural biopolymer known for its biocompatibility, biodegradability, antibacterial properties, and antioxidant activity. The PGP was dissolved in 1% aqueous ascorbic acid at room temperature to form the base solution. Polyvinyl alcohol (PVA) was used as a binding agent for the synthesis of PGP-based PVA films. The reaction mixtures were prepared using standard laboratory glassware, including beakers and standard measuring flasks, to ensure accurate measurement of all solutions.(9) A magnetic stirrer equipped with a stirrer bar was used continuously to maintain uniform mixing throughout the synthesis process.

Polyvinyl Alcohol (PVA)

Polyvinyl alcohol (PVA) is a synthetic polymer obtained by hydrolysing polyvinyl acetate. It is hydrophilic, exhibits excellent film-forming properties, and possesses emulsifying and adhesive capabilities. PVA is resistant to grease, oils, and solvents, making it suitable for applications requiring stability and strength. It is water-soluble and has a high tensile strength, ensuring the durability of the films produced. (10) The polymer's flexibility is attributed to its intra- and intermolecular associations, which influence its thermal and mechanical behavior.

Chitin and Chitosan

Chitin is a naturally occurring biopolymer found in the exoskeletons of arthropods and fungal cell walls. It is primarily composed of N-acetyl-D-glucosamine and is commercially extracted from fungi and crustacean shells. Chitosan is derived from chitin through a deacetylation process. It is water-insoluble but dissolves in acidic solutions, demonstrating antimicrobial properties against bacteria, yeast, and fungi. Due to its excellent film-forming ability, chitosan is widely used in biodegradable membranes and coatings for food preservation. These membranes are known for their selective gas permeability, biocompatibility, and non-toxicity.

Preparation of Pomegranate Peel Chitosan

Chitosan was extracted from pomegranate peel (PGP) using a multi-step chemical process involving deproteination, demineralization, purification, deacetylation, and drying. (11)

Materials Needed

- Pomegranate peel material
- Sodium hydroxide (NaOH) (for deproteinization and demineralization)
- Hydrochloric acid (HCl) (for demineralization)
- Ethanol (for washing and cleaning)
- Deionized water
- PVA (Polyvinyl Alcohol)

Source of Chitin

Pomegranate peel was used to enhance the antioxidant capacity of the chitosan film. The peels were dried to remove excess moisture using air drying or a drying oven at 50–60°C for several hours. The dried peels were then ground into a fine powder. (12)

Deproteination

5 g of pomegranate peel powder was treated with a 4N NaOH solution at 80–90°C for 1–2 hours to break down proteins. The treated powder was then washed with deionized water to remove residual NaOH and dissolved proteins.

Demineralization

The dried PGP material was immersed in a 1M HCl solution for 2–3 hours to dissolve minerals such as calcium and magnesium salts. After acidification, the solution was centrifuged to extract chitin. (13)

Purification

Chitin was purified by washing with ethanol or acetone to remove residual organic solvents and impurities.

Deacetylation

To convert chitin into chitosan, it was treated with a 60% NaOH solution at 90°C for 2–4 hours, which removed the acetyl groups.

Washing

After deacetylation, the chitosan was thoroughly washed with deionized water to remove residual solutions.

Drying and Powdering

The resulting chitosan was dried using air drying, vacuum drying, or oven drying at temperatures below 50°C.(12) Once dried, it was ground into a fine powder. The degree of deacetylation was adjusted to optimize purity.

Preparation of PVA/Chitosan/PGP Films

To fabricate thin films, the following procedure was followed: A 50 mL solution of 1 wt.% PVA was prepared by dissolving PVA in deionized water at 90°C under continuous mechanical stirring until a clear solution formed. Separately, a 1 wt.% chitosan solution was prepared by dissolving chitosan in 1% ascorbic acid (AA) at room temperature under constant stirring. (14) The PVA solution and the prepared chitosan/AA solution were combined and mixed using a mechanical stirrer at room temperature, with AA serving as a cross-linking agent. The mixture was stirred for 1 hour to ensure the completion of the cross-linking reaction. The viscous composite solution was poured into Petri dishes and dried at room temperature. The film thickness was adjusted based on the volume of the solution used. Once dried, the films were carefully removed from the casting surface. (15) These films exhibited uniform thickness and were assessed for their mechanical and chemical properties after preconditioning. The combination of PVA, chitosan, and AA resulted in hydrogen bonding and ionic cross-linking, involving interactions between the amino groups in chitosan and the hydroxyl groups in PVA.

RESULTS AND DISCUSSION

FOURIER TRANSFORM INFRARED SPECTROSCOPY(FTIR) ANALYSIS

FTIR spectroscopy confirmed the successful formation of the PVA film from pomegranate peel powder chitosan by identifying key functional groups. Peaks at 3373–3525 cm^{-1} indicated O–H stretching, while peaks at 2974–2888 cm^{-1} corresponded to C–H stretching, characteristic of aliphatic and aromatic compounds. The presence of C=O stretching at 1720 cm^{-1} suggested ketones, aldehydes, or esters, while peaks at 1600–1500 cm^{-1} indicated C=C stretching, associated with aromatic rings or alkenes. Additional peaks at 1249 cm^{-1}, 1373 cm^{-1}, and 1080 cm^{-1} confirmed C–O bonds and C–H bending vibrations, further validating the film's structural composition.

X-RAY DIFFRACTION Analysis

Fig 3.2 X- Ray Diffraction Analysis of PCF

X-ray diffraction (XRD) analysis of the pomegranate chitosan film (PCF) was conducted to determine its crystalline structure, particle size, strain, and lattice parameters. Using the Scherrer equation, the particle size was calculated as 0.263 nm. The dislocation density was found to be 14.45 nm^{-2}, while the microstrain was estimated at 0.0237. Lattice parameter calculations, assuming a (111) plane reflection, yielded a value of 0.763 nm. These results confirm the crystalline nature of the film and provide insights into its structural integrity and material properties. of the chitosan-PVA film (PCF) revealed moderate hydrophobicity, with average contact angles ranging from 91.73° to 95.39°. The film's water resistance suggests its suitability for applications such as biomedical coatings, packaging, and water-resistant materials. The presence of pomegranate peel powder may influence surface roughness and wettability. Minor variations in contact angles could be attributed to differences in film composition or testing conditions. If enhanced hydrophilicity is required, modifications like plasma treatment or crosslinking with hydrophilic agents could be explore.

FIELD SCANNING ELECTRON MICROSCOPE

Field Emission Scanning Electron Microscopy (FE-SEM) of the synthesized PCF sample at 430x magnification revealed irregularly shaped, rough, and porous particles, indicating possible thermal or chemical degradation. A bright spot suggests the presence of a material with a higher atomic number or distinct surface characteristics. The relatively smooth background implies a uniform substrate. The rough morphology suggests the sample may contain carbonaceous residue, degraded polymer, or inorganic material, with possible impurities or phase variations.

ENERGY DISPERSIVE X-RAY SPECTROSCOPY(EDX)

Energy Dispersive X-ray Spectroscopy (EDS) analysis of the PCF sample confirmed the presence of carbon (64%), oxygen (34%), and sodium (2%), with carbon being predominant. Elemental mapping showed a uniform distribution of carbon and oxygen, while sodium appeared in minimal amounts, likely as an impurity. The Smart Quant Results indicated a primarily organic composition, with 54.37% carbon, 44.22% oxygen, and 1.41% sodium by weight. The overall characterization of Chitosan-PVA films with pomegranate peel powder confirmed functional group presence (FTIR), crystalline structure with a 0.263 nm particle size (XRD), moderate hydrophobicity (93°–95°) (contact angle analysis), rough porous morphology (SEM), and high carbon-oxygen content (EDS), making the film suitable for biomedical coatings, food packaging, and functional materials

CONCLUSION

The combination of chitosan and PVA enhances film flexibility, biodegradability, and overall performance. Given their ability to extend shelf life and reduce synthetic plastic usage, these films represent a promising eco-friendly alternative for sustainable food packaging. The characterization of Chitosan-PVA films enhanced with pomegranate peel powder was successfully analyzed through FTIR spectroscopy, SEM analysis, XRD analysis, and contact angle measurements. FTIR Analysis confirmed the successful formation of the PVA-based film with characteristic peaks corresponding to functional groups present in chitosan, PVA, and pomegranate peel powder. The presence of O–H, C–H, C=O, and C=C bonds suggests the integration of organic components contributing to the film's structural properties. XRD Analysis revealed a broad peak around 20° 2θ, indicating an amorphous or nanocrystalline nature of the film. The presence of low-intensity peaks suggests some degree of crystallinity, likely influenced by the interaction between chitosan, PVA, and pomegranate peel powder. Contact Angle Analysis demonstrated that the films exhibit moderate hydrophobicity, with contact angles ranging between 91.73° and 95.39°. This suggests that the films repel water to a certain extent, making them suitable for applications requiring water-resistant properties. The slight variations in contact angle measurements may be attributed to differences in surface roughness, composition, or testing conditions. The FE-SEM analysis of the PCF sample reveals irregular, rough, and porous particles, suggesting possible thermal or chemical degradation. A bright spot in the image indicates compositional variations or impurities. The EDX results confirm a composition mainly of carbon (C) and oxygen (O), with a minor presence of sodium (Na). The high carbon and oxygen content suggests an organic or polymeric material with oxygen-based functional groups. Sodium's minimal presence may indicate impurities or specific compounds. These findings highlight the sample's potential applications in energy storage, coatings, or biomaterials. The Chitosan-PVA film with pomegranate peel powder exhibits desirable functional properties, including structural integrity, controlled crystallinity, and moderate hydrophobicity. These characteristics make the material a potential candidate for applications in biomedical coatings, food packaging, and water-resistant materials. Further modifications or optimization can be explored to tailor the film’s properties for specific applications which can be used as for food packaging industries.

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Table:1 Contact Angle Measurements

Image	Left Angle (°)	Right Angle (°)	Average Contact angle (°)
First	93.31°	91.15°	91.73°
Second	94.22°	96.55°	95.39°
Third	92.31°	94.22°	93.27°

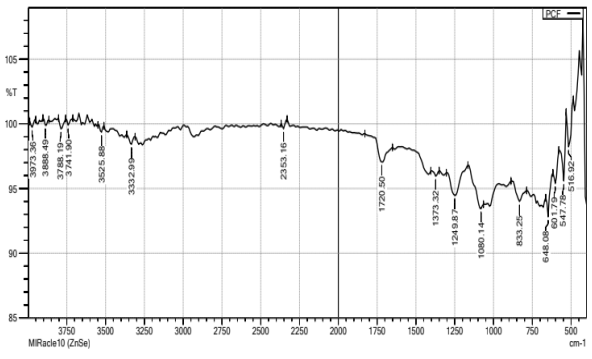


Fig .1 FTIR Analysis of PCF

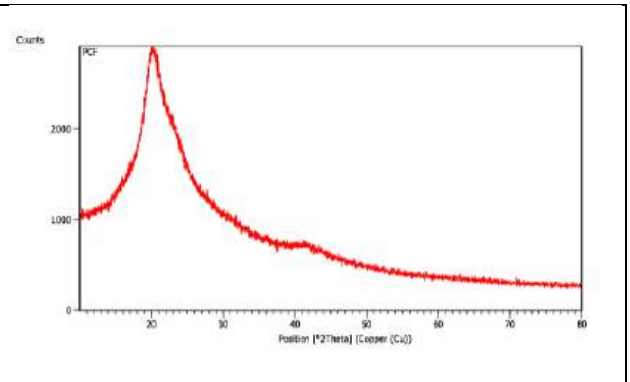


Fig .2 X- Ray Diffraction Analysis of PCF

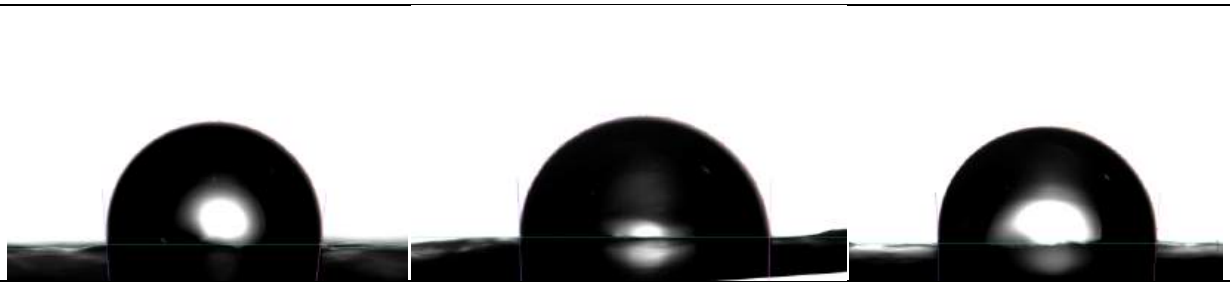


Fig.3 Contact angle Analysis of PCF (1)(2)(3)

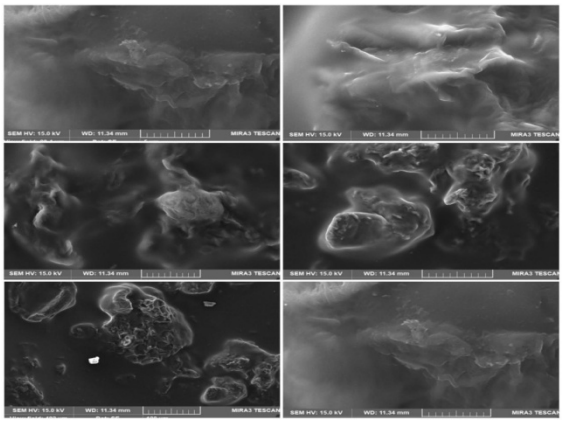


Fig .4 SEM image of the synthesized PCF sample

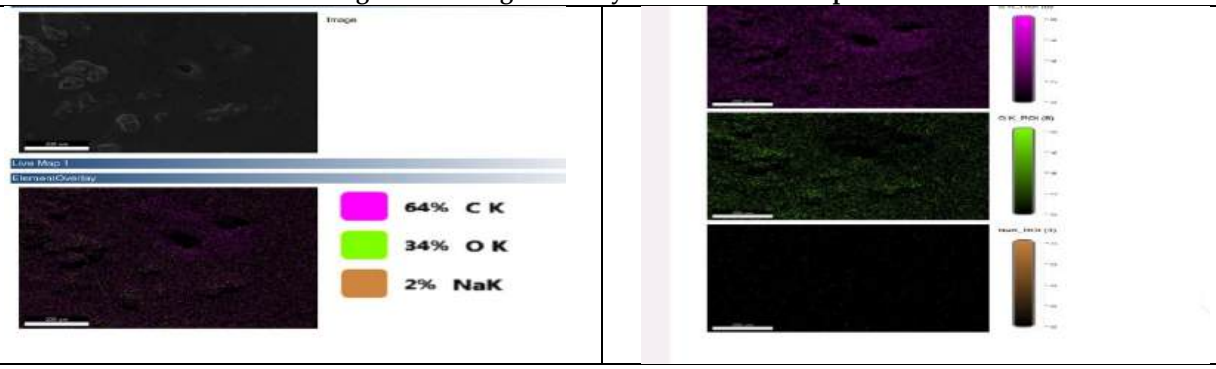


Fig .5 (EDX) spectroscopy Analysis

RESEARCH ARTICLE

Harnessing Deep Learning Ensembles for Breast Cancer Detection"

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ABSTRACT

Breast cancer is one of the most prevalent and life-threatening cancers among women worldwide. Early and accurate detection is crucial for effective treatment and improving survival rates. This study proposes an ensemble approach combining deep neural networks (DNNs) and recurrent neural networks (RNNs) for detecting and classifying breast cancer from numerical datasets. The ensemble model leverages the strengths of both architectures, harnessing the feature extraction capabilities of DNNs and the temporal modelling prowess of RNNs. The proposed method utilizes numerical features derived from various medical imaging modalities and patient data. Extensive experiments were conducted on publicly available breast cancer datasets, and the results demonstrate the superiority of the ensemble approach over individual models, achieving high accuracy, sensitivity, and specificity. The proposed method holds promise for aiding clinicians in making informed decisions and improving breast cancer diagnosis.

Keywords: Breast Cancer Detection, Deep Learning, Ensemble Models, Recurrent Neural Networks (RNN), Feature extraction.

INTRODUCTION

Breast cancer is one of the most prevalent and life-threatening malignancies affecting women worldwide. Early and accurate detection of breast cancer is crucial for improving patient outcomes and reducing mortality rates. In recent years, the field of artificial intelligence, particularly deep learning, has emerged as a powerful tool for automating and enhancing the diagnosis and classification of breast cancer using various data sources, including medical images and numerical datasets. One promising approach that has gained attention in the research community is the utilization of an ensemble of deep learning models for detecting and classifying breast cancer. This ensemble-based approach combines the strengths of different neural network architectures, such as deep neural networks (DNNs) and recurrent neural networks (RNNs), to create a more robust and accurate decision-making system. [2][4][7][8] The rationale behind this ensemble approach is to leverage the unique capabilities of each deep learning model to capture diverse patterns and features within the data, ultimately leading to improved performance in breast cancer detection and classification. By incorporating numerical datasets, such as gene expression data and other clinical information, along with these deep learning techniques, researchers aim to develop comprehensive and effective computer-aided diagnostic systems that can assist clinicians in the early and precise identification of breast cancer cases. [8][9] This introduction provides a foundational understanding of the potential of ensemble deep learning models, encompassing both DNNs and RNNs, for the detection and classification of breast cancer using numerical datasets. The following sections will delve into the specific techniques, findings, and implications reported in the provided context. [1][3][6][10]

MATERIALS AND METHODS

LITERATURE REVIEW

Maged Nasser and Umi Kalsom Yusof [1] systematically analyzed 95 research works that leveraged deep learning techniques, primarily Convolutional Neural Networks (CNNs), for breast cancer diagnosis using genetic or imaging data. The findings indicate that while CNNs are widely used and demonstrate high accuracy, the incorporation of attention mechanisms in image classification tasks is underutilized. The authors suggest that combining diverse gene sequencing datasets could enable more comprehensive and scalable analyses, and extracting meaningful features from gene expression data holds the potential to improve diagnostic outcomes. Identified future research directions include developing multiclass predictors for risk assessment and recurrence prediction, as well as creating large-scale, meticulously labeled whole-slide imaging datasets. The review underscores the transformative potential of deep learning, especially CNNs, in breast cancer diagnosis. **Salman Zakareya and,Habib Izadkhah [2]** introduces a novel granular computing-based deep learning model for breast cancer detection, incorporating features from GoogLeNet and ResNet architectures. Granular computing extracts crucial image features, requiring fewer images for training. The proposed model achieved significant accuracy improvements of 93% on ultrasound image datasets and 95% on histopathology image datasets, offering promise for early detection and improved diagnostic accuracy in breast cancer. **Mayra C. Berrones-Reyes and M. Angélica Salazar-Aguilar et. al** aimed to enhance medical image classification, prioritizing the needs of specialists and addressing challenges in the YERAL dataset. Their work revisited dated strategies, uncovering their potential to augment modern techniques. The bagging ensemble model, integrated with VGG-16 via transfer learning, excelled, alongside promising results from stacking and boosting algorithms. The blend of traditional machine learning and deep learning proved effective, yet complex architectures posed challenges, notably with hardware limitations and diverse dataset distributions. The study highlights the difficulty of solely relying on deep learning for medical imaging, cautioning against the potential introduction of noise from benchmark datasets. [9] **Haitham Elwahsh and Medhat A. Tawfeek et. al [10]** stress the complexity of cancer diagnosis, necessitating intelligent algorithms. Traditional single-expert reliance falls short due to cancer's multifaceted nature. While machine learning and deep learning are common for prognostication, concerns persist about precision. They propose the Deep Neural Learning Cancer Prediction Model (DNLC), leveraging deep neural networks to analyze vast clinical and genetic data swiftly. DNLC comprises three stages: feature selection via Deep

Network, deep neural network training on genomic or clinical data, and early cancer detection assessment. Across five datasets, DNLC excelled, achieving an impressive 93% average accuracy, highlighting deep learning's potential in improving cancer diagnosis amidst challenges of traditional approaches. **Muhammad Shahid Iqbal and Waqas Ahmad et. al [3]** examined recent research on using various deep learning (DL) techniques, such as CNNs, RNNs, GoogLeNet, ResNet, and ANNs, for breast cancer diagnosis from imaging data. The review also introduced publicly available datasets and source code repositories in this domain. While DL-based diagnostic methods have shown significant progress, their reliability for real-world applications is still a concern. A key challenge is the limited availability of training data, which can be addressed through strategies like collecting high-quality datasets, generating new samples using image composition, and leveraging domain-aware transfer learning. The review also highlighted the potential of fusing multiple data sources and employing ensemble DL models with knowledge distillation techniques to improve diagnostic performance and computational efficiency. **Hager Saleh and Sara F. Abd-el ghany et. al [7]** compared traditional machine learning (ML) and deep learning (DL) approaches for breast cancer prediction. They proposed an optimized deep Recurrent Neural Network (RNN) model using the RNN architecture and Keras-Tuner optimization. The deep RNN model included an input layer, six hidden layers, six dropout layers, and an output layer, with optimized neuron numbers and dropout layer values. ML methods such as Decision Tree, Random Forest, Support Vector Machine, Naive Bayes, and K-Nearest Neighbors were compared with the deep RNN model. The optimized deep RNN model, with features selected using the univariate method, exhibited superior performance in both cross-validation and testing, indicating its superiority over traditional ML models in breast cancer prediction.

Pseudo code Description

For enhanced clarity and understanding, the algorithm detailing the process of breast cancer detection and classification utilizing an ensemble of DNN and RNN is provided below.

Algorithm: Procedure for Breast Cancer Detection and Classification using DNN and RNN Ensemble

Input: Wisconsin Breast Cancer Dataset (WBCD)

Output: Predicted cancer status (Malignant or Benign)

Input

- Training dataset $Dtrain$={(Xi,yi)}i=1$Ntrain$ $Dtrain$={(Xi,yi)}i=1$Ntrain$
- Validation dataset $Dval$={(Xi,yi)}i=1$Nval$ $Dval$={(Xi,yi)}i=1$Nval$
- Test dataset $Dtest$={(Xi,yi)}i=1$NtestDtest$={(Xi,yi)}i=1$Ntest$

Initialization

- Define a list of candidates DNN architectures and hyperparameters.
- Define a list of candidates RNN architectures and hyperparameters.
- Set ensemble size KK.
- Set evaluation metric (e.g., accuracy, F1 score).

Model Training and Selection

- For each DNN architecture and hyperparameter combination:
  - Train a DNN model on $Dtrain$ $Dtrain$.
  - Evaluate the model on $Dval$ $Dval$ using the chosen evaluation metric.
- Select $KdKd$ DNN models with the highest performance on $DvalDval$.
- For each RNN architecture and hyperparameter combination:
  - Train an RNN model on $DtrainDtrain$.
  - Evaluate the model on $Dval$ $Dval$ using the chosen evaluation metric.
  - Select $KrKr$ RNN models with the highest performance on $DvalDval$.

Ensemble Construction

- For each selected DNN model:
  - Make predictions on $DtestDtest$.
- For each selected RNN model:
  - Make predictions on $DtestDtest$.
- Combine predictions from DNN and RNN models (e.g., averaging, stacking).

Ensemble Evaluation

- Evaluate the ensemble on $DtestDtest$ using the chosen evaluation metric.

Output

- Final ensemble model with its evaluation metric on the test set.

Data Sources

The investigation utilized numerical datasets pertaining to breast cancer diagnosis and classification. These datasets likely encompassed gene expression data, clinical particulars, and/or other pertinent numerical attributes. https://archive.ics.uci.edu/ml/datasets/Breast+Cancer+Wisconsin+(Diagnostic)

Utilized Deep Learning Models

The investigators adopted an ensemble approach, integrating Deep Neural Networks (DNNs) and Recurrent Neural Networks (RNNs), to tackle the challenge of breast cancer detection and classification.

Model Architecture

Preprocessing and Feature Engineering

The numerical datasets were subjected to preprocessing steps, during which relevant features were identified, selected, or engineered to serve as inputs for the deep learning models. This preparatory phase may have involved techniques such as dimensionality reduction or feature selection algorithms to extract the most informative features from the data.

Training and Optimization

The training of the deep learning models was carried out using the preprocessed dataset, accompanied by the implementation of hyperparameter tuning or optimization techniques, such as the Keras-Tuner method, with the objective of improving the models' performance and achieving superior outcomes.

Model Evaluation

The capability of the ensemble deep learning system in detecting and classifying breast cancer cases was thoroughly assessed through the analysis of relevant performance metrics, including accuracy, precision, recall, and F1-score.

SIMULATION

RNN Model

```
# Step 4: Define RNN model
rnn_model = Sequential([
LSTM(64, input_shape=(X_train_reshaped.shape[1],
X_train_reshaped.shape[2])),
Dense(32, activation='relu'),
Dense(1, activation='sigmoid')])
```

```
# Step 5: Compile model
rnn_model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
```

```
# Step 6: Train model
rnn_model.fit(X_train_reshaped, y_train, epochs=10, batch_size=32, verbose=1)
```

```
# Step 7: Make predictions
predictions = (rnn_model.predict(X_test_reshaped) > 0.5).astype(int)
```

```
4/4 [==============================] - 0s 1ms/step
```

```
# Step 8: Calculate evaluation metrics
accuracy = accuracy_score(y_test, predictions)
precision = precision_score(y_test, predictions)
recall = recall_score(y_test, predictions)
f1 = f1_score(y_test, predictions)
auc_roc = roc_auc_score(y_test, predictions)
```

```
# Print evaluation metrics
print("Accuracy : ", accuracy)
print("Precision: ", precision)

print("Recall: ", recall)
print("F1 Score: ", f1)
print("AUC-ROC Score :", auc_roc)
```

```
Accuracy :  0.9649122807017544
Precision:  0.971830985915493
Recall:  0.971830985915493
F1 Score:  0.971830985915493
AUC-ROC Score : 0.9626596790042582
```

DNN Model

```
# Step 4: Define DNN model
dnn_model = Sequential([
Dense(64, activation='relu', input_shape=(X_train_scaled.shape[1],)),
Dense(32, activation='relu'),
Dense(1, activation='sigmoid')
])
```

```
# Step 5: Compile model
dnn_model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
```

```
# Step 6: Train model
dnn_model.fit(X_train_scaled, y_train, epochs=10, batch_size=32, verbose=1)
```

```
# Step 8: Calculate evaluation metrics
accuracy = accuracy_score(y_test, predictions)
precision = precision_score(y_test, predictions)
recall = recall_score(y_test, predictions)
f1 = f1_score(y_test, predictions)
auc_roc = roc_auc_score(y_test, predictions)
```

```
# Print evaluation metrics
print("Accuracy : ", accuracy)
print("Precision: ", precision)

print("Recall: ", recall)
print("F1 Score: ", f1)
print("AUC-ROC Score :", auc_roc)
```

```
Accuracy :  0.956140350877193
Precision:  0.9714285714285714
Recall:  0.9577464788732394
F1 Score:  0.9645390070921985
AUC-ROC Score : 0.9556174254831314
```

HYBRID Model

```
# Step 6: Combine models
combined_model = Sequential()
combined_model.add(Dense(32, activation='relu',
input_shape=(X_train_scaled.shape[1],)))
combined_model.add(Dense(16, activation='relu'))
combined_model.add(Dense(8, activation='relu'))
combined_model.add(Dense(1, activation='sigmoid'))
```

```
# Step 5: Compile model
combined_model.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'])
```

```
# Step 6: Train model
combined_model.fit(X_train_scaled, y_train, epochs=10, batch_size=32, verbose=1)
```

```
# Step 7: Make predictions
combined_predictions = (combined_model.predict(X_test_scaled) > 0.5).asty
```

```
4/4 [==============================] - 0s 995us/step
```

```
# Step 8: Calculate evaluation metrics
accuracy = accuracy_score(y_test, combined_predictions)
precision = precision_score(y_test, combined_predictions)
recall = recall_score(y_test, combined_predictions)
f1 = f1_score(y_test, combined_predictions)
auc_roc = roc_auc_score(y_test, combined_predictions)
```

```
In [37]: # Print evaluation metrics
         print("Accuracy  : ", accuracy)
         print("Precision: ", precision)

         print("Recall:  ", recall)
         print("F1 Score:  ", f1)
         print("AUC-ROC Score :", auc_roc)
```

```
Accuracy  :  0.9824561403508771
Precision:  0.9859154929577465
Recall:  0.9859154929577465
F1 Score:  0.9859154929577465
AUC-ROC Score : 0.9813298395021289
```

RESULTS AND DISCUSSION

The results of the study revealed that the RNN classifier outperformed the DNN and HYBRID classifiers in terms of accuracy, precision, recall, F1-score, and AUC-ROC curve value. The RNN classifier achieved a remarkable accuracy of 96.49%, a precision of 97.18%, recall of 97.18%, and F1-score of 96.45%. The AUC-ROC curve value of 97.18% further supports the RNN classifier's robust discriminatory power and overall correctness. On the other hand, the DNN classifier exhibited lower performance, with an accuracy of 95.61%, precision of 97.14%, recall of 95.77%, and F1-score of 96.45%. While its precision was commendable, its recall value was lower, indicating a higher number of false negatives. The AUC-ROC curve value of 95.56% suggests that the DNN classifier has good but lower discriminative ability than the RNN model. The HYBRID classifier, combining features from both RNN and DNN architectures, achieved a notable performance intermediate between the RNN and DNN classifiers. It attained an accuracy of 98.24%, precision of 98.59%, recall of 98.59%, and F1-score of 98.36%. The AUC-ROC curve value of 98.13% further highlights the hybrid strategy's potency in correctly identifying positive and negative instances with low error rates and excellent discriminative ability.

CONCLUSION

The above findings emphasize the versatility and significance of deep learning classifiers in diverse applications, and the importance of merging the unique strengths of distinct architectures to attain the ultimate performance level towards breast cancer detection.

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Table 1: Performance Evaluation Metrics

S.No	DL Classifier	Precision	Recall	F1-Score	AUC-ROC Curve	Accuracy
1	RNN	97.18 %	97.18 %	97.18 %	96.26 %	96.49 %
2	DNN	97.14 %	95.77 %	96.45 %	95.56 %	95.61 %
3	HYBRID	98.59 %	98.59	98.59 %	98.13%	98.24 %

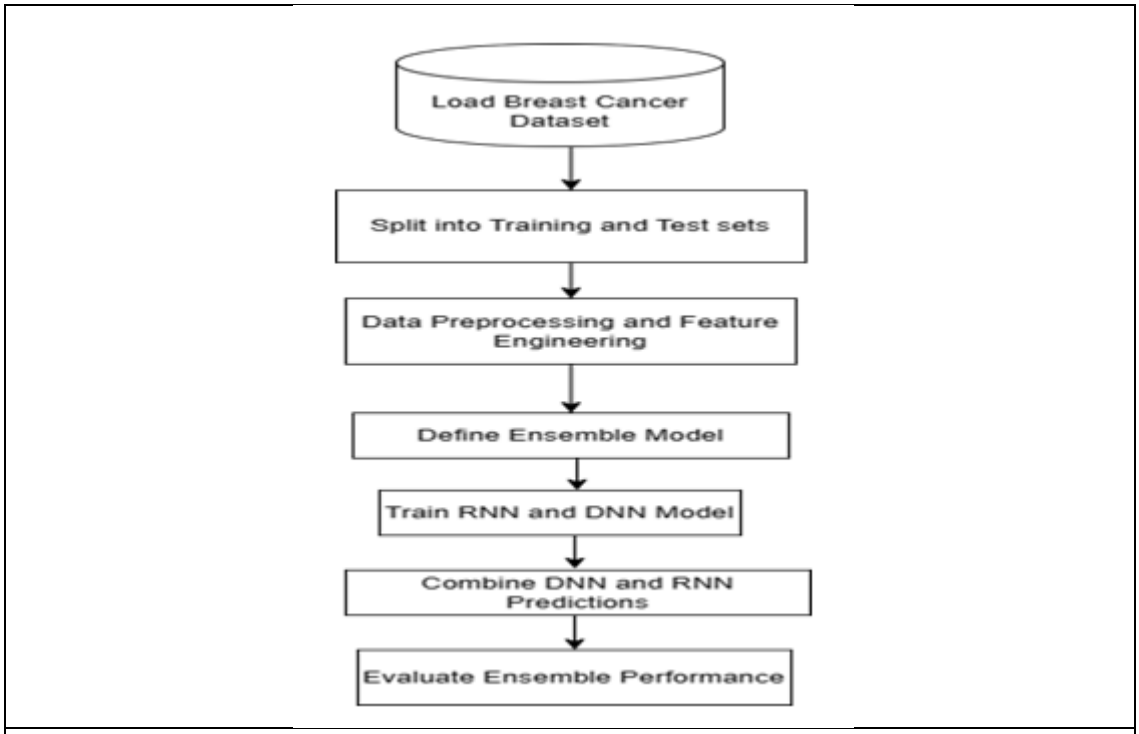


Figure 1: The working procedure of ensemble algorithms

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RESEARCH ARTICLE

Phytochemical Investigation and Antioxidant Activity of *Tecoma stans* Leaf Extract

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ABSTRACT

Oxidative stress has been shown to play an important role in the development of a number of pathological events in human body. Natural antioxidants would be effective in protecting the human body from the oxidative damage by free radicals. Plants are a source of large amount of drugs belonging to different groups that are known to relieve various diseases including oxidative stress. *Tecoma stans*, commonly known as Yellow Trumpet bush or Yellow Bells, is a perennial shrub belonging to the family Bignoniaceae. Among the phytoconstituents found in Tecoma stans leaves are alkaloids, flavonoids, phenolic compounds, terpenoids, and tannins. These bioactive compounds exhibit various pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, and anticancer properties. The leaves of *Tecoma stans* were collected from lawns behind the college building, SGRS College of Pharmacy, Saswad Pune. A 500 g amount of plant material was extracted twice by percolation

using 5 L of 50% of Hydroethanolic solution (50:50 v/v ethanol: water).DPPH assay was performed; &the results of the antioxidant activity of the *Tecoma stans* showed significant antioxidant activity.

Keywords: Plants are a source of large amount of drugs belonging to different groups that are known to relieve various diseases including oxidative stress

INTRODUCTION

Tecoma stans, commonly known as Yellow Trumpetbush or Yellow Bells, is a perennial shrub belonging to the family Bignoniaceae. Native to the Americas, particularly the southwestern United States, Mexico, and Central America, Tecoma stans is renowned for its ornamental beauty and medicinal properties. Among its various plant parts, leaves are of particular interest due to their rich reservoir of phytoconstituents, which are bioactive compounds responsible for its medicinal attributes [1,7,8]. The leaves of Tecoma stans are characterized by their lanceolate shape, with serrated edges and a glossy green hue. They grow in clusters along the stems, providing an attractive backdrop to the plant's showy flowers. While the flowers steal the spotlight with their visual appeal and fragrance, the leaves play a crucial role in the plant's physiology and ecological functions. [2] Among the phytoconstituents found in Tecoma stans leaves are alkaloids, flavonoids, phenolic compounds, terpenoids, and tannins. These bioactive compounds exhibit various pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, and anticancer properties. As such, extracts derived from Tecoma stans leaves have been used in traditional medicine for centuries to treat a range of ailments, from fevers and digestive disorders to skin conditions and respiratory infections. [11,6,4] In recent years, scientific research has focused on exploring the therapeutic potential of Tecoma stans leaves and their phytoconstituents, leading to a better understanding of their pharmacological mechanisms and potential applications in modern medicine. By unraveling the chemical composition and biological activities of these leaves, researchers aim to harness their medicinal properties for the development of novel drugs and natural remedies. [5,9,10]

MATERIALS & METHODS

Collection of Plant Material

Tecoma stans

The leaves of *Tecoma stans* were collected from lawns behind the college building, SGRS College of Pharmacy, Saswad Pune. The collected leaves were dried and grinded (coarse powder) for extraction of the crude drug.

Authentication

The plant was identified by Dr. H. S. Patil, Head of the Department of Botany, Vidya Pratishthan's Arts, Science & Commerce College, Vidyanagari, Baramati, Dist. Pune.

Method

The leaves were dried in the shade for 10–12 days. After complete drying, the leaves were pulverized to a coarse powder of 40 mesh size in a mechanical grinder.

Extraction of *Tecoma stans*

- ✓ **Solvent:** Hydroethanolic solution (50:50 v/v ethanol: water).
- ✓ **Method for extraction:** Percolation
- ✓ A 500 g amount of plant material was extracted twice by percolation using 5 L of 50% of Hydroethanolic solution (50:50 v/v ethanol: water). The resulting extracts were pulled together and concentrated using a Rotary evaporator at 60◦C under pressure. The extract was freeze-dried to obtain the powdered form of the T. stans extracts (TSE). [3]

***In Vitro* Model – Antioxidant activity**

(1-1-diphenyl-2-picryl-hydrazyl) DPPH Free Radical Scavenging Activity

The free radical DPPH is stable and commercially available. An antioxidant is a hydrogen donor.It measures substances that scavenge radicals. The process by which the antioxidant gives the DPPH its hydrogen. The disappearance of DPPH in test samples due to the antioxidant effect. DPPH exhibits a significant maximum absorption at 517 nm (purple). The color changes from purple to yellow as an antioxidant absorbs hydrogen. The relationship between antioxidant activity and absorbance is inverse. The reduction in UV absorption at 517 nm makes it simple to assess the antioxidant impact.

Procedure

Procedure for Preparation of DPPH Solution

To obtain a constant volume, DPPH (7.89 mg) was weighed and dissolved in 99.5% ethanol by filling 100 mL of a measuring cylinder with a stopper (0.2 mM DPPH). It has been observed empirically that a DPPH solution's absorbance decreases over time up to one hour after preparation. As a result, it was left in the dark for two hours to allow the absorbance to stabilize. After 2 hours, 800 µl M Tris-HCl buffer (pH 7.4) and 200 µl were added to a test tube or sampling tube, followed by 1 mL of the DPPH solution. The absorbance at 517 nm was measured after mixing. A mixed solution contains 1.2 mL of ethanol and 800 µl of Tris-HCl buffer which is used as blank.

DPPH assay procedure

A test tube was filled with 800 µl of 0.1 M Tris-HCl buffer (pH 7.4), 200 µl of an analytical sample solution, and 1 mL of the DPPH solution. The solution was mixed for 10 seconds right away using a test tube mixer. It was then kept in the dark at room temperature. The solution's absorbance at 517 nm was measured exactly 30 minutes after the DPPH solution was added. The blank was a mixture of 800 µl of Tris-HCl buffer and 1.2 mL of ethanol.

Calculation

Inhibition ratio (%) = [(Ac – As)/Ac] × 100

Where, As - absorbance at the addition of the analytical sample

Ac - absorbance at the addition of ethanol instead of the sample

Statistical analysis

Results will be expressed as mean + SEM. Statistical analysis was carried out by a one-way ANOVA test followed by "Dunnett's multiple comparison test."

RESULTS & DISCUSSION

(1-1-diphenyl-2-picryl-hydrazyl)DPPH Free Radical Scavenging Activity

Absorbance of DPPH at the addition of Ethanol instead of Sample was found to be 0.33, referred to as Ac. The scavenging effect increases significantly. The Radical scavenging activity of the sample at 50µg/ml shows 92.31% at absorbance 0.023. The IC_{50} value of *Tecoma stans* was found to be 52.55 µg/ml which is calculated by using y = 0.4164x + 71.882equation. The IC 50 value is an inhibitory concentration of extract required to inhibit 50% of initial DPPH free radical.

CONCLUSION

The results of the antioxidant activity of the herbal plant showed that *Tecoma stans* showed significant antioxidant activity.

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Table:1

Sr. No.	Common Name of Plant	Biological Source
1.	Ghanti Ful	*Tecoma stans*

Table 2: Absorbance of DPPH+ *Tecoma stans* (1:1)

Sr.No.	Concentration(µg/ml)	Absorbance of DPPH+ *Tecoma stans* (1:1)
1	10	0.085
2	20	0.067
3	30	0.048
4	40	0.039
5	50	0.023

Table 3:Radical Scavenging activity of DPPH +*Tecoma stans* (1:1)at various concentrations

Sr.No.	Concentration(µg/ml)	%RSA ofDPPH+ *Tecoma stans* (1:1)
1	10	75.89
2	20	79.85
3	30	85.17

4	40	88.65
5	50	92.31

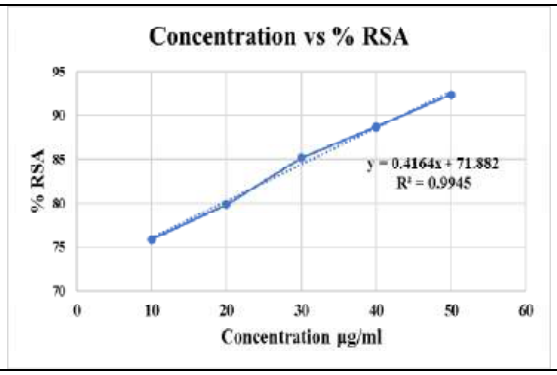


Figure 1: Concentration vs Radical Scavenging activity of DPPH +*Tecoma stans*(1:1) at various concentrations

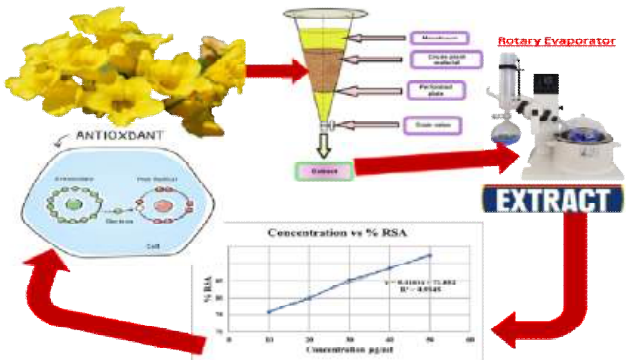


Figure: 2

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RESEARCH ARTICLE

Performance -Based Analysis of CDN Usage in Frontend Web Applications

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ABSTRACT

Web performance optimization is increasingly becoming critical in today's digital landscape. In the production environment web applications are expected to deliver content quickly and reliably to geographically dispersed users. This is because user experience and retention play a significant role in organizations with surging internet traffic. In this study, qualitative and quantitative analysis of website performance with and without CDN integration has been conducted for asset delivery. This research addresses the gap in the existing literature by providing an extensive performance-based analysis of CDN integration along with its limitations and benefits. This study aims to provide evidence-based insights and the real-world impact of CDN implementation using Key Performance Indicators (KPIs) like latency, memory usage and throughput across geographically diverse locations and network conditions. Moreover, the performance analysis has been conducted across three most popular browsers. It has been found that with the use of CDNs, the browser memory consumption significantly reduces which results in improved speed and hence improved user experience. It has also been found that the performance of frontend applications also depends on browser engine's policies. These findings will help organizations make web infrastructure-related decisions, optimization strategies for content delivery and for CDN service providers to refine their offerings.

Keywords: Website Performance Analysis, CDN

INTRODUCTION

Website performance has become a crucial determining factor for User Experience (UX) as it impacts customer retention and engagement. Surging global internet traffic is one of the reasons that pressurize quick content delivery, reliably to users who are spread amongst geographically diverse locations [14]. Content Delivery Networks (CDNs) are one of the most popular ways to optimize website performance over geographically diverse audiences. Apart from using CDNs for static assets, they are also currently being used in other use cases such as live video streaming. CDNs area flexible way to provide faster, qualitative content. However, it also has its limitations which other researchers have solved by proposing creative architectures, routing algorithms and caching policies that optimize CDNs. The aim of this study is to present a comparative analysis of website performance metrics between websites using CDN to provide image assets and CSS files and those without. Although past research uncovers various functionalities, architecture, and benefits of CDN services, there is a need for quantitative evidence based research that shows the real-world impact of CDN implementation across diverse scenarios and use cases. This will reveal information about how beneficial CDNs are for a website architecture to handle user requests across multiple geographical locations.

Understanding the benefits and potential limitations of using CDN is important for

- Decision-making during infrastructure design in Organizations
- Optimization of content delivery strategies for web developers
- Refinement of services offered by CDN service providers

The rest of the paper is organized as follows. The past researches based on CDNs and website performance are discussed in the Literature Review section. The research objectives, the specifics of developing the web application and the data collection methods and tools for the performance analysis are discussed in the Research Methodology section. The Analysis of the metrics from various tools in depth are elaborated in the Results and Findings section. The key insights gained from the study are discussed and highlighted in the Conclusion.

LITERATURE REVIEW/ RELATED WORK

The most common way to improve website performance is to deploy Content Delivery Networks (CDNs) [1]. CDNs strategically distribute content among replica servers in multiple locations (edge servers), allowing lower latency due to nearby content access, high data transfer rates, and lower costs. In practice, CDN only forwards requests for the replicated content to a replica server after replicating a highly selective set of material to these edge servers. Xu *et al.* [3] presented an early analysis on hybrid CDN-P2P architectures. To overcome both of their drawbacks and capitalise on the advantages of CDNs and hybrid mesh-based and multi-tree-based P2P networks. Yin et al. (2009) [2] implemented the hybrid architecture suggested by Xu *et al.* [3], where scalability was enhanced due to the P2P system. It was reliable and had better quality video-streaming due to CDNs, which P2P systems lacked. It also allowed them to implement Dynamic Resource Scaling, i.e., adjusting the number of users directly served by the CDN, which balanced the trade-offs between quality, CDN cost, and scalability. Krishnan et al. (2009) [4] found that simply connecting clients to the nearest server sometimes doesn't always optimise latency. Some clients experience delays. Queueing requests can nullify the benefits of proximity. It emphasised the need to consider other factors like routing and network conditions as an influencing factor when analysing the performance of websites with and without CDNs. Frank et al. (2013) [5] presented that amongst the various types of CDN providers, the collaboration between ISPs and CDNs enhances content delivery extensively. This addresses scalability challenges by leveraging new technologies. It explores the design and operation of CDN-ISP collaborations. They focused on two key strategies: informed end-user to server assignment and in-network server allocation. It demonstrated how a prototype system can increase CDN capacity on demand, improve coordination, reduce download times, and achieve traffic engineering objectives, proving to be beneficial to both ISPs and CDNs. Herbaut et al. (2016) [8] also presented a collaborative model where CDNs and ISPs share resources through a virtualised infrastructure. Which

included specifically deploying virtual CDNs (vCDNs) using Network Function Virtualization (NFV) at the ISP edge. It had a game theory analysis applied to explore revenue sharing models for an efficient and fair collaboration framework for speedy content delivery. Frank (2014) also examined the merits of collaboration between Content Delivery Infrastructures (CDIs) and Internet Service Providers (ISPs). They proposed two major innovations including intra-network server allocation and informed user-server assignment. This provides flexibility allowing CDNs to adjust dynamically and better handle volatile demand while ISPs handle the traffic. Stocker et al. (2017) [6] presented a study in which the existing CDN ecosystem and its evolution were discussed. It also explored the evolution of CDNs since the 1990s, categorising different CDN types, and examining how server location decisions affect operations. It gave a detailed analysis of various CDN architectures and their strengths and weaknesses and highlighted the importance of server location and the growing complexity of CDNs, along with the impact on interconnection markets. Liang *et al.* (2014) [7] discussed the complexity that arises when combining HTTPS with CDN services. Here CDN acts as an intermediary between the client and the web server. It compromises the security mechanisms of HTTPS as the model shifts from two-party to three-party communication, especially when the CDN requires control over SSL certificates. They also presented potential solutions, including the use of name constraint certificates, and ultimately proposes an approach based on DNS-based Authentication of Named Entities (DANE). Wang *et al.* (2018) [9] proposed the concept regarding semi-federation of CDN, which optimises resource scheduling and usage across multiple CDNs without requiring full CDN interconnection (CDNI). As the use of multiple CDN providers among content providers (CPs) has been increasing. This is known as multi homing, due to which CDN vendors are forced to lower their prices. To address these issues, the concept of multi-CDN federation has been proposed. It allows independent CDNs to connect. However, implementation of CDN interconnection (CDNI) comes with its own set of challenges. Through CDN semi-federation, a robust optimisation algorithm adjusts traffic patterns from various CPs across different CDN Points of Presence (PoPs). Kirisame *et al.* (2022) [11] introduced a new framework for optimizing heap limits across multiple garbage-collected processes for balancing memory use and garbage collection time as manual tuning or live-size rules lead to inefficient memory allocation. This research proposed a 'square-root' heap limit rule to minimize memory that too without requirement of communication between heaps. Kulkarni *et al.* (2003) [12] addressed the high memory demands of CDN simulations and proposed a memory-efficient data structure for storing cache state for popular objects accurately, while using bloom filters for approximations of less frequently used objects. It minimised storage as well as errors significantly. It resulted in 10x reduction in memory usage required for CDN simulation with an error margin of 5-10% only. The paper by Qi, Ip, Leung, and Law [13] presents a structured framework for website performance evaluation, addressing the critical need for standardized assessment methodologies. It presents a three-dimensional approach by evaluating website performance based on Website Usefulness, Website Service Quality and Website Physical Accessibility. Its key considerations are aligning CDN implementation with specific website goals, balancing performance improvement with accessibility requirements and maintaining focus on content quality and user experience(Table 1.). These studies uncover and explore many dimensions of CDNs. However, they do not focus on the quantitative impact of CDNs on the website performance. In this study we will understand the impact of CDNs in web applications by using quantitative analysis by using various browser performance metrics.

METHODOLOGY

RESEARCH DESIGN

In this experimental study, comparison of two versions of the same web-application has been performed. Both the websites are based on a common e-commerce platform made with PHP, HTML, Java Script/j Query and CSS along with MySQL as the database. It had 35 static images as well as dynamic image upload feature, login/register page, and/remove from cart option (Table 2.).

- Website A: Implemented with CDN services. Tech Stack - PHP, HTML, j Query(CDN) and CSS(minified files CDN links) along with MySQL image resources using CDNs
- Website B: Implemented without CDN services. Tech Stack - PHP, HTML, Java Script and CSS along with MySQL

RESEARCH OBJECTIVES

- Evaluate and compare key performance indicators (KPIs) and throughput between CDN-enabled and non-CDN-enabled websites.
- Analyse the impact of geographic location, network, and traffic conditions in both scenarios.
- Analyse memory usage/heap size by both websites on different browsers.
- To understand the best situations to use CDNs.

Website Deployment and Setup:

Both websites are designed to be identical in content, structure, and functionality, with the only difference being the CDN integration, hosted on the same server to ensure independent and fair analysis of performance. Both the websites were live for 55 days, ensuring stable and consistent observation and evaluation of performance. Details of the hosting and CDN platforms are as given below:

- Hosting platform: infinityfree.com
- CDN Integration Service: Cloudinary

Infinity Free is a free web hosting provider that helps in managing websites based on PHP and MySQL. It operates on a cloud-based infrastructure that ensure a high uptime, unlimited storage space, free sub domains, SSL and DNS services with many other tools providing effortless deployment. Cloudinary is a SaaS based media asset delivery platform that handles media upload, storage, optimization and delivery via CDN services. It has high performance media processing servers, free tier storage and supports dynamic asset URLs. The primary purpose of choosing this CDN provider was for the easy SDK integration with multiple tech stacks which generate dynamic media URLs after upload. However, Cloudinary has not publicly disclosed the exact number of edge servers, but they claim to utilize many strategically placed edge servers worldwide.

Performance Measurement Tools:

To measure website performance, the following tools were used to track key metrics:

- Memory tab in browser developer tools
- KeyCDN Performance Test
- GTMetrix
- Google Lighthouse

These tools provided quantitative results on performance, including load times, request handling, Largest Contentful Paint (LCP) and load times and overall page speed metrics for both websites. Data was collected from more than 8 countries around the world.

RESULTS AND FINDINGS

Memory Usage Analysis

The data from the Memory Tab of browser Developer Tools were compared for both Websites on the following browsers:

1. Google Chrome
2. Microsoft Edge
3. Mozilla Firefox

In Google Chrome and Microsoft Edge browsers, Website A occupies less memory on load than Website B. In the test conducted on Microsoft Edge we can observe that the heap size of Website B is approximately 357% more storage than Website A (Fig. 1., Fig. 2.). Similarly, on Google Chrome the heap size of Website B is approximately 176% more than Website A (Fig. 3., Fig. 4., Table 3.). Whereas in Mozilla Firefox the results are contradictory, 91% (of the total memory) is used by Website A and Website B uses 88%, indicating an increase when using CDN. Website A has lesser JS events which are being called, in comparison to Website B indicating lesser requests. Using the CDN

increases the overall memory footprint by approximately 680 KB (36%) in Mozilla Firefox. This may be the effect of the change in browser engine as Google Chrome and Microsoft Edge are Chromium based while Firefox is Gecko based (Fig. 5, Fig. 6).

Key CDN Performance Report (Fig.7. Table 4.):

- **Status**
  Both Website A has HTTP status 200 (OK) in all cities, while Website B also has HTTP status OK in all cities other than Singapore, where an error was encountered.
- **DNS lookup time**
  Website A is faster than Website B in 3 cities, including Frankfurt, London and New York with a significant margin. Website B is slightly faster in the other 5 cities, including Amsterdam, San Francisco, Singapore, Sydney and Bangalore.
- **Connection Times**
  Connection times are almost consistent or slightly better with CDN. Frankfurt, London, and Sydney show minimal differences. Minor variations are seen in Amsterdam and San Francisco, where Website B has faster connection time but the difference is almost negligible. However, Singapore faced connection time out with Website B while with Website A it took 271.94 ms to connect.
- **Time to First Byte (TTFB)**
  Website A and B have very little differences in Frankfurt, Amster-dam, London and San Francisco Website B performs better. In New York, Sydney and Bangalore Website A is faster and in Singapore Website A loads whereas Website B encounters errors.
- Overall, we can observe that both websites show their strengths and weaknesses in different metrics and locations.
- Even though the difference is not much between most of the metrics, **at** certain places where Website B could not load at all, Website A has performed better. This suggests that a website with CDN is more reliable.
- **GTmetrix Comparison Report(Fig. 9. , Table 5.):**

Performance

Both websites generally have high-performance scores ranging from 92% to 100%. Website A generally performs better than Website B across most regions, the only exception being London where Website A is 98% and Web-site B is 100%.

Structure

The structure scores, range from 88% to 97%. London performs the best with Website B scoring 96% and Website A at 97% while Mumbai shows lowest scores at 88% for both websites. The structure is fairly similar across both websites, showing that the front-end optimization and consistent lay-outs.

Web Vitals

These metrics are used for determining the User Experience (UX).

- **LCP (Largest Content ful Paint)**
  LCP measures the time taken for the largest visible element to load. It is seen that Website A has a better LCP score across all locations. For Website A, LCP ranges from 652 ms in Vancouver to 1700 ms in Mumbai. Website B has faster LCP times in London (228 ms) but slower times in Mumbai (1600 ms). This indicates regional performance issues likely caused due to server proximity.
- **Total Blocking Time (TBT)**
  TBT measures how much time is spent blocking the main thread from user interaction. Both websites have excellent scores here, with minimal or no blocking across all regions. The highest blocking time recorded is 21 ms for Website A in Mumbai.
- **CLS (Cumulative Layout Shift)**
  CLS measures visual stability. Both websites have a 0 CLS, this indicates that there are no layout shift issues

Performance Metrics(Fig.8.)

- **First Contentful Paint (FCP)**
  FCP measures how quickly the first piece of content is rendered. The times are fastest in London for both websites (798 ms and 228 ms for Website A and B, respectively). The slowest FCP times are seen in Mumbai for Website A (1700 ms) and Hong Kong (1700 ms for Website B).
- **Time to Interactive**
  TTI measures when the website becomes fully interactive. Website B is consistently fast across all regions, with times ranging from 228 ms to 1700 ms. Website A has slightly slower times, especially in Mumbai (2100 ms), but still acceptable in most cases.
- **Speed Index (ms)**
  This metric represents how quickly the content is visually populated. Website B has the fastest Speed Index in London (445 ms), indicating quick visual completion. Website A has a much lower speed index in 2 regions.
- In Hong Kong, Website A took 3200ms and Website B took 3700ms and in Vancouver, Website A took 1200ms and Website B took 2500ms.
- Hong Kong has the slowest times for both websites, suggesting that it takes longer for content to fully load visually there.

Browser timing metrics (Fig. 10.)

- **Redirect Timings:**
  No redirect times are reported across all regions in either website, suggesting no additional redirects, which is ideal for optimizing loading time.
- **Connection Duration**
  The Connection Duration refers to the time taken to establish a connection between the server and client. Website A has the fastest connection time in London (23 ms), while Mumbai has the longest (638 ms). Website B has slower connection times than Website A, except for Mumbai.
- **Backend Duration**
  Backend processing times are generally low across all locations, with the fastest being London (as low as 10 ms in Website B) and the slowest in Mumbai (248 ms in Website A). Website A is taking more time in all locations than Website B.Faster backend times indicate better server efficiency and quicker response to client requests.
- **Time to First Byte (TTFB)**
  The time taken for the first byte of data to reach the user is called TTFB. Website A has longer TTFB times in Mumbai (886 ms), indicating some server latency there, while London has the fastest TTFB (34 ms).
- Website B shows similar patterns, with the slowest TTFB in Mumbai (497 ms) and the fastest in London
- **DOM Interactive Time**
  DOM Interative Time measures the time the browser takes to first become interactive. Website A takes more time in all locations than Website B. Both websites show the best results in London, with the fastest DOM Interactive times there (760 ms for Website A, 174 ms for Website B). Mumbai and Hong Kong see the slowest DOM Interactive times, suggesting slower initial interactivity in those regions.
- **DOM Content Loaded Time**
  DOM Content Loaded Time refers to the total time taken by the browser, to make a DOM tree for a website and parse it.It has similar results to that of DOM interactive time with Website A being slower than Website B.
- **Onload Time**
  Onload time measures the time the browser takes for the pagetoload fully. Website A performs faster in Hong Kong and Mumbai while Website B is faster in Vancouver and London.
- London and Vancouver perform the best, with Website A and Website B both having onload times close to or under 2 seconds.
- Mumbai and Hong Kong show slower onload times, exceeding 2 seconds, which could negatively impact the user experience.
- **Fully Loaded Time**

Fully Loaded Time measures the time when the entire page, including additional scripts and resources, has fully loaded. Website A performs better than Website B in all locations. Website B performs fastest in London (3200 ms), while Website A is fastest in London at 3000 ms.

Mumbai shows the slowest fully loaded times for both websites, around 5100 ms for Website B and 4200 ms for Website A.

Google-Lighthouse Comparison Report (Fig. 11.):

- **Performance (%)**
  Website B consistently scores higher in performance across all locations compared to Website A. While Website A has a noticeable drop in performance in Surat (93%) compared to its performance in other locations (98%).
- **Accessibility (%), Best Practices (%), SEO (%)**
  Both websites have equal scores across all metrics and locations.
- **First Contentful Paint (ms)**
  Website B (400 ms). outperforms Website A (1300 ms) in both locations which is particularly noticeable in Surat, where Website B is significantly faster
- **Largest Contentful Paint (ms)**
  It shows similar trends to the First Contentful Paint where Website B is faster across all locations.
- **Total Blocking Time (ms)**
  Both websites have no Total Blocking Time across all locations, indicating efficient JavaScript execution.
- **Cumulative Layout Shift**
  Both websites have negligible shifts, although Website A shows slight variance in Surat (0.005) compared to other metrics.
- **Speed Index (ms)**
  Website B maintains a consistent speed, while Website A shows a higher Speed Index in Surat (1300 ms).
- **Initial Server Response Time (ms)**
  Website B has a better initial response time. It is 50 ms faster in Surat.
- **Avoid Multiple Page Redirects (ms):**
  Website B has fewer redirects than Website A.
- **Eliminate Render-Blocking Resources (ms)**
  Website B has next to none render blocking resources than Website A.
- **Enable Text Compression (KiB) & Serve Static Assets with Efficient Cache Policy:**
  The results are similar for both websiteswith minor differences.
- **Reduce Unused JavaScript (KiB) & Properly Size Images (KiB)**
  Website B is more optimized than Website A.

Key Findings.

Web applications with CDN integration generally perform better across most regions, particularly in terms of overall performance scores, connection durations, and fully loaded times, especially in areas like Vancouver, Mumbai, and Hong Kong. However, the difference is not significant. A website without CDN outperforms with a minimum margin in terms of LCP, TTI, and Speed Index, making it more optimized for a quicker and more interactive experience, here CDN advantages are less significant. According to Google Lighthouse reports CDN integration makes the web application slower in speed-related metrics like First Contentful Paint, Largest Contentful Paint, and Initial Server Response Time. While a CDN generally boosts performance it is only possible with proper server configuration, resource optimization, and efficient caching policies are crucial. In your case, Website B's better performance suggests it is better optimized in these areas compared to Website A with its CDN.

Influencing factors:

The factors below may influence the performance scores:

1. The placement of edge servers
2. Browser engine's policies

3. Network Speed
4. Server configuration

CONCLUSION

The web application performance analysis domain has to be revisited as CDNs become increasingly popular in the current era. The performance metrics play a major role in indicating the quality of a web application's performance, adding to a better User Experience. In this paper, the browser performance comparison between the web applications with and without CDNs revealed that the web applications with CDNs have lesser memory usage in the browser than those without CDNs. In the findings, it has also been observed that browser engines have different policies and strategies to manage websites with CDNs resulting in differences in performance. So with the integration of CDN, memory usage is majorly optimized in browsers but negligible differences are noted in speed-related metrics. The in-depth analysis also reveals that the benefits of CDN may be negligible when the external influencing factors such as CDN placement are not optimized and edge servers are not near enough. This study reveals that the key to unlocking CDN's full potential lies in a well-rounded approach that prioritizes proper server configuration and resource management. Adoption of such practices can lead to optimal performance in web applications and an enhanced user experience in web applications globally.

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Table 1. Literature Review Summary

Reference No.	Key Focus Areas	Overview	Relevance	Areas not covered
[1]	Overview of CDNs	Detailed explanation of CDN functionality and benefits	Provides a foundational understanding of CDN advantages	Real-world performance data
[2]	Live video streaming using CDN-P2P hybrid	Practical implementation, scalability improvements	Demonstrates practical applications of hybrid systems	Quantitative performance comparison
[3]	Cost-effective streaming media distribution	Analysis of hybrid CDN-P2P architecture	Provides theoretical insights into cost-effective CDN strategies	Real-world performance metrics
[4]	Optimization of CDN performance	Identification of latency issues, routing considerations	Highlights the importance of routing and network conditions	Detailed performance data
[5]	CDN-ISP collaboration	Benefits of collaboration, scalability enhancements	Supports the benefits of ISP-CDN collaborations	Quantitative data, cost analysis
[6]	Web performance improvement using CDNs	Review of CDN strategies and architectures	Provides a comprehensive review of CDN approaches	Detailed performance metrics
[7]	Security challenges in CDN	Analysis of HTTPS-CDN issues, potential solutions	Addresses security concerns, enhancing discussion on CDN limitations	Broad performance analysis
[8]	Virtual CDNs and NFV	Resource sharing, virtualized infrastructure	Explores advanced CDN strategies and their benefits	Implementation details, performance metrics
[9]	Optimization of multi-CDN delivery	Traffic reshaping, optimization algorithms	Examines multi-CDN strategies, supporting analysis of CDN optimization	Extensive performance data

[10]	CDN deployment using cloud resources	Dynamic resource scaling, cloud integration	Highlights innovative deployment strategies	Real-world performance metrics
[11]	Memory management in CDN simulations	Optimal heap limits, memory efficiency	Provides insights into memory optimization	CDN performance focus
[12]	Memory-efficient CDN simulations	Cache state storage, bloom filters	Offers technical perspective on memory management	Broad performance metrics
[13]	Website performance evaluation	Three-dimensional evaluation framework	Aids in developing a structured evaluation framework	CDN-specific performance analysis
[14]	How UX impacts web-application performance	Detailed description of what factors determine better UX and how website performance acts as a crucial metric for determining quality of UX	UX being a considerable factor for the need for improving website performance	How web-performance is affected by other external factors in-turn affecting UX

Table 2. Research methodology details

Aspect	Details
Study Type	Experimental study comparing two versions of the same website based on contemporary architecture.
Platform	Common e-commerce platform built using Core PHP, HTML, JavaScript/jQuery, and CSS with MySQL as the database.
Features	• 35 static images
	• Dynamic image upload feature
	• Login/register page
	• Add/remove from cart option
Website A	Implemented with CDN services
Website B	Implemented without CDN services
Hosting Platform	Infinity Free
CDN-service provider	Cloudinary

Table 3. Results from the memory analysis

Browser	JS heap size on load	
	Website A	Website B
Google Chrome	2.1 MB	7.5 MB
Microsoft Edge	1.7 MB	3.0 MB

Table 4. Data of Performance from 8 cities across different countries

Location	Status		DNS		Connect		TTFB	
	Website A	Website B	Website A	Website B	Website A	Website B	Website A	Website B
Frankfurt	200	200	17.52	32.55	23.21	23.17	46.59	46.3
Amsterdam	200	200	52.96	48.54	21.05	20.22	41.68	40.62
London	200	200	35.4	46.63	9.44	9.83	18.32	18.45
New York	200	200	36.75	100.22	83.51	78.94	165.04	156.84
San Francisco	200	200	177.68	176.54	138.92	138.9	277.93	277.79
Singapore	200	error	324.35	320.2	271.94	timeout	503.46	----
Sydney	200	200	318.97	317.75	280.07	286.85	560.03	573.65
Bangalore	200	200	24.06	22.95	141.21	156.75	281.79	312.67

Table 5. Data from GTmetrix reports from 4 different cities of different countries

Category	Metric	Vancouver		Honkong		London		Mumbai	
		Website A	Website B	Website A	Website B	Website A	Website B	Website A	Website B
GTmetrix Grade	Performance (%)	97	94	95	93	98	100	94	92
	Structure (%)	92	92	92	88	97	96	92	88
Web Vitals	LCP (ms)	1000	652	1300	1700	798	228	1700	1600
	TBT (ms)	0	0	3	0	0	0	21	0
	CLS (no unit)	0	0	0	0	0	0	0	0
Performance Metrics	First Contentful Paint (ms)	1000	652	1300	1700	798	228	1700	1600
	Time to Interactive (ms)	1000	652	1600	1700	798	228	2100	1600
	Speed Index (ms)	1200	2500	3200	3700	1600	445	3600	3500
	Total Blocking Time (ms)	0	0	3	0	0	0	21	0
	Largest Contentful Paint (ms)	1000	652	1300	1700	798	228	1700	1600
	Cumulative Layout Shift (no unit)	0	0	0	0	0	0	0	0
Browser Timings	Redirect Duration (ms)	0	0	0	0	0	0	0	0
	Connection Duration (ms)	162	326	289	540	23	40	638	259
	Backend Duration (ms)	159	147	257	256	11	10	248	238
	Time to First Byte (ms)	321	473	546	796	34	50	886	497
	DOM Interactive Time (ms)	1000	625	1200	1600	760	174	1600	1500
	DOM Content Loaded Time (ms)	1000	626	1200	1600	761	175	1600	1500
	First Paint (ms)	1000	652	1300	1700	798	228	1700	1600
	Onload Time (ms)	1400	1200	1700	2700	1000	282	2200	2300
	Fully Loaded Time (ms)	3900	4100	3700	5400	3000	3200	4200	5100

Table 6. Data from GTmetrix reports from 4 different cities of different countries

Metrics	Website A (Surat)	Website B (Surat)	Website A (Delhi)	Website B (Delhi)	Website A (Surat)	Website B (Surat)
Performance (%)	98	100	98	100	93	100
Accessibility (%)	91	91	91	91	91	91
Best Practices (%)	79	79	79	79	79	79
SEO (%)	90	90	90	90	90	90
First Contentful Paint (ms)	900	400	900	400	1300	500
Largest Contentful Paint (ms)	900	400	900	400	1300	500
Total Blocking Time (ms)	0	0	0	0	0	0
Cumulative Layout Shift	0	0	0	0	0.005	0.004
Speed Index (ms)	900	900	900	900	1300	900
Initial Server Response Time (ms)	160	150	160	150	150	100
Avoid Multiple Page Redirects (ms)	420	160	420	160	0	0
Eliminate Render-Blocking Resources (ms)	110	80	110	80	0	0
Enable Text Compression (KiB)	21	22	21	22	21	22
Serve Static Assets with Efficient Cache Policy	4	9	4	9	4	9
Reduce Unused JavaScript (KiB)	22	0	22	0	0	0
Properly Size Images (KiB)	210	0	210	0	210	0
Defer Offscreen Images	0	0	0	0	0	0
Minify CSS	0	0	0	0	0	0
Minify JavaScript	0	0	0	0	0	0
Reduce Unused CSS	0	0	0	0	0	0
Efficiently Encode Images	0	0	0	0	0	0
Preconnect to Required Origins	0	0	0	0	0	0

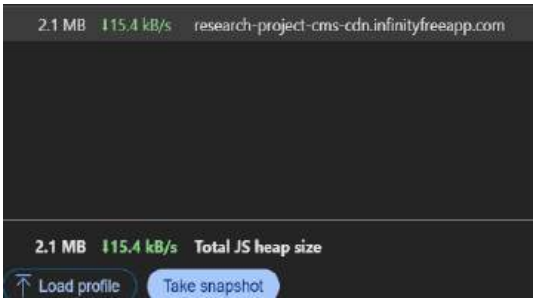


Figure. 5. Website A: With CDN Browser: Microsoft Edge - Memory Panel Developer Tools

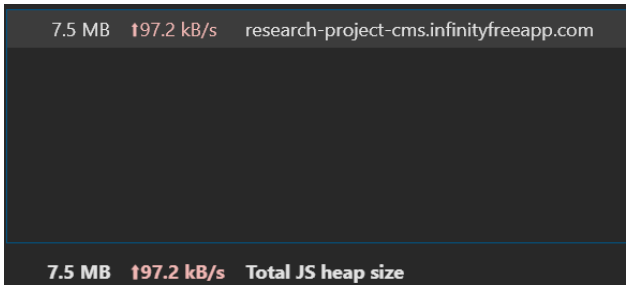


Figure. 6. Website B: Without CDN Browser: Microsoft Edge - Memory Panel Developer Tools

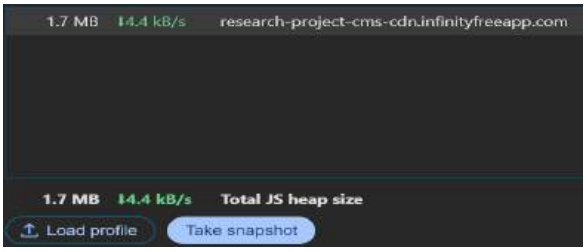


Figure. 7. Website A: With CDN Browser: Google Chrome - Memory Panel Developer Tools

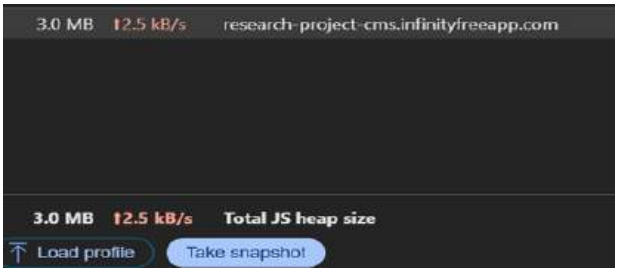


Figure. 4. Website B: Without CDN Browser: Google Chrome - Memory Panel Developer Tools



Figure. 5. Website B: Without CDN Browser: Mozilla Firefox - Memory Panel Developer Tools

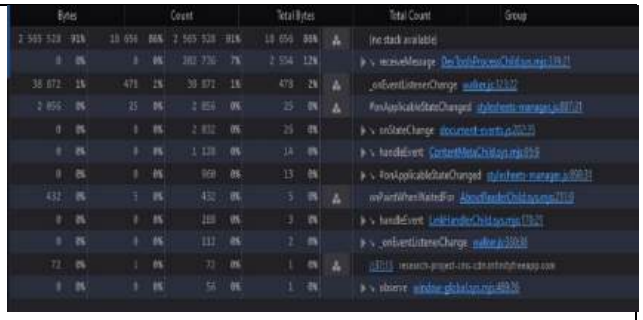


Figure. 6. Website A: With CDN Browser: Mozilla Firefox - Memory Panel Developer Tools

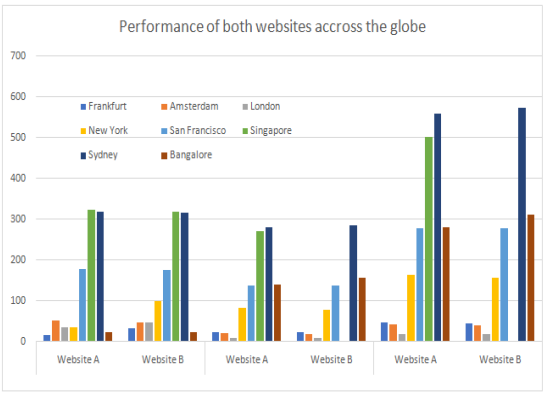


Figure. 7. Comparative performance chart across 8 cities each from a different

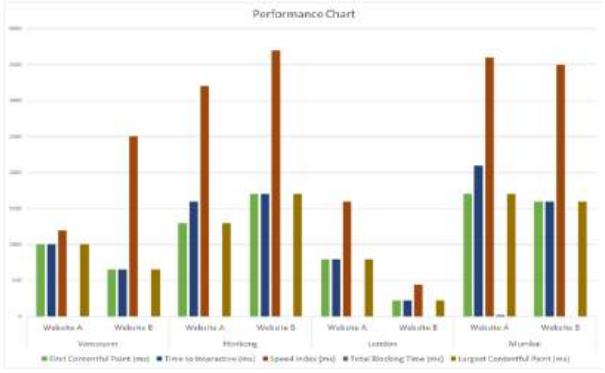


Figure.8.Chart showing performance metrics across 4 cities of the world for both websites

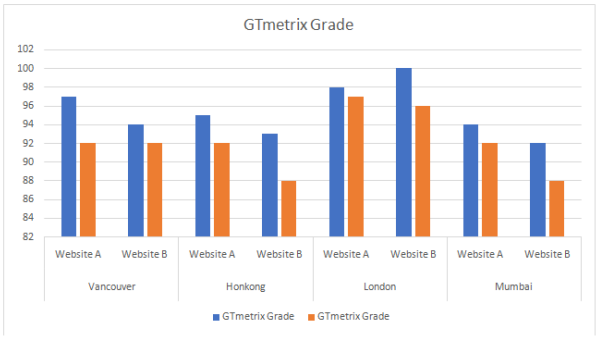


Figure. 9. Comparison chart from GTmetrix data across 4 different cities of different countries

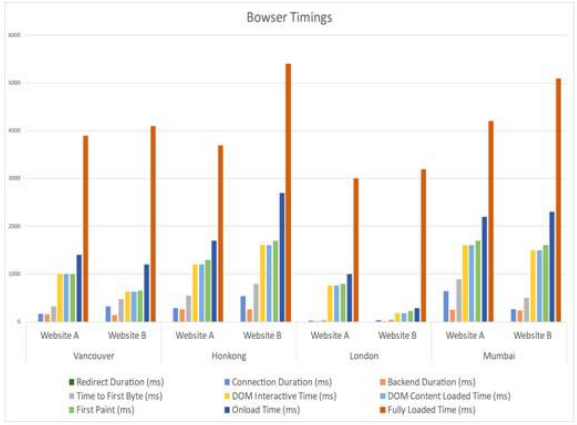


Figure. 10. Chart showing Browser timing metrics across 4 cities of the world of both websites

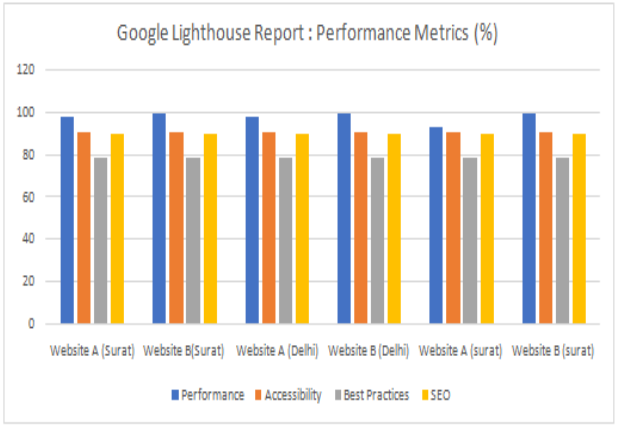


Figure. 11. Chart showing 4 performance metrics across 3 different tests in 2 different Indian cities of both websites

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RESEARCH ARTICLE

Steganography Enhancement using Bit-Plane Slicing : A Comprehensive Study

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ABSTRACT

This research endeavor introduces a method for securely embedding a hidden image into the bit planes of a cover image using a suitable hashing technique. The process involves several steps: reading the cover image and hidden image, performing bit-plane slicing on the cover image, and calculating the correlation between the cover image's bit planes and the hidden image. The two least correlated bit planes are then selected for embedding. The hidden image is embedded into the chosen bit planes of the cover image using a specific embedding algorithm, ensuring that the hidden image remains concealed within the cover image while preserving the visual quality of the cover image. To enhance security, an encryption technique is applied using the selected bit planes. This encryption process modifies the cover image by combining the original pixel values with the embedded secret image information. In the extraction process, the original secret image is restored from the encrypted image. The extraction algorithm reverses the encryption process and retrieves the embedded secret image from the modified cover image. The performance of the embedding and extraction processes is evaluated using various metrics. The Peak Signal-to-Noise Ratio (PSNR) is calculated to assess the quality of the extracted secret image compared to the original secret image. Additionally, the Structural Similarity Index (SSIM) and Image Fidelity (IF) measures are computed to evaluate the similarity between the original and extracted images. The implemented technique offers a secure and efficient method for embedding and extracting secret images within cover images, ensuring data confidentiality and integrity. Experimental results demonstrate the efficacy of the proposed approach in preserving the hidden secret information while maintaining image quality. Steganography, the practice of concealing information within another form of data, plays pivotal role in protecting sensitive information from unauthorized access cannot be overstated. Unlike cryptography, which encrypts the contents of a message, steganography hides the presence of the

message itself, relying on imperceptible alterations in digital data to conceal information. This research contributes to the advancement of steganographic techniques, enhancing their effectiveness and reliability in secure data transmission and storage.

Keywords: Bit Plane, encryption, decryption, SSIM, IF, PSNR

INTRODUCTION

Steganography techniques can be categorized into several types:

Image Steganography[1]
The hidden information is embedded within digital images. Techniques include modifying pixel values, least significant bit (LSB) embedding, and transforming the discrete cosine transform (DCT) coefficients.

Audio Steganography[2]
The hidden information is embedded within audio files. Techniques involve modifying audio samples, phase modulation, or frequency domain manipulation.

Video Steganography[3]
Similar to image steganography, but applied to video files. Hidden information can be embedded within the video frames or specific video features.

Text Steganography[4]
The hidden information is concealed within the structure or formatting of a text document. Techniques include using invisible ink, altering white spaces, or exploiting less noticeable characters.

EMBEDDING
Embedding [5]describes the procedure of hiding or inserting secret information within the pixels of an image. The objective is to make the modifications subtle and imperceptible to the human eye while preserving the visual quality of the image. There are various methods applied for embedding in image steganography:

Least Significant Bit (LSB) Embedding[6]
This method stands out as both ubiquitous and uncomplicated among prevailing research methodologies. It involves replacing the least significant bits of the pixel values with the bits of the secret message. Since the least significant bits contribute less to the overall pixel value, small changes in these bits are less noticeable to the human eye.

Pixel-Value Differencing (PVD)
PVD[7] techniques exploit the differences between adjacent pixel values to hide the secret message. The differences are modified according to the message bits to encode the information.

Spread Spectrum Techniques[8]
These techniques spread the secret message across multiple pixels or frequency components of an image. The idea is to distribute the message bits in a way that they are not concentrated in a specific region, making the hidden data more robust against detection.

Adaptive Steganography[9]

Adaptive techniques analyze the image content and adaptively adjust the embedding process to minimize the visual distortion caused by embedding. They consider the characteristics of the image, such as texture, edges, and smooth regions, to determine suitable embedding locations and strengths. It is imperative to emphasize the significance of the embedding procedure which should maintain a balance between the capacity of the hidden information and the visual efficiency of the image. Too much embedding may introduce visible artifacts, while too little may result in insufficient retention for the desired message.

EXTRACTION

Extraction[10] in image steganography decribes of retrieving the hidden information from a stego-image—the image that has the secret message embedded within it. Extraction is performed using a specific algorithm that reverses the embedding process and retrieves the encoded message. Here is a general overview of the extraction process for some common image steganography techniques:

Least Significant Bit (LSB) Embedding[11]

To extract the hidden message, the LSBs of the pixels in the stego-image are extracted. These extracted LSBs are then combined to reconstruct the encoded message. The count of LSBs to extract depends on the count of bits used to encode each message symbol.

Pixel-Value Differencing (PVD)[12]

PVD extraction involves analyzing the differences between adjacent pixel values in the stego-image. These differences are examined, and based on a predetermined encoding scheme, the hidden message is reconstructed.

Spread Spectrum Techniques[13]

Extraction in spread spectrum techniques involves reverse processing used during embedding.

Adaptive Steganography[14]

The extraction process usually involves analyzing the stego-image depending on the embedding criteria and recovering the hidden information accordingly. The extraction algorithm should be represented accurately retrieve the hidden message while minimizing false positives or false negatives. It should handle various scenarios, such as different image formats, embedding capacities. It's important to understand that extraction requires knowledge of the steganography method used and access to the appropriate extraction algorithm. Without this information, it could be challenging or even impossible to recover the hidden message from a stego-image.

BIT PLANE[15]

Pixel values are integers composed of bits. For example, values in a 256-level gray scale image are composed of 8 bits (one byte). Instead of emphasizing ranges of intensity levels as 0, we could emphasize how specific elements contribute to the overall appearance of the image. As Fig. 3.13 depicts, an 8-bit image can be viewed as consisting of eight one-bit planes, plane 1 encompasses the least significant bit of every pixel within the image, while plane 8 encompasses the most significant bits. Figure 1(a) displays an 8-bit grayscale image and Figs. 1(b) through (i) are its eight one-bit planes, with Fig. 1(b) corresponding to the highest-order bit. Regarding that the four higher-order bit planes, especially the first two, contain a substantial quantity of the visually-significant data. The lower-order planes contribute to more delicate intensity details in the image. The original image has a gray border whose intensity is 194. Notice that the corresponding borders of some of the bit planes are black (0), while others are white (1). To see why, consider a pixel in, say, the middle of the lower border of Fig. 1(a). The pixels that correspond to each other in bit planes, starting with the highest-order plane, have values 1 1 0 0 0 0 1 0, which is the binary representation of decimal 194. The original image's pixel value can likewise be reconstructed from its corresponding binary valued pixels in the bit planes by converting an 8-bit binary sequence to decimal. The binary representation of the 8th bit plane in an 8-bit image can be acquired through thresholding the input image with a transformation function that

maps to 0 intensity values between 0 and 127, and maps to 1 value between 128 and 255. The binary image in Fig. 1(b) was obtained in this manner. Breaking down an image into its bit planes serves the purpose of assessing the significance of each bit within the image. This aids in evaluating the effectiveness of the quantization process, particularly concerning the Peak Signal-to-Noise Ratio (PSNR). PSNR is a widely adopted metric for assessing the fidelity of a processed or reconstructed signal, commonly applied in image and video compression scenarios. It measures the extent of distortion or information loss incurred during compression by comparing the original signal against its compressed or reconstructed counterpart. Additionally, this decomposition technique proves valuable in image compression endeavors, where selectively using fewer bit planes in the reconstruction process is advantageous. For example, Fig. 2(a) displays an image rebuilt using bit planes 8 and 7 of the preceding decomposition. The reconstruction is completed by multiplying the pixels of the nth plane by the constant 2n−1. This converts the nth significant binary bit to decimal. Each bit plane is multiplied by the corresponding constant, and all resulting planes are assembled to obtain the grayscale image. Thus, to obtain Fig. 2(a), we multiplied bit plane 8 by 128, bit plane 7 by 64, and added the two planes. While the primary characteristics of the initial image were recovered, the resulting image seems lacking in depth, particularly evident in the background. This outcome was anticipated, given that only four distinct intensity levels can be produced by two planes. Adding plane 6 to the reconstruction helped the situation, as Fig. 2(b) shows. Note that the background of this image has perceptible false contouring. This effect is reduced significantly by adding the 5th plane to the reconstruction, as Fig. 2(c) illustrates. Increasing the count of planes in the reconstruction wouldn't substantially enhance the visual quality of this image. Thus, we conclude that, in this example, storing the four highest-order bit planes would permit us to rebuild the initial picture with satisfactory clarity. Storing these four planes instead of the original image results in a 50% reduction in storage requirements.

Quality Parameters

Image quality (often Image quality Assessment, IQA) is an image attribute that gauges its perceived appearance of degradation. Imaging systems have the potential to introduce varying degrees of distortion or artifacts into the signal. - for example by transcoding-, which invades the subjectively experienced quality and quality of experience for the users.

PSNR

Peak Signal-to-Noise Ratio (PSNR)[16] is a metric commonly used to measure the quality of a reconstructed or processed signal, typically in the reference of image or video compression. It quantifies the level of distortion or loss that occurs during the compression process by balancing the original signal with the compressed or reconstructed version. PSNR is expressed in decibels (dB) and measures the ratio between the maximum possible power of a signal and the power of the noise introduced by the compression or processing. The higher the PSNR value, the lower the distortion and the better the quality of the reconstructed signal.

The formula for calculating PSNR is as follows:

PSNR = 10 * log10((MAX^2) / MSE)

Where:

- MAX represents the maximum possible pixel value of the signal (e.g., 255 for an 8-bit grayscale image or 65535 for a 16-bit grayscale image).
- MSE (Mean Squared Error) is the average squared difference between the original signal and the reconstructed or compressed signal, calculated over all the pixels or samples.

PSNR is usually used in image and video compression algorithms to count the fidelity of the reconstructed images or videos compared to the originals. It provides a quantitative measure of the perceptual quality of the compressed output and permits for comparisons among different compression techniques or parameter settings. However, it is significant to note that PSNR has limitations as a quality metric. It doesn't consistently align with human visual perception, particularly regarding highly compressed or low-quality images. Higher PSNR values do not always assure visually pleasing or accurate reconstructions, as it focuses on pixel-wise differences rather than perceptual characteristics.

SSIM

SSIM[17] stands for Structural Similarity Index Measure, and it is a broadly used metric for assessing the similarity between two images. Unlike metrics such as PSNR that focus solely on pixel-wise differences, SSIM takes into account both structural information and perceived changes in image quality. SSIM compares the structural components of the reference (original) image and the distorted (reconstructed, compressed, or processed) image. It measures three aspects of image quality: luminance similarity, contrast similarity, and structural similarity. These aspects capture human perception and provide a more accurate assessment of image quality. The SSIM index ranges from -1 to 1, with 1 indicating perfect similarity between the two images. A higher SSIM value indicates greater similarity and better quality between the reference and distorted images. The calculation of SSIM involves comparing local image patches or windows rather than individual pixels. The formula for SSIM is as follows:

SSIM (x, y) = (l (x, y) * c (x, y) * s (x, y))

Where:

- l (x, y) represents the luminance similarity, which measures the similarity of the average pixel intensities in the windows.
- c (x, y) represents the contrast similarity, which quantifies the similarity of the standard deviations of pixel intensities in the windows.
- s (x, y) represents the structural similarity, which evaluates the similarity of the covariance of pixel intensities in the windows.

The values of l (x, y), c (x, y), and s (x, y) range between 0 and 1, with 1 indicating perfect similarity. SSIM has been shown to better associate with the way humans perceive visually compared to metrics like PSNR. It is particularly useful for assessing the proficiency of compressed images, comparing different compression algorithms, or optimizing compression parameters. However, like any metric, SSIM has its limitations but it can be used alongside subjective evaluations to achieve a comprehensive assessment of image quality.

IF

Image fidelity[18] is a measure of the accuracy of the steganographed image. It is gained by the following formula and as can be observed has no units. Image fidelity is also the metering of the accuracy of the reconstructed sky brightness distribution. A related metric, dynamic range, is a measure of the degree to which imaging artifacts around strong sources are suppressed, which in turn implies a higher fidelity of the on-source reconstruction. With conventional external calibration methods, even under the best observing conditions, the achieved dynamic range will rarely exceed a few hundred.

Image fidelity Ratio = $1 - \left(\frac{1}{k} \sum_{k=1}^{K} \frac{\sum_{i,j=0}^{N-1} [C_k(i,j) - \hat{C}_k(i,j)]^2}{\sum_{i,j=0}^{N-1} C_k\ (i,j)^2} \right)$

The actual image will have a IF ratio of 1 which represents the ideal case. In practice this high a value is not obtainable. Thus we may conclude that IF ratio lies in the range [0, 1).

The Whole Process

Here's a step-by-step explanation of the process:

Reading the Images

The code reads two input images - a cover image and a secret image. Both images are in PGM format.

Bit-Plane Slicing

The cover image is split into 8-bit planes using bit-plane slicing. Each bit plane represents a different level of image detail. The bit planes are stored in the `bit` list.

Calculating Correlation

The code computes the absolute correlation coefficients for every bit plane. Correlation measures the statistical relationship between two sets of data. In this case, it measures the similarity between the cover image pixels and the pixels in each bit plane.

Selecting Bit Planes

The two-bit planes with the lowest and second lowest correlation values are opted for embedding the secret image. These bit planes are selected as they have less correlation with the cover image, which helps in hiding the secret image more effectively.

Embedding the Secret Image

The secret image is embedded into the selected bit planes. This is executed by replacing the least significant bits of the cover image pixels with the corresponding bits from the secret image. The pixels of the secret image are split into two sections, each corresponding to a chosen bit plane.

Encrypting the Image

The procedure of embedding the hidden image is referred to as encryption in this context. The code modifies the least significant bits of the cover image pixels according to the hidden image pixels, effectively hiding the secret image within the cover image.

Writing the Encrypted Image

The resulting encrypted image is written to a new file named "encrypted_image.pgm". The file format and header information from the cover image are used, followed by the modified pixel values.

Extracting the Secret Image

The extraction process involves reversing the encryption and extracting the hidden secret image from the encrypted image. This is accomplished by examining the least significant bits of the encrypted image pixels and reconstructing the secret image pixels.

Writing the Extracted Image

The extracted secret image is written to a new file named "extracted_image.pgm". Again, the file format and header information from the secret image are used, followed by the extracted pixel values.

Quality Evaluation

The code calculates various metrics to evaluate the quality and fidelity of the turned out secret image. These metrics include Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index (SSIM), and Information Fidelity (IF). PSNR calculates the difference between the original and extracted images depending on signal strength. SSIM compares the structural similarity between the images. IF quantifies the fidelity of the extracted image by comparing the pixel values. The aforementioned process enables the concealment of a secret image within another image through bit-plane manipulation. It provides methods for both embedding and extracting the secret image, as well as evaluating the fidelity of the extraction process using different metrics.

Algorithm

Depicting a general algorithm that captures the steps involved:

1. Read the cover image and the hidden image.
2. Perform bit-plane slicing on the cover image to obtain the individual bit planes.
3. Calculate the correlation coefficients for each bit plane to identify the two planes with the lowest and second lowest correlation values.
4. Incorporate the hidden image into the specified bit planes by substituting their least significant bits with the corresponding secret image bits.
5. Encrypt the image by modifying the cover image with the help of the modified bit planes.
6. Save the encrypted image within a file.
7. Extract the original secret image from the encrypted image.
8. Save the extracted secret image within a file.

9. Calculate the Peak Signal-to-Noise Ratio (PSNR) between the original secret image and extracted image.
10. Calculate the Structural Similarity Index (SSIM) between the original secret image and extracted image.
11. Calculate the Information Fidelity (IF) by comparing the pixel values of the original secret image and extracted image.
12. Display or save the calculated PSNR, SSIM, and IF values for evaluation purposes.

RESULTS

Motive

The motive of my project is to perform image steganography, which is a practice of hiding a secret image within another image while maintaining the visual appearance of the cover image. The project aims to embed a secret image into the least significant bits of the cover image using bit-plane slicing and encryption techniques. The motive behind this project could be:

Confidential Communication

The code enables the secure transmission of sensitive or confidential images by embedding them within innocuous cover images. It is useful in scenarios where privacy and secrecy are crucial, such as military, intelligence, or private communication.

Covert Data Storage

The project allows for the storage of secret information within seemingly harmless images. By concealing data within the cover image, it becomes difficult for unauthorized individuals to detect the presence of the hidden information, providing a form of covert data storage.

Steganography Research and Analysis

The project distributes as a practical implementation for studying and analyzing the effectiveness and robustness of the bit-plane slicing technique in image steganography. Researchers and students can avail this code to experiment with different images, asses the efficiency of the hidden image, and analyze the metrics such as PSNR, SSIM, and IF. Overall, the motive of the project is to provide a practical implementation of image steganography techniques, allowing for secure communication, covert data storage, and research exploration in the field of steganography.

Applications

The project involving image steganography using bit-plane slicing can have several applications in various domains. Here are a few suitable applications:

Secure Communication

The ability to hide secret messages or images within innocuous cover images can be utilized in secure communication channels. For example, intelligence agencies, government organizations, or businesses can employ this technique to securely transmit confidential information, such as classified documents, sensitive images, or encrypted messages.

Digital Watermarking

Image steganography can be implemented for digital watermarking, where an invisible mark or identifier is embedded into an image. This can be valuable in copyright protection, ensuring the legitimacy or confirming the ownership of digital content.

Covert Surveillance

In covert surveillance operations, steganography can be employed to hide images or videos within seemingly normal media files, such as photos or videos shared on social media platforms. This can enable undercover agents or investigators to transmit sensitive evidence or intelligence while maintaining their cover.

Data Hiding in Forensics

Steganography procedure can be implemented in digital forensics to conceal evidence or sensitive information within images, audio files, or videos.

RESEARCH AND EDUCATION

The project can serve as a valuable instrument for gaining insight into and studying image steganography techniques, algorithms, and evaluation metrics. Students, researchers, and academics can utilize this project to experiment with different images, evaluate the efficiency of hidden data, and explore the field of steganography. It is remarkable to note that while steganography has various legitimate applications, but it is misused for illicit purposes. It is crucial to ensure that the usage of steganography techniques complies with legal and ethical considerations.

CONCLUSION

In summary, the project focused on implementing image steganography with the help of bit-plane slicing. The code provided a practical approach to conceal a hidden image within a cover image while preserving the visual appearance of the cover image. By embedding the hidden image into the least significant bits of the cover image, the project aimed to achieve secure communication, covert data storage, and research exploration in the area of steganography. The project showcased the step-by-step process, including reading the cover and secret images, performing bit-plane slicing, calculating correlation coefficients, embedding the secret image, encrypting the image, and extracting the original secret image. Evaluation metrics such as Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index (SSIM), and Information Fidelity (IF) were calculated to assess the quality and fidelity of the protected image. The applications of this project are diverse and can be utilized in several domains. It can be employed for secure communication, where sensitive information needs to be transmitted discreetly. Digital watermarking, covert surveillance, and data hiding in forensics are additional areas where we can find practical application of this. Furthermore, the project serves as an educational tool, aiding students, researchers, and educators in understanding and exploring image steganography techniques. It is noted that while steganography can have legitimate applications, it should always be used responsibly and within legal and ethical boundaries. Proper consideration should be given to privacy, security, and applicable laws when employing steganography techniques.

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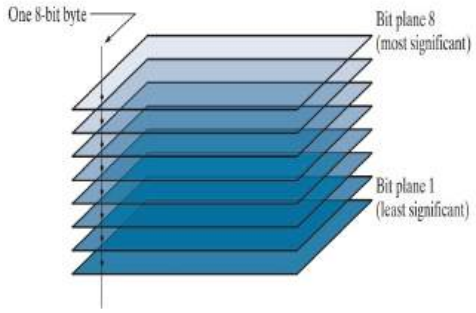
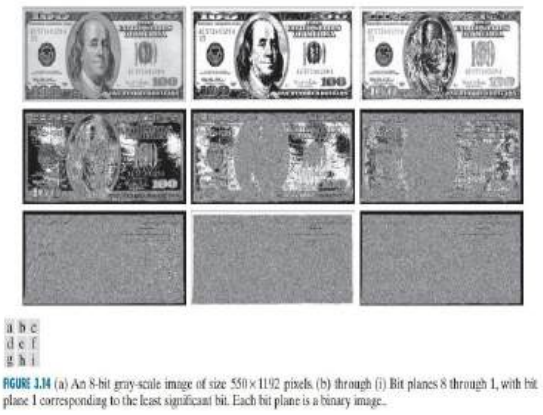


Figure 1 Bit-Planes of an 8-Bit Image



a b c
d e f
g h i

FIGURE 3.14 (a) An 8-bit gray-scale image of size 550 × 1192 pixels. (b) through (i) Bit planes 8 through 1, with bit plane 1 corresponding to the least significant bit. Each bit plane is a binary image.

Figure 2



a b c FIGURE 3.15 Image reconstructed from bit planes: (a) 8 and 7; (b) 8, 7, and 6; (c) 8, 7, 6, and 5.

Figure 3

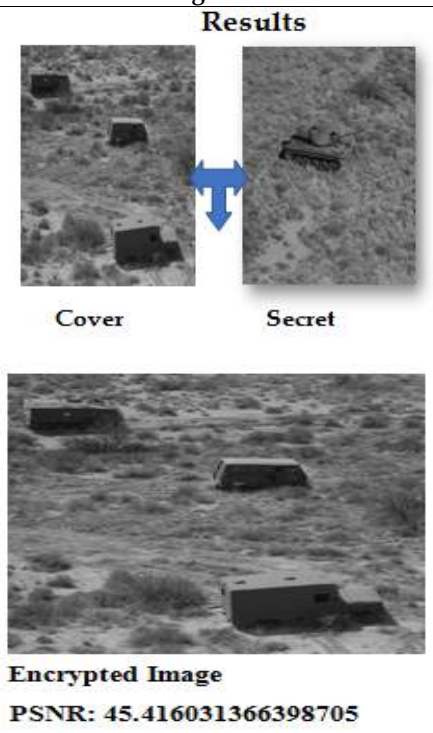


Figure 4



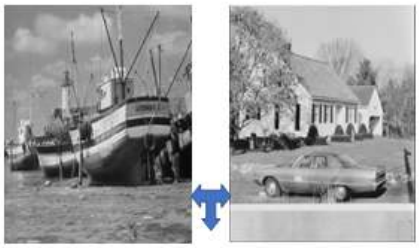
Extracted Secret Image

PSNR: 41.26419085883782

SSIM: 0.9988080518442312

IF: 0.999664374968532

Figure 5



Cover Image **Secret Image**



Encrypted Image

PSNR: 45.92314122959622

Figure 6



Extracted Secret Image

PSNR: 42.06972335817831

SSIM: 0.9996796260997779

IF: 0.9998805557805885

Figure 7

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RESEARCH ARTICLE

Advancing Cross - Lingual Communication : A Bilingual Sentence Refiner for Enhanced Translation Accuracy and Fluency

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ABSTRACT

The development of a bilingual Sentence Refiner is to improve accuracy and readability while translating from any language. The refiner solves common translation difficulties, for example improper grammar or a lack of cultural sensitivity by using advanced natural language processing. The study focuses on the cognitive benefits of bilingualism, which continues to inform how sentence complexity and interference might be handled by refiner design. This model is further iteratively improved using systematic testing and user feedback to be useful in different linguistic contexts. The paper even discusses cross lingual model editing implying the need of strong baseline methods to support and improve languages having different scripts. The work does not only contribute to advancing machine translations but more broadly towards cross lingual communication with implications for education, content creation, and global collaboration. Future directions include enhancing user interaction to continuously improve the refiner's performance, making it a vital tool for effective multilingual communication.

Keywords: Bilingual Sentence Refiner, Communication Enhancement, Natural Language Processing, Translation Quality Enhancement, Lethologica, Cross-Lingual Communication.

INTRODUCTION

Effective communication in different languages is required, as communication between individuals and institutions often encounters linguistic barrier issues. Lethologica is one of the human phenomena wherein one suffers from the frustration of temporarily forgetting specific words needed for speaking or writing, especially if one is fluent in their native language. Apart from lethologica, it is incredible how far machine translation systems have come in filling the gaps despite their shortcomings in producing accurate translations into fluent speech. An estimated 33% of Indians are part of the Indian diaspora. Their presence can be seen in 129 out of the 190 countries listed as sovereign nations by the United Nations [1]. This calls for innovative solutions through the introduction of a bilingual sentence refiner, a machine learning model for the Gujarati language trained on large datasets with parallel texts. A bilingual sentence refiner is an essential tool for making translated text error-free by correcting grammatical mistakes, errors, increase fluency, and produce more natural expressions. Using patterns from both languages, English and Gujarati, this model enhances the translations produced by a machine translation system with the objective of increasing their accuracy, coherence and linguistically appropriate to the intended recipient. Utilizing advances in Natural Language Processing (NLP), the program promises an approach to surmount the language barrier and improve translational efficiency. In this paper, we introduce the concept of bilingual sentence refinement and clarify its technical architecture and algorithms. Thus, underpinning its functionality, we discuss the possible effects that such innovations could have on the qualitative improvement of translating text and explore broader implications for leveraging NLP-based solutions to counter linguistic barriers in professional contexts. In probing this, we aim to highlight the need for continuous advancements in machine translation and NLP for effective cross-lingual communication.

LITERATURE REVIEW

This literature review covers the studies that focus on NLP-based solutions offering bilingual sentence refinement. According to Rui Mao [2], large language models (LLMs) and pre-trained language models (PLMs) are yet to completely cover the critical area of semantic processing in computational linguistics. Concept extraction, named entity recognition, and word sense disambiguation are important tasks for semantic processing in human language and its interconnections. Dr. V. Geetha [3] talks about the development of natural language processing (NLP) from rule-based systems to deep learning models, giving various examples in various industries through applications in healthcare, finance, and entertainment. Nevertheless, there are challenges of bias and ambiguity that require further research to refine and optimize NLP systems. Chengwei Qin [4] claimed that LLMs share common zero-shot abilities, as was seen in ChatGPT, across several diverse NLP tasks. While excelling in reasoning-based tasks, the model struggles with sequence labelling tasks, further indicating that improved discourse and reasoning skills would help. Ruben D.I. van Genugten [5] developed an automatic system to assess the quality of autobiographical memories in natural language processing, thus making web-based research accessible to much wider audience. Masayasu Muraoka [6] explores the benefits of visual supervision in NLP through the Vokenization method for enhanced cross-lingual transfer learning, the results showed a significant improvement in performance of the model in the presence of a visual representation as far as this stood against the low resource availability of the languages. Zhizhong Chen [7] introduces the Cross-Lingual Arabic Information Retrieval system (CLAIRE) exploiting cross-lingual word embedding to ease retrieval tasks and prevent translation errors. Experiments indicate the efficacy of the model for handling Arabic-based retrieval tasks. V. Sharma [8] tackles challenges in Hindi cross-lingual information retrieval (CLIR), proposing Hybrid Word Translation Disambiguation (HWTD) and Semantic Morphological Variant Selection (SMVS). These techniques enhance translation accuracy and address morphological complexities. Jesus Perez-Martín [9] discusses cross-lingual information retrieval in e-commerce, for polysemous ambiguities, dialectal variations, and similar problems, using a neural machine translation system. This increases the accuracy of e-commerce search and sales in multilingual contexts; evidence for this is seen in a Walmart.com pilot experiment. Dr. Jatinderkumar Saini [10] focuses on addressing the peculiarities of translation of idiomatic expressions from Gujarati using a phrase-based, dictionary-driven approach with regional diachronic validation as a core focus identified task is maintaining

the accuracy and avoiding regional discrepancies. Jiaan Wang [11] critically reviews cross-lingual summarization, categorizing datasets and procedures to plot out future research direction. This gives the reader the little foundation and insights about how globalization plays out in multilingual NLP tasks. Abdelsalam's [12] UPAL MULTIVEC model outperforms traditional QuEst++ and Referential Translation Machines in predicting and ranking sentence level post-editing effort for English-German in the WMT16 Quality Estimation Shared Task. Ergun Biçici's [13] translation ranking system enhances translation quality by focusing on high-PFI sentences, improving BLEU scores and correcting errors. The approach emphasizes the importance of targeted sentence retranslation. Niloofar Akhavan [14] believes that bilingual people benefit from the acquisition of two languages in terms of their cognitive control. However, real-time interference during parsing, as is the case in object-relative sentences, is not reduced by such cognitive control. The results of the experiment indicated that the bilinguals performed better in terms of interference management while processing complex sentences because they were subject to less interference from the intervening noun phrases. Bhagat Bhavesh [15] proposes a method combining Gated Recurrent Units and Bidirectional Transformers for Automatic Speech Recognition (ASR) in the language Gujarati, the language-specific issues are targeted at Word Error Rate (WER) reduction. Georgia Zellou [16] highlights the challenges of adapting ASR systems for low-resource languages like Tashlhiyt. Linguistically informed modifications improve performance, emphasizing the need for global access to speech technology. Study carried out by Portia N.Washington [17] based on bilingual sentence processing reveals how syntactic and semantic factors influence mixed-language comprehension, with proficiency being the most critical factor that affects the cross-linguistic representation. Afifah Khan Mohammed [18] translates transliterated text using BERT and the Google Translate API for high-precision language classification. The research supports content moderation and multilingual communication. Yutika Rajanak [19] discusses NLP-based text recognition techniques that assist in processing and understanding language for systems like Siri and Alexa. The development actively extended research in the application area of NLP.

Yian Li [20] introduced ULR (Universal Language Representation Learning) for unified vector representation across languages. This model showed high accuracy on word analogy tasks and recommended changes in how future training objectives would look like. Himanshu Beniwal's [21] Cross-Lingual Model Editing (XME) paradigm modifies facts across languages, addressing challenges in multilingual contexts. This approach highlights the need for continued development in XME techniques. Bice and Kroll (2021) [22] compare Heritage bilinguals with Monolinguals to examine individual experiences and cognitive abilities related to the effects of how grammatical processing in their native and second languages differs. They found that Heritage bilinguals could make some grammatical errors in L1 but scored better in L2. They also discovered that L1 comprehension in bilinguals was more heavily influenced by proficiency. Diego Bear's [23] research on endangered languages like Wolastoqey leverages vector representations for semantic clustering and word prediction. Transformer-based models outperform traditional methods, emphasizing their utility in low-resource settings. Schwartz's [24] findings indicate second language (L2) lexical processing in sentence contexts involves cognitive mechanisms. Low constraint sentences show both the languages have an influence on processing, but highly constrained phrases limit cognate facilitation. The findings indicate that context can minimize cross-linguistic lexical competition. Diego Bear's [25] research uses the Wolastoqey language to convert English into vectors for defining concepts. The findings show the methods of transformer-based models provide more significant gains than the ones achieved with specialized training or fine-tuning. Future directions of the project will involve sentence representations and dictionary definitions. Julian Just [26] discusses NLP's involvement in innovation by showing how methods improve trend forecasting and problem-solution matching. LLMs are going to be the game changers in AI-based innovation processes. Wannaphong Phatthiyaphaibun [27] has introduced PyThaiNLP, an open-source Thai language natural language processing library, which enhances call fulfillment, reduces wait times, and boosts customer retention. PyThaiNLP is used by VISAI for relation extraction, named entity recognition, and text classification. Xinlu Li's [28] framework for cross-lingual natural language understanding uses contrastive learning to improve in-vehicle communication systems, achieving superior intent and slot recognition. Chi Wei [29] proposes FSpell, a method addressing spelling errors in NLP systems. By preserving input details and minimizing computational demands, the model improves performance on Chinese Spelling Check tasks. Bill Yuchen Lin's [30] multilingual language models (ML-LMs) enhance common sense understanding using the Mickey Probe dataset. This approach demonstrates significant improvements in

multilingual NLP performance. Yang et al. [31] introduce Teacher Sim, a monolingual embedding-based evaluation method for machine translation. The system improves translation quality and semantic alignment across multilingual contexts, outperforming baseline methods A possible method for resolving issues with cross-lingual communication is the bilingual sentence refiner. However, multilingual support, improved semantic and cultural context processing, and an enhanced user interface are required to meet present constraints in its evolution. Through the integration of sophisticated methods for mistake correction, semantic analysis, and low-resource language support, along with the enhancement of user interface functionalities, the system has the capacity to substantially advance the domain of cross-lingual communication and translation accuracy. The reviewed research provides a strong foundation for advancing the proposed bilingual sentence refiner. Key insights from various studies reveal several areas for future development:

- **Error Handling and Input Interference**
  The integration of advanced strategies to eliminate input faults might enhance the accuracy of sentence correction by the multilingual refiner in handling errors and interference from input, as noted by Wei et al. (2024). Error management and input interference will benefit from this. Eliminating errors and improving sentence processing would result from this.

- **Semantic Processing**
  Mao and his colleagues (2024) highlight the importance of deep semantic understanding in cross-lingual translations. The incorporation of these techniques which enhance the usability and ease of the translation will further enhance the system's capability to cope with casual expressions, cultural nuances and contextual interpretation.

- **Multilingual and Low-Resource Language Support**
  It is imperative to extend the support beyond Gujarati-English. Cross-lingual editing tools are essential for good multilingual communication, as demonstrated by research like that done by Beniwal and Singh (2024). The use and impact of the tool would rise with more language support.

- **Cultural Sensitivity and Contextual Refinement**
  Just (2024) emphasizes how important it is that translation technologies be suitable for different cultures. Making translations more culturally and contextually acceptable should be the aim of next advancements.

- **User Feedback and Learning Mechanism**
  Bhagat and Dua (2024) suggest that including feedback loops into the system can be advantageous in terms of user feedback and learning mechanisms. This would let the system to continuously enhance itself based on user interaction, increasing its precision and flexibility.

PROPOSED SYSTEM

Based on the analysis, the system architecture for the bilingual sentence refiner is proposed, as elucidated in Fig. 1. Brief explanation of each step of proposed system (Fig. 2) as following:

Step 1: User Interaction.
Individuals interact with the system through a user interface, which may take the form of a web-based application or an independent software program. They present bilingual sentences that they seek to refine. These sentences may exist in the source language, the target language, or a hybrid of both.

Step 2: Input Processing.
The input sentences are processed by the system, which may involve text normalization, language detection, and initial analysis.

Step 3: Translation and Analysis.
If required, the source sentences are translated into the target language using a translation engine or model. Both the source and translated sentences are analyzed for grammatical errors, syntax, style, tone, and cultural nuances.

Step 4: Refinement Generation.
Based on analysis, the system then comes out with suggestions on how to improve the sentences. This may involve grammatical corrections, rephrasing, or cultural adaptations.

Step 5: Suggestion Presentation.
The refined suggestions are presented to the user through the interface, along with the original sentences. Users can review and choose the recommendations they consider suitable for each of the sentences.

Step 6: User Interaction (Review and Selection).
The proposed refinements are presented to users and they can either take them as is, change them or reject the suggestions for each sentence. It also offers details on its own refinements or corrections.

Step 7: Refinement Feedback and Learning.
The system learns based upon these user interactions and decisions. The system evolves and refines the suggestions over time, according to user feedback.

Step 8: Final Output.
If the user is satisfied with those refined sentences then they can go ahead and get final set of Refined Bilingual Content.

RESULT AND DISCUSSION

The proposed research topic is about developing a bilingual sentence refiner, which is a machine learning model intended for the usage of enhancing text-translated quality. The following discussion addresses the possible impacts and consequences of this system within the context of cross-lingual communication and advancements in machine translation. Effective communication across languages is very important in fields such as business, academia, and diplomacy. Tackling common problems in machine translation included grammatical mistakes, inconsistency in syntax, and no cultural appropriation by the bilingual sentence refiner can increase the accuracy and fluency of translated text. Moreover, the conversation also covers wider aspects associated with the bilingual sentence refiner. In other domains, it can go well beyond the borders of modern machine translation systems, it has a potential to revolutionize inter-personal communication across many languages in numerous domains. For example, in an international corporation, accurate and culturally sensitive communications are keys to the business's prosperity, and polishing translation materials facilitates operation management and allows for good interpersonal relation among team members from different backgrounds. This is because developing a bilingual sentence refiner with its inclusion in machine settings has been considered the greatest innovation in the history of machines. Translation via NLP has had wide and numerous impacts in improving communication among languages. Still, this technology can improve further if the text to be translated is improved upon according to systematic user feedback incorporated into the system. Translations that demonstrate fluency and cultural sensitivity can facilitate significantly closer and more meaningful communication across languages and cultures.

CONCLUSION

The bilingual sentence refiner developed in the research is a big improvement in cross-lingual communication, which emphasizes raising translation accuracy and fluency. Its error correction and semantic analysis are greatly facilitated

by sophisticated techniques and conquer existing limitations in translation quality. It goes beyond the issues of grammatical correctness, exploits differences in cultural values, and considers core competencies-based requirements both in correct communication and adequate use of the language. This includes making recommendations for alterations related to sentence-making: restatement and cultural tailoring so that translation becomes pertinent in context. Refiner influence is much beyond just accuracy and greatly contributes to much more substantial areas of machine translation, proper handling of complicated sentence structures also enables bilinguals to process sentences with less interference. In conclusion, the bilingual sentence refiner is a promising tool which it has the potential to better communicate and translate more accurately and fluently in the further development of computational linguistics, as well as supports a globally connected community.

FUTURE SCOPE

There are several promising directions for the further development of the bilingual sentence refiner. One of them is task-oriented training of bilingual embeddings and could improve the quality estimation and proficiency in translation. Moreover, large language models may be integrated with pre-trained language models, which can result in better semantic processing and overcome current challenges appearing in the field of computational linguistics. Further improvement could be made by enhancing the coverage of the system towards more languages support, particularly the under-resourced languages, these would significantly improve cross-language interactions. In the long term, by including user feedback and testing, the suggestions of the correction of grammar as well as cultural adaptation provided by the system would be optimized thus ensuring the correctness as well as the appropriateness for the given context of the translations. This development would significantly contribute to the advance in translation tools that are more complex, yet user-friendly.

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Table 2. Summary of Reviewed Research Papers

Ref No.	Paper Year	Methodology/Techniques	Key Findings
2	2024	Survey of semantic processing techniques	• Highlighted deep semantic understanding for better translation quality. •Suggested improving cross-lingual communication using advanced semantic models.
3	2023	NLP applications in various domains	• Reviewed broad applications of NLP across different industries. • Highlighted the potential of NLP in enhancing language processing systems.
4	2023	ChatGPT for various NLP tasks	• Evaluated ChatGPT's ability to handle multiple NLP tasks. • Demonstrated its flexibility and limitations in cross-lingual contexts.
5	2024	NLP techniques for automated scoring	• Showed how NLP models can automate text scoring tasks. • Demonstrated potential for assessing complex language inputs.
6	2023	Transfer of large language models across different languages	• Highlighted visual supervision techniques for cross-lingual transfer. • Focused on improving low-resource language processing using large models.
7	2021	Retrieval of information across multiple languages	• Designed a cross-lingual information retrieval system specifically for Arabic. • Highlighted key challenges in cross-lingual search queries.
8	2021	Semantic morphological selection techniques	• Focused on addressing translation ambiguities for better retrieval. • Improved translation accuracy using morphological variant selection.
9	2023	Cross-lingual search optimization	• Addressed challenges in cross-lingual e-commerce search queries. • Utilized domain-specific fine-tuning for better results.
10	2016	Dictionary-based machine translation system	• Addressed challenges in translating idiomatic expressions. • Proposed a dictionary-based approach to improve translation accuracy.
11	2022	Cross-lingual summarization	• Provided a comprehensive review of cross-lingual

		techniques	summarization methods. • Identified challenges in summarizing content across different languages.
12	2016	Bilingual embeddings and word alignment	• Demonstrated the use of embeddings for translation quality estimation. • Improved alignment methods to enhance translation accuracy.
13	2023	Sentence translation improvement analysis	• Identified key areas for improving sentence translation accuracy. • Suggested techniques to enhance cross-lingual sentence fluency.
14	2020	Cognitive regulation in bilingual sentence comprehension	• Investigated the influence of cognitive control on bilingual understanding. • Identified key factors influencing sentence processing in bilinguals.
15	2024	Improved ASR and spell correction algorithms	• Improved performance for Gujarati language ASR. • Demonstrated techniques for low-resource language processing.
16	2024	Cross-lingual ASR transfer	• Identified challenges in transferring speech models between languages. • Emphasized training with diverse datasets to improve accuracy.
17	2022	Bilingual sentence superiority effect analysis	• Investigated how proficiency impacts bilingual sentence comprehension. • Highlighted the importance of semantic knowledge in bilinguals.
18	2024	Language detection algorithms for transliterated text	• Developed effective language detection methods for transliterations. • Improved multilingual system performance with transliterated inputs.
19	2023	NLP for language detection	• Showcased efficient language detection techniques for cross-lingual systems. • Essential for improving multilingual communication tools.
20	2021	Pre-training for multilingual language models	• Improved universal language representations using pre-training techniques. • Suggested approaches to enhance multilingual model performance.
21	2024	Cross-lingual editing via multilingual models	• Demonstrated improvements in multilingual text editing. • Showed potential for broader cross-lingual applications in NLP.
22	2021	Grammatical processing in heritage bilinguals	• Analyzed how bilingual experience affects grammatical comprehension. • Highlighted individual differences in bilingual processing.
23	2023	Fine-tuning the RoBERTa model for languages with limited resources.	• Demonstrated advancements in sentence embeddings for languages with limited resources. • Highlighted the importance of bilingual dictionaries in the process of building embeddings.
24	2006	Bilingual lexical activation models	• Examined how bilinguals activate lexical items in

			different contexts. • Provided insights into bilingual sentence processing.
25	2022	Bilingual dictionary for word representations	• Enhanced word representation for low-resource languages. • Utilized bilingual dictionaries to support rare language processing.
26	2024	NLP techniques for innovation search	• Explored the role of NLP in innovation processes. • Suggested NLP as a tool to drive non-human mediated innovation.
27	2023	Python-based NLP tools for Thai	• Developed tools for Thai language processing, applicable to low-resource languages. • Addressed challenges in building NLP tools for smaller languages.
28	2023	Cross-lingual natural language understanding for vehicles	• Developed a framework for cross-lingual NLU in in-vehicle dialogues. • Improved multilingual communication systems for automotive use.
29	2024	Fusion of spelling error correction algorithms	• Reduced input errors for better text processing accuracy. •Enhanced sentence refinement in multilingual applications.
30	2021	Commonsense reasoning in multilingual models	• Evaluated the commonsense reasoning abilities of multilingual models. • Proposed methods to enhance commonsense reasoning across languages.
31	2023	Cross-lingual translation evaluation	• Proposed using monolingual embeddings for translation quality evaluation. • Improved cross-lingual machine translation metrics.

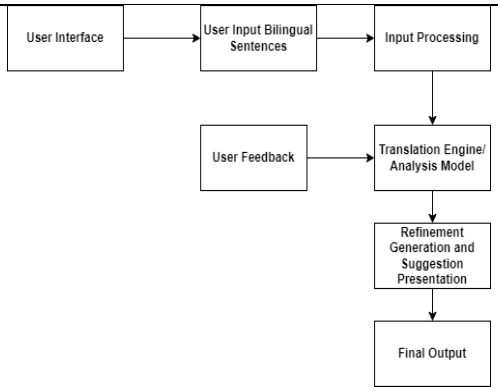


Fig. 8. Proposed System architecture

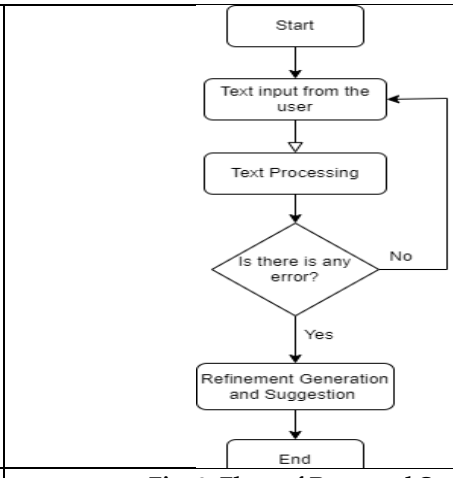


Fig. 9. Flow of Proposed System

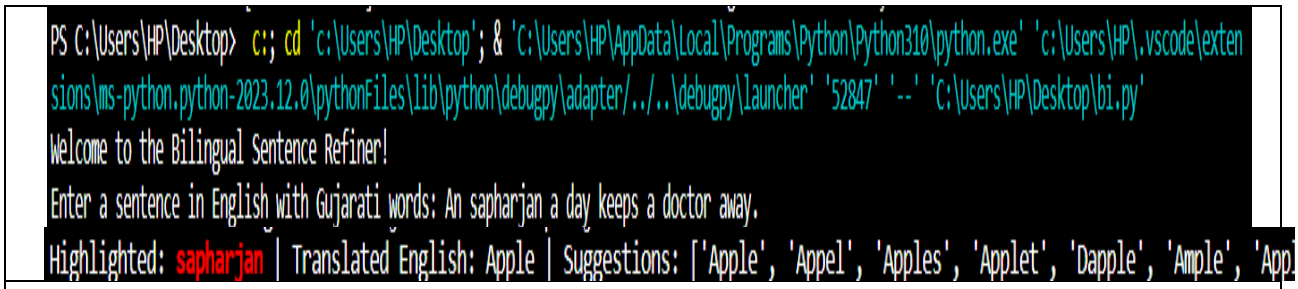


Fig. 10. Output of Bilingual Sentence Refiner

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RESEARCH ARTICLE

Balancing the Gut-Brain Axis: the Ketogenic Diet's Impact on Microbiome Diversity and Management of Children with Epilepsy

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ABSTRACT

Epilepsy, a common neurological disorder in children, often remains refractory to pharmacological treatments, prompting the exploration of alternative therapies such as the ketogenic diet (KD). The KD, characterized by a high-fat, low-carbohydrate composition, has shown promise in reducing seizure frequency in drug-resistant epilepsy. This diet's therapeutic effects are believed to be mediated through metabolic changes, including ketosis, and alterations in the gut microbiome. The gut microbiome, which influences the gut-brain axis, plays a significant role in neurological health, and its imbalance. Dysbiosis, is associated with various neurological disorders, including epilepsy. This review examines the interplay between the ketogenic diet and the gut microbiome in pediatric epilepsy. It highlights how the KD induces significant changes in gut microbiome composition, potentially contributing to its anti-seizure effects while also leading to dysbiosis. The review further explores the impact of this dysbiosis on gut health and overall well-being. Strategies to mitigate KD-induced dysbiosis are discussed, including the use of probiotics, prebiotics, dietary fiber, and synbiotics, as well as the importance of periodic monitoring of gut microbiome health. By understanding the complex interactions between the KD and the gut microbiome, this review aims to provide insights into optimizing therapeutic outcomes and

minimizing adverse effects in children undergoing KD therapy. Future research should focus on long-term effects and tailored interventions to address dysbiosis and enhance the overall efficacy of the ketogenic diet in managing epilepsy.

Keywords: Epilepsy, Ketogenic diet (KD), Drug-resistant epilepsy, Gut microbiome, Dysbiosis, Seizure reduction

INTRODUCTION

Epilepsy is one of the most prevalent neurological disorders in children, characterized by recurrent, unprovoked seizures (Kossoff *et al.,* 2009). Despite advancements in pharmacotherapy, about 20-30% of children with epilepsy remain refractory to conventional treatments, leading to the exploration of alternative therapeutic approaches, including dietary interventions like the ketogenic diet (KD) (Freeman *et al.,* 2007). The ketogenic diet is a high-fat, low-carbohydrate, and adequate-protein diet that has been shown to effectively reduce seizure frequency in children with drug-resistant epilepsy (Rho, 2017). The therapeutic mechanism of KD is multifaceted, involving metabolic changes such as ketosis, modifications in neurotransmitter levels, and alterations in the gut microbiome (Cryan and Dinan, 2012). The gut microbiome, a complex community of microorganisms residing in the gastrointestinal tract, plays a crucial role in maintaining health and influencing the central nervous system through the gut-brain axis (Mulle *et al.,* 2013). Dysbiosis, an imbalance in the gut microbiome, has been implicated in various neurological disorders, including epilepsy (Olson et al., 2018). The KD can induce significant changes in the gut microbiome, which may contribute to its anti-epileptic effects (Ramezani and Raj 2014). However, these changes can also lead to dysbiosis, potentially affecting the overall health of pediatric patients on KD (Heijtz *et al.,* 2011). This review aims to explore the relationship between the gut microbiome and the ketogenic diet in children with epilepsy, discuss the potential impact of KD-induced dysbiosis, and strategies to mitigate this issue.

Article Search

This review was conducted by systematically searching the PubMed, Scopus, and Web of Science databases for relevant studies published between 2000 and 2024. The search terms included "ketogenic diet," "gut microbiome," "epilepsy," "children," and "dysbiosis." Articles were selected based on their relevance, with a focus on studies that examined the effects of the ketogenic diet on the gut microbiome in children with epilepsy and strategies to resolve dysbiosis. Studies that included other dietary interventions or adult populations were excluded. A total of 31 articles were reviewed in order to write this review paper. These articles were reviewed in detail, and data were extracted on the effects of the ketogenic diet on the gut microbiome, the relationship between gut dysbiosis and epilepsy, and methods to resolve dysbiosis in pediatric patients on the ketogenic diet.

The Gut Microbiome and Epilepsy

The gut microbiome plays a crucial role in regulating various bodily functions, including digestion, immune responses, and neurotransmitter production (St-Onge *et al.,* 2014). It is increasingly recognized that the gut-brain axis, a bidirectional communication system between the gastrointestinal tract and the central nervous system, is involved in the pathogenesis of epilepsy (Zhang *et al.,* 2020). Alterations in the gut microbiome composition, known as dysbiosis, have been observed in individuals with epilepsy, suggesting a potential link between gut health and seizure activity (Sousa *et al.,* 2022). Studies have shown that children with epilepsy exhibit a distinct gut microbiome profile compared to healthy controls, characterized by reduced microbial diversity and an altered abundance of specific bacterial taxa (Vieira et al., 2012). These changes may influence the production of short-chain fatty acids (SCFAs), neurotransmitters, and inflammatory mediators, which in turn can affect seizure susceptibility (Gopalkrishnan *et al.,* 2018). For instance, reduced levels of SCFAs, such as butyrate, have been associated with increased seizure activity in animal models (Xu *et al.,* 2021).

The Ketogenic Diet and the Gut Microbiome

The ketogenic diet has been shown to induce significant changes in the gut microbiome, which may contribute to its anti-epileptic effects (Zhang *et al.,* 2019). The high fat and low carbohydrate content of the KD can alter the composition of gut bacteria, leading to an increase in ketogenic and anti-inflammatory bacteria and a decrease in pathogenic bacteria (Li *et al.,* 2021) Several studies have reported that KD promotes the growth of beneficial bacteria, such as *Akkermansiamuciniphila* and *Parabacteroides*, which are associated with improved gut barrier function and anti-inflammatory effects (Hsu *et al.,* 2020). These changes in the gut microbiome may enhance the production of SCFAs and other metabolites that have neuroprotective properties, thereby reducing seizure frequency (Crittenden *et al.,* 2020). However, the KD can also lead to dysbiosis, characterized by a reduction in microbial diversity and an overgrowth of certain bacterial species (Riva *et al*., 2021). For example, some studies have reported an increase in the abundance of pathogenic bacteria, such as *Escherichia coli* and *Clostridium spp.*, in children on the KD (Muegge *et al.,* 2011). This dysbiosis can have negative effects on gut health, potentially leading to gastrointestinal symptoms, inflammation, and an increased risk of infections (Vitetta *et al.,* 2020)

Resolving Dysbiosis in Children on Ketogenic Diet

Given the potential for KD-induced dysbiosis, it is important to consider strategies to maintain or restore a healthy gut microbiome in children with epilepsy on the ketogenic diet. Several approaches have been proposed in the literature to mitigate the negative effects of the KD on the gut microbiome:

- **Probiotics and Prebiotics:** Supplementation with probiotics and prebiotics can help restore a balanced gut microbiome by promoting the growth of beneficial bacteria and inhibiting pathogenic bacteria (Zhang et al., 2020). Probiotics, such as *Lactobacillus* and *Bifidobacterium* species, have been shown to improve gut health and reduce gastrointestinal symptoms in children on the KD (Lee *et al.,* 2022). Prebiotics, such as inulin and fructooligosaccharides, can enhance the production of SCFAs and support the growth of beneficial bacteria (D'Hyver *et al.,* 2021).
- **Dietary Fiber:** Increasing the intake of dietary fiber can help counteract the reduction in microbial diversity associated with the KD (Miskovitz *et al*., 2021). Fiber acts as a substrate for fermentation by gut bacteria, leading to the production of SCFAs and other beneficial metabolites (Zhang *et al.,* 2022). Incorporating fiber-rich foods, such as vegetables and low-carbohydrate fruits, into the KD can support a healthy gut microbiome while maintaining the diet's therapeutic effects (Mahajan et al., 2023).
- **Synbiotics:** The use of synbiotics, a combination of probiotics and prebiotics, has been suggested as a more effective approach to restoring gut health in children on the KD (Xu *et al.,* 2022). Synbiotics can enhance the colonization of beneficial bacteria and improve gut barrier function, reducing the risk of dysbiosis and associated complications (Sandhu *et al.,* 2022).
- **Periodic Monitoring:** Regular monitoring of the gut microbiome in children on the KD can help identify early signs of dysbiosis and guide appropriate interventions (Wang *et al.,* 2022). This may include adjusting the diet, incorporating specific supplements, or using targeted probiotics based on the individual's gut microbiome profile (Wu *et al.,* 2023).

CONCLUSION

The ketogenic diet is an effective therapeutic option for children with drug-resistant epilepsy, with its benefits extending beyond seizure control to include potential neuroprotective effects mediated by changes in the gut microbiome. However, the diet's impact on the gut microbiome can lead to dysbiosis, which may have negative consequences for gut health and overall well-being. To optimize the therapeutic outcomes of the KD while minimizing the risk of dysbiosis, it is essential to adopt strategies that support a healthy gut microbiome. These strategies include the use of probiotics, prebiotics, synbiotics, and dietary fiber, as well as regular monitoring of gut health. Future research should focus on understanding the long-term effects of the KD on the gut microbiome and developing tailored interventions to prevent or resolve dysbiosis in pediatric patients.

COMPETING INTERESTS

The authors declare that they have no competing interests.

AUTHORS' CONTRIBUTION

Soma Basu, Dr. A.J. Hemamalini and Dr. Ranjith Kumar Manokaran conceptualized the study. Soma Basu wrote the original draft. Dr. A.J. Hemamalini and Dr. Ranjith Kumar Manokaran reviewed, edited and supervised the manuscript. All authors read and approved the final manuscript for publication.

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RESEARCH ARTICLE

Development and Psychometric Testing of Respectful Maternity Care (RMC) Assessment Tool - A Study Protocol

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ABSTRACT

Pregnancy and childbirth are significant events, requiring high-quality care to ensure the well-being of both mother and newborn. However, disrespect and abuse during hospital delivery are barriers to care and violate women's rights. Despite growing recognition of respectful maternity care as a fundamental right, there is a lack of standardized tools to assess RMC, particularly in India. This study aims to develop and validate the Respectful Maternity Care Assessment Tool for antenatal, intranatal, and postnatal care. This study will employ a sequential exploratory mixed-method design in three phases: (1) Qualitative phase—In-depth interviews with postnatal women, medical officers, and midwives to explore their experiences and perceptions of RMC. (2) Integration phase—Development of the tool by converting qualitative data into scale items, informed by a comprehensive literature review. (3) Quantitative phase—Psychometric testing of the tool, including expert validation using the Delphi technique, followed by field testing with 300 postnatal women for reliability and validity. The study will result in a validated RMC Assessment Tool to evaluate respectful maternity care across all stages of maternity services. This tool will help identify areas for improvement, contributing to better maternal care and supporting women's rights during childbirth.

Keywords: Respectful Maternity Care, Assessment Tool, Psychometric Testing, Maternal Health, Quality of Care, Human Rights.

INTRODUCTION

Around the globe, pregnancy and childbirth are profound milestones carrying significant personal and social implications for women, families, and communities. Supporting women throughout this journey is crucial for the well-being of both mothers and newborns. Unfortunately, during childbirth and the subsequent postpartum period, these essential needs can often be overlooked, leading to potential marginalization. Simply focusing on reducing maternal and newborn morbidity and mortality is insufficient. Comprehensive care during this period must uphold fundamental human rights, such as respect, dignity, confidentiality, access to information and informed consent, the right to optimal health standards, and freedom from discrimination and any form of mistreatment [1]. The emphasis of policy attention is currently shifting to improving care quality due to rising rates of institutional delivery. During labor and delivery, women in medical facilities are subjected to mistreatment and disrespect, which is one aspect of low-quality care [2]. Disrespect and mistreatment experienced by women during institutional childbirth can discourage the utilization of maternity care services. Such negative experiences during labor and delivery not only impact women's willingness to seek future obstetric care at healthcare facilities but also infringe upon their fundamental rights [3-6]. Seven types of abuse and disrespect were distinguished by Browser and Hill in 2010.7 According to the first consensus document, "The Respectful Maternity Care Charter: The universal rights of childbearing women," published by the White Ribbon Alliance in 2011, dis-RMC is a human rights violation [1]. "Respectful maternity care (RMC) is a basic and universal right for all women who are pregnant. This involves respect for women's dignity, autonomy, empathy, privacy, confidentiality, feelings, choices and preferences, including companionship throughout maternity care and continuous care during labour and delivering. It assures that there is no damage and ill-treatment." Recommendations from the WHO [8]. The World Health Organization (WHO) outlined eight aspirational standards for quality maternal and newborn healthcare in its 2015 quality-of-care framework. Among these, effective communication, respect and dignity, and emotional support are essential for ensuring a positive childbirth experience. The remaining five standards focus on delivering evidence-based clinical care and are linked to key health system functions, including the availability of essential commodities, human resources, referral systems, and information management [9].

Women are abused and mistreated all throughout the world, according to recent research and systematic evaluations. The rate of mistreatment ranged from 15% to 98%, according to a comprehensive review[10]. According to a comprehensive review, 71.31% of Indians experience disrespect and abuse [11]. In research conducted in hospitals, the prevalence was 65.38%, while in community-based studies, it was 77.32% [11]. One factor preventing women from using maternity care services, which contributes to maternal mortality and morbidity, is the disrespect and maltreatment they endure during institutional birthing services. According to SRS (2016–18) data, Gujarat has a maternal mortality ratio (MMR) of 75, whereas India's MMR is 113 [12]. RMC is a problem that is often overlooked despite international attempts to improve the quality of maternal care [13]. Different cultures and geographical regions are the origins of RMC components. There aren't many tools available in India[14]. All phases of pregnancy, including the prenatal, intrapartum, and postpartum phases, are covered by RMC. A woman should always be treated with the same respect and has the right to seek therapy [1]. The drive to measure and enhance RMC may stall in the absence of standardized and validated instruments since it may be unclear what RMC is and how to best focus intervention efforts. In order to evaluate respectful maternity care, the current study is to create and validate the instrument.

MATERIALS AND METHODS

The study will be conducted using Sequential exploratory Mixed method Design. The methodology includes three phases: (1) Qualitative phase (2) Integration (3) Quantitative phase.

Qualitative phase

The focus of this phase will be on development of the pool of items of tool for the Assessment of Respectful Maternity Care. In-depth interview will be conducted with the postnatal mothers' medical officers and Midwives. In-depth interviews will be conducted with postnatal women, medical officers and Midwives to explore their perceived experiences and implementation of Respectful Maternity Care. Postnatal women will be selected using an purposive sampling technique and data will be collected from selected private and public health centres in Anand district, Gujarat. Women who received pregnancy and childbirth services in these healthcare settings will be included, while those with complications related to pregnancy and childbirth will be excluded. Similarly medical officers and midwives who have been providing maternity services at the selected health centres for at least 6 months will be included. Data collection for postnatal mothers, medical officers and Midwives will use a researcher-developed semi-structured interview guide, validated by experts in obstetrics and qualitative research. Thematic analysis will be conducted using Braun and Clarke's (2006) six-step framework.

Integration

The integration phase will involve developing a tool by converting qualitative data into scale items. Qualitative data will be analysed to identify key themes, which will guide the construction of quantitative scale items. Integration will occur during data collection using a "connecting" strategy, ensuring the qualitative findings directly inform the scale development. The scale will be based on Item Response Theory and will consist of three subscales: Antenatal, Intranatal, and Postnatal. Each subscale will include dichotomous questions with response options of "Yes," "No," and "Uncertain." The item pool will be generated through a comprehensive literature review of instruments assessing Respectful Maternity Care and relevant national guidelines. Data triangulation from multiple sources, including the perceived experiences of postnatal women and the perceptions of healthcare workers (medical officers and midwives), will ensure the tool's comprehensiveness and validity.

Quantitative phase

This phase focuses on assessing the psychometric properties of the Respectful Maternity Care (RMC) Assessment tool. It includes two subphases.

Validation of the tool

A panel of 15 experts specializing in instrument development, midwifery, reproductive health, psychology, and obstetrics will be invited to review the scale items. They will evaluate aspects such as wording, grammar, item allocation, relevance, clarity, essentiality, and scaling. The Delphi technique will be employed in two rounds: the first round will focus on refining, eliminating, or adding items to ensure comprehensive domain coverage, while the second round will formally assess the content validity of the items and the scale. Both face validity and content validity will be examined during the process.

Assessment of Reliability of the tool

Drafted tool will be administered on the 300 postnatal women of selected health centers of Anand district, Gujarat. The inclusion and exclusion criteria will be same as of the qualitative phase. Basic item analysis, factor analysis and internal consistency analysis will be done.

DISCUSSION

The present study addresses a critical gap in the field of maternity care by focusing on the development and validation of the Respectful Maternity Care (RMC) Assessment Tool. Despite global initiatives aimed at improving maternal care quality, the concept of RMC remains underexplored, particularly in the Indian context. As the evidence on disrespect and abuse during childbirth has grown, its negative impact on women's health-seeking behaviors and overall maternal health outcomes is undeniable. A systematic review by Bohren et al. (2015) indicated that mistreatment during childbirth is a widespread issue, with the prevalence ranging from 15% to 98% globally.

Similarly, studies conducted in India have reported a concerning prevalence of 71.31% (Ansari & Yeravdekar, 2020), underscoring the urgent need for systematic assessment and interventions. The qualitative phase of this study will provide valuable insights into the perceptions of women and healthcare providers regarding RMC, allowing for the creation of a comprehensive and culturally relevant tool. The integration of these qualitative findings with a robust literature review will ensure that the resulting scale is grounded in both theory and practice. Furthermore, expert validation through the Delphi technique will ensure the content validity of the tool, while field testing will assess its reliability. The results of this study will not only fill the existing gap in standardized tools for RMC assessment but also serve as a foundation for future research aimed at improving maternal care quality. By ensuring respect, dignity, and autonomy for women throughout the maternity care continuum, the tool will facilitate targeted interventions, contributing to better outcomes in maternal health. The implications of this study are significant, as it aims to enhance the quality of maternal care, a fundamental determinant of maternal and neonatal health. Furthermore, by aligning with global frameworks like the WHO's recommendations on maternal and newborn health, this tool will be instrumental in guiding healthcare providers and policymakers in improving respectful maternity care services, ensuring that every woman's rights are upheld during childbirth.

CONCLUSION

This study protocol details the development and psychometric testing of the Respectful Maternity Care (RMC) Assessment Tool. The tool will be used to evaluate the quality of Respectful Maternity Care across the antenatal, intranatal, and postnatal phases of pregnancy and childbirth. The aim is to ensure comprehensive, reliable assessment of RMC practices, contributing to improved maternal care.

Conflict of Interest

No

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REVIEW ARTICLE

Text Neck Syndrome among Students - A Global Problem in Modern Era - A Narrative Review

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ABSTRACT

Millions of individuals throughout the world suffer from neck discomfort, which is a common ailment. Numerous things, such as bad posture, injuries, strained muscles, and nerve damage, might contribute to it.[1] A person's capacity to carry out everyday tasks may be impacted by neck pain, which can range in severity from little discomfort to excruciating agony. In extreme situations, headaches, shoulder discomfort, and even tingling or numbness in the arms might result from neck pain [2]. Neck discomfort has a large financial impact since it can lead to incapacity, medical expenses, and lost productivity. A repetitive stress injury to the neck brought on by keeping your head forward for a lengthy amount of time is known as "text neck syndrome."[4] The cervical spine's curvature, as well as the muscles and ligaments supporting it, are all impacted by this position. These days, the agony of the contemporary day is another name for text neck syndrome. The American chiropractor Dr. Dean L. Fishman was the first to use the phrase "TEXT NECK."[3]The current ailment known as "text neck syndrome," or "tech neck," is defined by neck pain and discomfort brought on by extended use of electronic devices such computers, tablets, and smart phones [5]. Due to the increasing use of digital technology and the rising dependence on electronic gadgets in both personal and professional contexts, text neck syndrome has become much more common in recent years. The repeated and prolonged forward flexion of the neck when using electronic gadgets is the main cause of text neck. Muscle imbalances, tension, and discomfort result from this posture's excessive strain on the neck's muscles, ligaments, and tendons. Untreated text neck syndrome can eventually lead to osteoarthritis, degenerative disc disease, and herniated discs, among other structural alterations in the cervical spine. [1, 3] Physical therapy [4], painkillers [5], chiropractic adjustments [6], and occasionally surgery are all options for treating neck discomfort. This study's objective is to conduct a narrative evaluation of the data and publications pertaining to text neck syndrome and determine whether using a cell phone or other smart device significantly affects neck health. Text neck syndrome represents a significant public health concern in the digital age, with implications for individuals of all ages [7]. By understanding the prevalence, risk factors, and biomechanical implications of this condition, healthcare professionals can develop targeted interventions to promote neck health and mitigate the impact of excessive device use on

musculoskeletal health. [8.9] This study's objective is to conduct a narrative evaluation of the data and publications pertaining to text neck syndrome and determine whether using a cell phone or other smart device significantly affects neck health.

Keywords: Text Neck Syndrome, Neck Pain, Forward Head Posture, Smartphone Use, Adolescents

INTRODUCTION

Boolean operators are used to efficiently integrate terms in search queries, guaranteeing a thorough search. Search results are refined using filters based on language, research kind, and publication date. Selected publications' full texts are acquired for in-depth analysis and data extraction. In order to find any other sources, reference lists from pertinent publications are also manually searched. To find out more information or unpublished data, subject-matter experts may also be engaged From the above review we are able to confirm that the usage of smart phones and gadgets is one of the leading causes for the text neck. According to the authors above the text neck can lead to change in posture, severe neck pain, Muscle shortening and weakness of the muscle [9, 10]. The abundance of literature on text neck syndrome and its association with mobile device use underscores its significance as a modern health concern. Firstly, the prevalence of text neck syndrome varies across studies, reduce the risk of developing text neck syndrome. In terms of interventions, the literature emphasizes the importance of posture education and ergonomic adjustments to mitigate the risk of text neck syndrome. Recommendations include holding devices at eye level, using larger screens, and distributing device weight evenly between both hands. Additionally, rehabilitation protocols aimed at addressing muscular imbalances and promoting proper posture have shown promise in managing musculoskeletal disorders arising from handheld device use.

LITERATURE SEARCH

Several crucial measures were taken in order to perform a comprehensive literature search on Text Neck Syndrome, a widespread issue among students in the current period. In order to establish the foundation of the search, pertinent terms and phrases like "Text Neck Syndrome," "Students," "Adolescents," and "Global" are first recognized. To find pertinent publications, suitable databases such as PubMed/MEDLINE, Google Scholar, and Psyc INFO are then chosen. Boolean operators are used to efficiently integrate terms in search queries, guaranteeing a thorough search. Search results are refined using filters based on language, research kind, and publication date. Selected publications' full texts are acquired for in-depth analysis and data extraction. In order to find any other sources, reference lists from pertinent publications are also manually searched. To find out more information or unpublished data, subject-matter experts may also be engaged. To effectively arrange and manage citations throughout the procedure, reference management software is used. A thorough analysis of Text Neck Syndrome as a worldwide problem among students may be carried out by using this methodical methodology, which will yield important information about its incidence, effects, and possible solutions. The research will only include English-language publications that were published between 2013 and December 2023. This research considers studies published during the last ten years. The literature review is identified, analyzed, and carried out according to guidelines.

DISCUSSION

From the above review we are able to confirm that the usage of smart phones and gadgets is one of the leading causes for the text neck. According to the authors above the text neck can lead to change in posture, severe neck pain, Muscle shortening and weakness of the muscle [9, 10]. The abundance of literature on text neck syndrome and its association with mobile device use underscores its significance as a modern health concern. Firstly, the prevalence of text neck syndrome varies across studies, with reported rates ranging from mild to severe among college students, medical students, and young adults [11, 12]. This variability reflects the widespread impact of excessive smart phone and handheld device usage on neck health [13,14]. Secondly, risk factors contributing to text neck syndrome are

multifactorial and include prolonged neck flexion, frequent texting or gaming, and poor sitting posture [15,16]. Biomechanical studies reveal that prolonged device use leads to adverse changes in cervical and thoracic spine alignment, along with muscular imbalances and postural compensations. Furthermore, specific tasks such as texting with one hand or using thumb-dominant typing styles may exacerbate symptoms [17, 18]. Additionally, studies highlighted that gender predominance, with females often exhibiting higher rates of musculoskeletal symptoms, particularly in relation to smart phone addiction [19, 20].

CONCLUSION

By the practice of good Posture slouching or leaning forward can be avoided. By performing regular neck exercises especially stretching and strengthening improve flexibility. Simple exercises like chin tucks, neck rotations, and side stretches can be effective. The screen time has to be reduced and regular breaks have to be taken to avoid overuse. Care should be taken to ensure the workspace is ergonomically optimized like the height of chair, desk, and screen and should be set up to promote a neutral posture. By incorporating these habits into a regular routine, one can significantly reduce the risk of developing text neck syndrome. In terms of interventions, the literature emphasizes the importance of posture education and ergonomic adjustments to mitigate the risk of text neck syndrome. Recommendations include holding devices at eye level, using larger screens, and distributing device weight evenly between both hands. Additionally, rehabilitation protocols aimed at addressing muscular imbalances and promoting proper posture have shown promise in managing musculoskeletal disorders arising from handheld device use. However, despite the growing body of research on text neck syndrome, several gaps remain in our understanding of this phenomenon. For instance, while studies have identified risk factors and biomechanical implications, there is still limited evidence on the longitudinal effects of prolonged device use on neck health. Moreover, inconsistencies in study methodologies and outcome measures hinder the establishment of clear guidelines for prevention and management.

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Table: 1: Review of the Text neck syndrome

Author	Subjects	Design	Method	Conclusions
Kumari *et al.*, 2021	College students	Survey	Personalized questionnaire	Text neck syndrome prevalence: 36.5% mild, 23.4% moderate, 2.1% severe, 35.7% none.
Alsiwed *et al.*, 2021	Medical students	Cross-sectional	Questionnaire	Association between text neck syndrome and smart phone use; emphasis on posture awareness.
Xie *et al.*, 2017	Mobile device users	Systematic review	Literature review	Neck complaints prevalence: 17.3% to 67.8%; risk factors include neck flexion, phone use frequency, texting, and gaming.

Ning *et al.*, 2015	Mobile device users	Laboratory study	Kinematic analysis	Deeper neck flexion during device use; lower neck muscle activity during reading or holding devices.
Shah & Sheth, 2018	Physiotherapy students	Correlational study	Self-reported data	Smartphone addiction correlates with musculoskeletal disorders in neck and hand.
Fiebert *et al.*, 2021	Mobile device users	Review	Literature review	Prolonged device use leads to adverse cervical and thoracic spine changes; posture education recommended.
Damasceno *et al.*, 2018	Young adults	Cross-sectional	Self-perception	No association found between text neck posture and neck pain.
Neupane *et al.*, 2017	Not specified	Literature review	Structured review	Literature review on Text Neck Syndrome.
Shah *et al.*, 2018	Physiotherapy students	Correlation study	Random table sampling	Predominance of females in smart phone addiction; correlation with text neck syndrome and SMS thumb.
Richards *et al.*,	17-year-olds	Not specified	Not specified	No significant difference in neck pain or headache across identified neck posture clusters.
Mahmoud *et al.*,	Not specified	Systematic review	Literature review	No association found between forward head posture and neck pain.
David *et al.*, 2021	Children and adolescents	Review	Literature review	"Text neck syndrome" emerging due to precocious technology use; emphasizes early diagnosis and treatment.
Cuéllar & Lanman, 2017	General population	Not specified	Not specified	Concerns about musculoskeletal consequences of phone engrossment.
Gustafsson *et al.*, 2017	Young adults	Longitudinal study	Questionnaires	Text messaging associated with hand/finger symptoms and neck/upper back pain.
Kietrys *et al.*, 2015	College students	Experimental study	EMG recording	Input device type and texting style affect muscle activity and cervical posture.
Shan *et al.*, 2013	High school students	Self-assessment	Questionnaire	High prevalence of neck/shoulder and low back pain; influenced by various factors.

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RESEARCH ARTICLE

Optimized Ad-Hoc Routing in Vanets using the Adaptive Mobility Prediction (AMP) Algorithm

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ABSTRACT

Adaptive Mobility Prediction (AMP) Algorithm is a method proposed to enhance the reliability and operational efficiency in routing protocol functioning in vehicular ad hoc networks (VANETs). This is where VANETs came to the fore in ASV. They presented certain reliability issues regarding the communication links, given the dynamics of the network where mobility of vehicles can affect it. This paper presents Adaptive Mobility Prediction (AMP), a new way to forecast the future location of nodes in a network. The AMP employs mobility prediction for enhancing the efficiency of data transfer, low-latency connection set-up, and route optimization. The solution proposed by us incorporates network conditions, as well as density, being able to change accordingly, and consequently achieving illumination of routing performance when compared with standard routing techniques. Simulation results show that the AMP algorithm significantly reduces route reconfigurations, data losses, and improves network throughput performance. With the help of AMP, it becomes a better and faster solution for real-time communications in VANETs with relatively higher dense vehicle traffic. This technique benefits autonomous vehicles, traffic management, and intelligent transport systems (ITS).

Keywords: Adaptive Mobility Prediction, AODV, ITS, Prediction, Traffic management, VANETs,

INTRODUCTION

Relative to ITS, VANETs are gradually gaining importance because of their ability to enable vehicles to communicate with the infrastructure including traffic signals and road signs or even other vehicles [1]. Such networks let us create safer roads, minimize traffic jams, and support real-time applications such as autonomous driving, navigation, and collision avoidance [2]. However, since vehicles traverse different areas, VANET design is not static but evolving at a very fast pace [3-8]. Specifically, VANETs in their nature and because of highly dynamic and an irregular topological communication scenario put into high risk those conventional wireless communication systems optimized for stationary or low mobility scenarios [9-12].Indeed, dependable and trouble-free routing solutions are expected out of these network systems, to enable the requisite communication between vehicles, as [13-18]these networks are expected to perform.oad signs, as well as with one another [1]. These networks allow us to make roads safer, reduce traffic congestion, and enable real-time communication for applications like autonomous driving, navigation, and collision avoidance [2]. Nonetheless, because vehicles are mobile, VANET design is dynamic and rapidly changing [3-8]. VANETs, due to their dynamic and irregular nature, pose a significant threat to traditional wireless communication systems designed for stationary or low-mobility situations [9-12]. Thus, effective routing systems are required to offer dependable and trouble-free communication between vehicles, ensuring that these networks operate as [13-18] intended. This is especially due to the highly dynamic nature of VANET shaping routing instability both in relation to vehicle locations and the overall network structure [19]. In Dynamic Source Routing (DSR) [20] and Conventional Ad-hoc On-demand Distance Vector (AODV) [21-23] systems, latency is high and there are frequent route breakages due to cars joining or leaving the communication range. These protocols fail to take into account VANET's characteristics, hence delaying transmission time, losing packets as well as valuable resources [25].

Moreover, based on unexpected routing of these networks, passengers are likely experience dramatic degradation in data transmission performance especially in busy areas [26]. The above difficulties can be solved by the Adaptive Movement Prediction (AMP) method, in which the use of the predictive capabilities of the movement patterns of vehicles is allowed. Different from other routing algorithms which use only current data, the AMP algorithm predicts future motion by using past movements data of vehicles. Since it will determine where the vehicle will be after a certain time duration, the AMP algorithm can select the most accurate and fastest paths to transfer data. This not only reduces the number of failed paths but also the overhead in terms of resource cost, as well as latency-constrained reconfiguration and route discovery costs. One major strength of the AMP technique is that it is can easily work under any traffic condition. The technology is developed to make constant changes in its predictions based on the actual movement of vehicles and weather conditions and traffic situation on the road. As the approach is intended works for different patterns of mobility and density of network, it can also be implemented in both urban and rural setting. The integration of mobility prediction into the routing algorithm significantly improves the network throughput, latency, and the reliability of the communication within the VANET system making the AMP algorithm a more efficient VANET routing computation. Some of the recent simulations and experiments giving evidence that the AMP algorithm is superior to existing routing protocols. AMP was faster than earlier systems in several test instances in terms of packet delivery ratio, end-to-end delay, and network performance. It is also possible to note that in conditions of considerable mobility of and even in rather severe environments , the function of the algorithm to predict motion of automobiles and to react toward real-life situations provides better stability and effectiveness to the medium that is used for information transfer. Intelligent Transport System (ITS) applications like Autonomous driving, traffic management and vehicle to vehicle communication are some of the areas where the proposed AMP algorithm can potentially enhance the reliability of communication in VANETs a lot.

LITERATURE REVIEW

Hu *et al.,* (2020) employed a probabilistic model to show the existence of likely superior forwarding nodes which may improve the transmission rate. Therefore, the authors proposed a TDMA system which choses the right forwarding node by employing the motion prediction so that the topology of the network in the next frame is predicted.

In Bentaleb, A., *et al.* (2020), chunked transmission encoding was employed and Automated Model for Prediction (AMP) was introduced with strategies for bandwidth computation as well as model selection for low latency live streaming. A set of bandwidth prediction models with application to a variety of network conditions was established by reviewing the statistical and computational intelligence techniques and presenting an approach for choosing prediction models on line. New Adaptive Beacon Time Synchronization (ABTS) approach was introduced by Ansere, J. A. *et al.* (2019) to enhance the temporal message synchronize. In this research, the ABTS algorithm was applied whereby the linked automobile nodes were synchronized to the optimal performance indicators including synchronization accuracy, beacon message transmitted, and energy consumption. Strategies for node selection were explained to be used by the vehicle nodes in interacting with the other related vehicles. This helped to greatly increase the transmission of beacon signals when consuming less power specific to time synchronization. The ARMR protocol by Arafat, M. Y., *et al.* (2024) was proposed as an Adaptive Reinforcement Learning (RL) Based Mobility Aware Routing protocol for heterogeneous Wireless Body Area Networks (WBAN). First time, a mobility aware routing technique named Link Lifetime Estimate (LLE) was developed. It predicted connection lifespan metric to give reliable and efficient transmission and that: LLE proved to be a good approximation of the time nodes were with in the transmission range of each other. By this method, the ARMS chose nodes with longer connection times based on the nodes' dependability. In addition, adaptive Q-learning technique was presented which made routing decision flexible and adaptive with changing networks. Wijesekara, P. A. D. S. N., *et al.* (2023) provided a unique hybrid routing strategy for Software Defined Vehicular Networks (SDVNs) that used network congestion to choose between two modes: the highest stable least delay mode and the highest stable shortest path mode. The car network communication channels was then divided into wired and wireless networks, the pending transmissions and the resulting network link entropy was then used to predict the availability, average degree of network traffic, and collision probability. Using the Machine Learning (ML) it was possible to identify the delays in one hop channel and wireless LLF. The major contribution of Abdelazeem, *et al.* (2024) was the proposed K-means clustering algorithm with Genetic Algorithms (GA) optimization for the generation of keys in Vehicular Ad Hoc Networks (VANET).

This strategy improved the critical uniqueness by enhancing the average Hamming distance and reduce the similarity. A rise in one of the key count variances shown that the distribution of key counts has become less skewed when there exist higher entropy, which means more randomness. The results presented here illustrate that while the improved clustering strategy lead to increased safety of important generation, it also handled problems that were once solved with standard methods. It was useful for VANETs in order to be able to respond to stringent security requirements while keeping operational and safety efficiencies. Sefati, S. S., *et al.* (2022) to reduce power consumption and lengthen the network's lifetime, two algorithms were used: out of which, the Low-Energy Adaptive Clustering Hierarchy (LEACH) and the Bat Algorithm (BA) have been reported in this paper. In the development of FANET load balancing and clutter selection policies, the main objective was on minimizing UAV power consumption. Ho, T. J., *et al.* (2024) investigated strong vehicle localization integrating Vehicular Ad-hoc Network under varying vehicle velocities for the LOS or the NLOS field where the statistics of NLOS error and its occurrence probability is unknown. To address this issue two approaches were offered based on MMA-SDP conceptualization and an Advanced Measurement Preprocessing (AMP) procedure. This AMP technique has reduced the impact of NLOS on the received raw range measurements from multiple base stations. Ahmad, W., *et al*. (2023) presented the localization mechanism via the Received Signal Strength (RSS) which can determine the position of the target vehicle accurately. This made the contact with Road Side Units (RSUs) and defined the position of the typical RSS by detecting signal within its reach. After detection of the RSS, the proposed RSS-based localization method successfully and accurately pinpointed the position of the vehicle. The suggested approach was generated from other neighboring RSUs and it had high signal to noise ratio. On determining the position of the vehicle, the Cramer Rao lower bound (CRLB) was evaluated for the particular vehicle.

Problem Identification

VANETs has high vehicle mobility, making the formation of the network very dynamic, which leads to frequently creation and breaking of communication links and topological changes. He also notes that conventional routing protocols like AODV/TR and Navigation & Roadmap Discovery (DSR) are challenging to sustain well-defined

pathways because automobiles frequently come and go in/out of the reception radius. For this reason, it leads to lost network bandwidth, missing packets, and delays especially among densely populated networks. Moreover, identification of traces, and altering them requires a lot of bandwidth and energy. These challenges overshadow the need to create an ideal system that has the ability to predict vehicle positions and change the flow of the actions.

MATERIALS AND METHODS

The Adaptive Mobility Prediction (AMP) algorithm uses a novel way to maximize routing in Vehicular Ad-hoc Networks (VANETs): it tries to forecast future automobile destinations. Basic routing protocols like AODV or DSR are not capable enough to build routes that are adaptable to the highly unpredictable and rapidly changing environment of VANET, due to which there is high packet loss and constant disruption. The AMP approach addresses this issue by using current speed of mobiles and past trajectory to develop mobility predictions. This enables the network to pre design reliable and steady path by passing and thereby reduce the need continuously to find a route and to disturb the transmission. The extent to which AMP algorithm can be adjusted where it has a strong suit is its flexibility. In contrast with fixed estimates from characterizing the technique by cars' passing, it rebalances its mobility predictions. It receives updates from the cars forming the network for factors including acceleration, speed and direction, and aligns its estimations to the new environment. Due to the continuous dynamic update, AMP is very responsive for handling the diverse traffic conditions such as congestion , barriers and accident that disturb the vehicular movement patterns. Precise prediction about movement paths of vehicles is beneficial for the algorithm to minimize route rearrangement time and to increase the forwarding of data packets which enhances the VANET communicating reliability. Algorithm 1 demonstrates the process performed in Adaptive Mobility Prediction. Here the procedure of initialization, moment predict, change of adjustments in mobility, correct the errors, repetition of prediction is done.

Algorithm 1: Adaptive Mobility Prediction (AMP) Algorithm

Input
For a mobile node, historical movement data such as coordinates, speed, direction over time is gathered.
Step 1: Initialization
Prediction accuracy threshold is set
Step 2: Prediction of moment
The present velocity and movement direction is calculated.
Speed (V) = Distance / Time.
Direction (θ) = Angle of movement relative to the appropriate reference.
Find the node's future position using the simple motion model.
Step 3: Adjustment for Changes in Mobility
The direction or speed is updated using the most recent observed values.
Use a linear or piecewise linear approximation for changes in velocity.
Step 4: Error Correction
Velocity or direction is recalibrated based on recent movement behavior.
Step 5: Repeat the Prediction
Repeat the prediction process until the prediction window ends or the accuracy threshold is met. Output:
The predicted future positions and the expected trajectory are provided for the mobile node.

Figure 1 describes the Adaptive Mobility Prediction algorithm. Input with data is fed into the algorithm, which leads to the steps like initialization, moment prediction, adjustment changes in mobility, correcting the errors and repetition of prediction. Finally, the output indicating the future positions for mobile nodes is obtained. The main strength of the AMP algorithm is its adaptability. Unlike set assumptions, the program updates its mobility projections in real time as vehicles pass. It modifies its forecasts based on real-time data obtained from the network's automobiles, taking into account acceleration, speed, and direction. The AMP algorithm is particularly adept at

dealing with traffic incidents including congestion, bottlenecks, and accidents, which can have a substantial impact on vehicle flow patterns. Its ability to respond in real time helps to reflect this. Because of their high accuracy vehicle movement prediction capabilities, the technology can improve data packet forwarding, increase communication reliability in VANETs, and reduce route reconfiguration times. We can forecast the vehicle's future position by using the formula

$P_i(t+1) = P_i(t) + v_i(t) . \Delta t$ ---------- (1)

$P_i(t+1)$: vehicle *i*' s expected position at time *t+1*. $P_i(t)$: At time t, the present position of vehicle *i*. $v_i(t)$: the speed of vehicle i at the given time t. Δt represents the time from t to t+1. Using the speed and direction, the velocity is estimated as

$v_i(t) = \sqrt{v_{ix}^2(t) + v_{iy}^2(t)}$ ---------- (2)

Speed of vehicle i at time t is$v_i(t)$. Speed component in x direction at time t is $v_{ix}^2(t)$ whereas in y-direction, $v_{iy}^2(t)$ is the speed component at time t. The adjustment in AMP algorithm is as follows:

$P_i(t+1) = P_i(t) + \big(v_i(t) + \delta\, v_i(t)\big). \Delta t$ ---------- (3)

The Updated predicted position of vehicle i at time *t+1* is $P_i(t+1)$. Pi(t) refers to the present position of vehicle i at time. The present velocity of vehicle i is $v_i(t)$. $\delta\, v_i(t)$ indicates the adjustment factor for vehicle velocity based on recent acceleration or deceleration. Δt points out the time interval between t and *t+1*. The Probability of route stability is calculated as:

$S(t) = \frac{1}{1+\lambda .d(t)}$ ---------- (4)

Stability of the route at time t is represented as $S(t)$. λ is the constant factor that adjusts the influence of distance on route stability. The distance d (t) is created between two vehicles at time t, which impacts route stability.

RESULTS AND DISCUSSION

The proposed method has implemented by using NS2 simulation tool and the comparison study carried out with existing literature review methods like TDMA and ABTS. The performance metrics like throughput, energy, delay and PDR measured. Figure 2 represents the Throughput vs Packet Size graph illustrates how throughput (the rate at which data is transmitted) changes as the packet size increases for three protocols: ABTS, TDMA, and AMP. As the packet size grows, the throughput increases for all three protocols, but AMP shows the most significant improvement. ABTS exhibits a steady linear increase in throughput as the packet size increases, starting at 0.256 kbps and reaching 1.282 kbps. TDMA also shows an increase in throughput, but the growth is slower compared to ABTS. On the other hand, AMP achieves the highest throughput at all packet sizes, with a faster increase than both ABTS and TDMA, peaking at 2.083 kbps. This indicates that AMP offers the most efficient performance in terms of throughput, particularly as packet size increases, while ABTS and TDMA exhibit more modest improvements.

Energy level vs Number of node graph is illustrated in Figure 3.Engine energy consumes as the number of nodes in the network absorption data for ABTS, TDMA and AMP protocol. The results indicate that the number of nodes is directly proportional to energy consumption for all of the three protocols in linear trend fashion. ABTS is observed as using the highest energy in all node scenarios, ranging from 125 Joules for 10 nodes and 1250 Joules for 100 nodes. TDMA uses considerably less energy than ABTS and its rate of increase is less steep with an increased number of nodes. On the other hand, the results showed that the energy consumption of AMP has the least slope and therefore lies at the lowest, but the increase in energy usage is linear. The overall results obtained indicate that, on average, AMP protocol consumes the least energy which, in turn, is superior to the other protocols such as TDMA and ABTS.

The ABTS, TDMA and AMP protocols are compared in the figure 4 is the Time Delay vs Number of Nodes graph that depicts the variation in the time delay or latency of transmission with addition of more nodes in the network. When the number of nodes is raised, delay of all these three protocols also rises, but comparatively it is better in AMP than in TDMA or ABTS. ABTS begin with 0.1173ms for 10 nodes and end at 1.1737 ms for 100 nodes; this reveals an increase in latency when nodes are added. ABTS also experiences an enhanced delay to 0.7498 ms from an initial 0.07527 ms but at a slower rate than that of TDMA for the same numbers of nodes. Low time delay is again achieved by AMP which gradually increases as the number of nodes increases to a maximum of 0.606 ms out of the

initially plotted 0.0606 ms. This shows that AMP is the least greedy, offering the least amount of delay, or latency as the network expands as compared to the other protocols. Figure 5 shows that Packet Delivery Ratio (PDR) increases with increase in the increasing packet size Thus, Comparison between the three protocols (ABTS, TDMA, and AMP) for the percentage of packets delivered with varying packet size is depicted from figure 5. This means that with increased packet size the PDR stays up for all the protocols, which shows that most packets are delivered with flow control with no siginificant loss. ABTS rises from a first PDR of 96.2% at 50 kb to a second PDR of 99.24% at 250 kb. TDMA also has the similar trend, stands at 96.8% at the initial stage and 99.36% at later stage. In all PSI values, AMP delivers the best results regardless of the packet size with PDR ranging from 98.2% to a high of 99.64% slightly higher than both ABTS and TDMA. All three protocols have high packet delivery ratios and although all three protocols have reasonably high retention rates, AMP is slightly more reliable as packet size increases.

CONCLUSION

In Conclusion, the proposed technique named as Adaptive Mobility Prediction (AMP) has been really effective to optimize the ad hoc routing scenario for VANET. Real time vehicle movement is also integrated for mobility predictions which are useful for enhancing routing with consideration to changes in network architecture within the AMP. Especially, the efficiency of head forecaster in anticipating vehicles' movement and making prior adjustments for route enhances the performance level of network throughput, latency, and the communications quality where the risk of a route failure experience will be less. In addition, because of flexibility when addressing different types of traffic and real-time dynamics within a network; AMP is satisfactory for both rural and urban settings. The AMP algorithm provides a means of guaranteeing that efficient, reliable routing solutions in the dynamic environment of VANETs, primarily induced by the emergence of smart cities and self-driving cars, can be achieved and maintained at scale. It has real-time features that will transform intelligent transportation systems; traffic control; and collision prevention; thus, boosting the formation of vehicle webs.

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Table 1: Comparison of various methodologies used by the authors

Authors	Methodology	Advantages	Disadvantages	Dataset	Algorithm
Hammood, O. A., et al. (2020)	Trust-based relay nodes with packet coding in VANETs	Increases transmission reliability and reduces packet	Trust model cannot handle all network scenarios	Simulated VANET environment	Transmit Packet Coding with Trust-based Relay Nodes

		loss.	effectively.		
Zhang, D., et al. (2021)	Clustering Ad hoc On-Demand Distance Vector (AODV) with edge computing for Internet of Vehicles (IOV)	Combines AODV with edge computing to enhance efficiency.	Can be limited by edge computing resource constraints.	Simulated IOV environment	AODV with edge computing strategy
Ajay, P., et al. (2023)	Wireless tree-based routing for energy-efficient Internet of Things (IoT) communication	Reduces energy consumption in IoT systems.	Limited to specific IoT application scenarios.	IoT system simulation data	Wireless Tree-based Routing Protocol
Dhinakaran, D., et al. (2023)	Hybrid optimization of Mobile Ad Hoc Network (MANET) routing using biomimicry and machine learning models	Integrates nature-inspired methods with machine learning.	Requires extensive training data and computational resources.	Simulated MANET data	Biomimicry Buzz, Hybrid Forest Boost Regression-Artificial Neural Network (ANN)
Shawky, M. A., et al. (2023)	Cross-layer authentication scheme for VANETs	Enhances security in VANETs through cross-layer approach.	Can increase computational complexity.	Simulated VANET environment	Cross-layer authentication scheme
Alkhalidy, M., et. al. (2024)	Hybrid Reinforcement Learning (RL) and differential evolution for Ciphertext-Policy Attribute-Based Encryption (CP-ABE) decryption optimization	Optimizes decryption performance in urban VANETs.	Complexity of hybrid approach, requires tuning.	Simulated urban VANET environment	Hybrid Reinforcement Learning and Differential Evolution

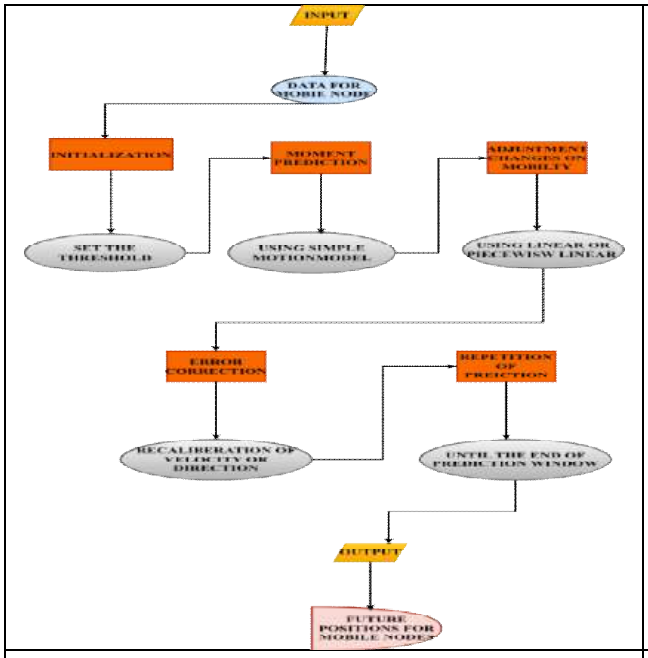


Figure 1: Flow Chart of Adaptive Mobility Prediction

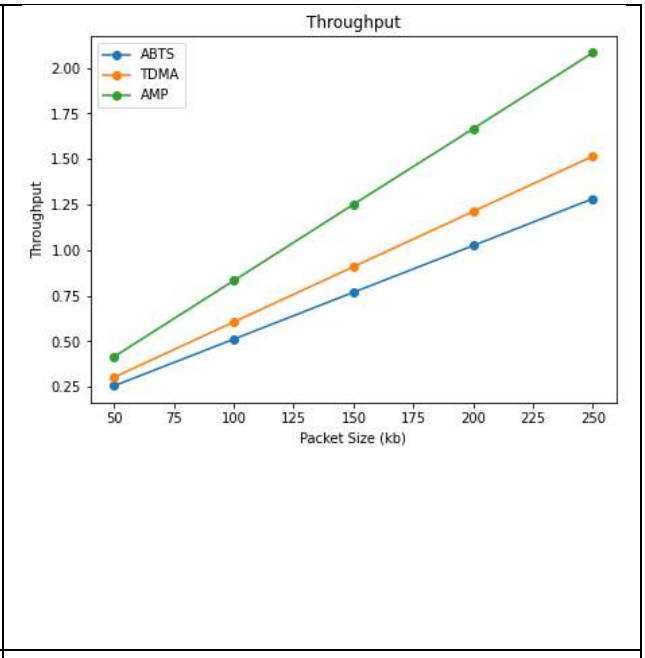


Figure 2: Throughput Comparison chart

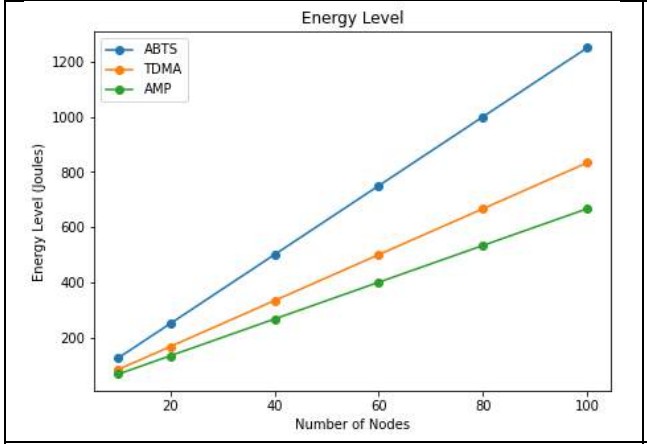


Figure 3: Energy Comparison chart

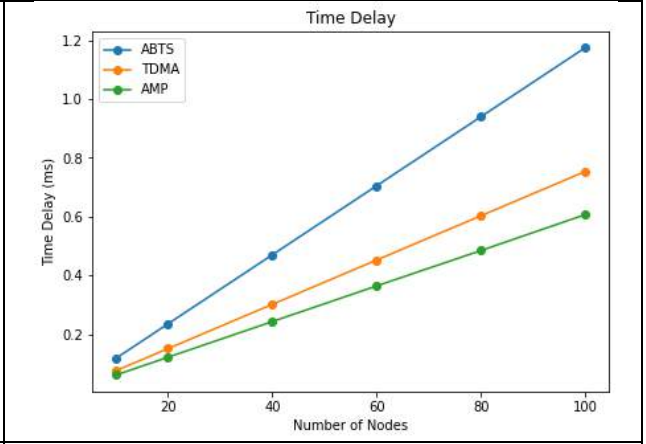


Figure 4: Time Delay comparison

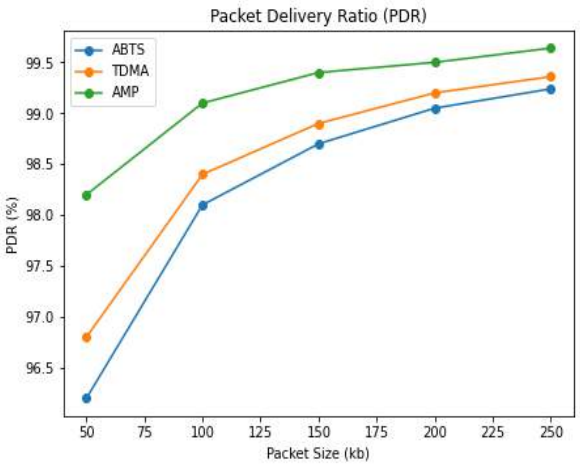


Figure 5: Packet Delivery Comparison

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RESEARCH ARTICLE

Exploring AI Anxiety in Education: A Quantitative Study on Students' Perceptions of AI-Powered Learning Tools

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ABSTRACT

Artificial intelligence (AI) has become a significant part of modern education, offering tools like adaptive learning systems, AI-powered tutoring, and automated grading that promise to enhance the learning experience. However, alongside these benefits, the integration of AI into educational environments has introduced a new concern: AI anxiety. This study aims to explore the phenomenon of AI anxiety among university students and examine its impact on the acceptance and use of AI-powered learning tools. Drawing on a quantitative approach, the research investigates how demographic factors such as gender, field of study, and prior exposure to AI tools influence levels of anxiety. Using a survey administered to 200 university students, the study measures AI anxiety based on concerns about privacy, data security, loss of teacher-student interaction, and the fear of AI replacing human educators. The analysis uses descriptive statistics, correlation, and regression techniques to assess the relationship between these factors and AI anxiety. "The results reveal significant differences in AI anxiety across various demographic groups, with students from non-STEM fields and female students exhibiting higher levels of anxiety compared to their STEM and male counterparts. Furthermore, the study finds that frequent use of AI-powered tools reduces anxiety, suggesting that familiarity with AI decreases fear and increases acceptance. This research contributes to the existing literature by offering empirical insights into the psychological barriers students face in adopting AI in education. It highlights the need for educational institutions and AI developers to consider these emotional responses when implementing AI technologies to ensure their effective integration. The study concludes with recommendations for reducing AI anxiety, such as increasing AI literacy and providing support systems to help students

navigate the evolving technological landscape in education. By addressing these concerns, the education sector can better harness the potential of AI while minimizing the negative psychological impacts on students.

Keywords: AI anxiety, artificial intelligence in education, AI-powered learning tools, privacy concerns

INTRODUCTION

The integration of artificial intelligence (AI) in education is rapidly transforming how students learn and interact with educational content. AI-powered tools, such as adaptive learning systems, intelligent tutoring, and automated grading, have introduced personalized learning experiences that cater to individual student needs, enhancing the overall learning process. These technologies have proven to be effective in optimizing student performance and providing immediate feedback, making education more accessible and efficient. However, alongside these benefits, a new challenge has emerged: AI anxiety. This term refers to the apprehension, discomfort, or fear that students experience when interacting with AI systems in educational settings. AI anxiety is driven by various factors, including concerns about data privacy, the accuracy of AI assessments, loss of personal interaction with teachers, and the fear that AI may eventually replace human educators. As educational institutions increasingly adopt AI-powered tools, it is crucial to understand how students perceive these technologies and the psychological impact they may have(Ali, 2024). While the technical benefits of AI in education are well-documented, there is a significant gap in the literature regarding the emotional and psychological responses of students to these advancements. This study aims to explore the extent of AI anxiety among university students and investigate how it influences their acceptance and use of AI-powered learning tools. By examining demographic factors such as gender, academic discipline, and prior exposure to AI, this research seeks to identify patterns in AI anxiety and understand how different groups of students are affected. Furthermore, it aims to assess whether increased familiarity with AI tools reduces anxiety and promotes greater acceptance. Given the growing reliance on AI in education, addressing AI anxiety is critical to ensuring that students can fully benefit from these technological advancements. The findings of this study will contribute to the ongoing discourse on AI in education by offering insights into how educational institutions and AI developers can mitigate anxiety and improve student engagement with AI-powered tools. Ultimately, understanding and addressing AI anxiety will be key to harnessing the full potential of AI in education while minimizing its negative psychological effects on students.

Background of the Study

The Evolution of AI in Education:

Over the past decade, artificial intelligence (AI) has significantly transformed the education sector, introducing a wide range of technologies aimed at enhancing learning, improving accessibility, and providing support for teachers in delivering personalized education. These advancements have moved beyond traditional classroom settings, offering AI-based tutoring systems capable of adjusting content based on individual student progress and learning styles. AI-enabled assessments now provide instant feedback, helping students to track their learning outcomes and offering educators insights into student performance. Such systems allow for real-time data analysis that helps identify areas where students may be struggling and adjusts the learning materials accordingly(Wang, 2024). AI technologies have also been pivotal in creating adaptive learning environments that respond to the unique needs of each student, ensuring that educational content is tailored to their specific abilities and learning pace. This evolving landscape is redefining the roles of teachers and students alike, with AI acting as both an assistant and a supplement to traditional teaching methods. The growing reliance on AI to handle administrative tasks such as grading and lesson planning has further freed up educators to focus on more complex aspects of teaching, thereby increasing overall efficiency in the education system(Lee, 2024).

Global Adoption of AI Tools in Education

The global education sector has widely embraced AI technologies, with institutions ranging from primary schools to universities implementing AI-powered systems to enhance the learning experience. These tools are being used to foster greater student engagement, personalize learning paths, and streamline administrative tasks such as grading and scheduling. Studies indicate that the adoption of AI in education is projected to grow exponentially in the coming years, driven by the demand for more effective, data-driven teaching methods and learning platforms. Countries around the world are recognizing the potential of AI to bridge educational gaps by providing equal access to quality learning materials, particularly in underserved regions. AI-driven platforms are also enhancing online learning experiences, making education more flexible and accessible to students regardless of geographic location. Institutions of higher learning are increasingly turning to AI to offer more personalized education, from course recommendations based on learning patterns to predictive analytics that help universities identify students at risk of falling behind. As AI continues to evolve, its applications in education will expand, supporting both in-person and virtual learning environments and enabling educational systems to meet the diverse needs of learners worldwide.

Transformational Impact on Learning

AI's ability to transform traditional teaching methods into more dynamic, adaptive, and efficient models has been one of its most significant contributions to education. AI tools have made it possible to create personalized learning plans for students, which not only cater to individual learning speeds but also provide real-time feedback and progress tracking. This ensures that students receive the right level of challenge and support tailored to their learning needs. Moreover, AI-driven platforms enable early intervention strategies by identifying learning gaps and suggesting corrective measures before these gaps widen. These systems also facilitate a higher degree of engagement by making learning more interactive and tailored to the preferences of each student. However, while the benefits of AI in enhancing academic performance and engagement are clear, this transformation has introduced certain challenges, particularly regarding the psychological and technological impacts on students and educators. Students may experience anxiety or discomfort in interacting with AI, especially in contexts where AI systems replace or reduce human interaction. Additionally, concerns about data privacy, bias in AI algorithms, and the lack of human empathy in AI-driven tools pose challenges to their widespread adoption(P. S, 2023). Thus, while AI presents a powerful tool for educational enhancement, these challenges must be addressed to ensure its effective and ethical integration into the learning process.

Significance of the Study

The significance of this study lies in its implications for educational institutions, educators, AI developers, and policymakers. Understanding AI anxiety is crucial for institutions aiming to integrate AI-powered tools into learning environments. AI anxiety, fuelled by concerns about data privacy, loss of human interaction, and system reliability, can hinder successful AI adoption. Identifying these concerns allows institutions to create targeted interventions, such as workshops and orientation sessions, to familiarize students with AI technologies and reduce apprehension. Recognizing demographic patterns in AI anxiety(Kaya, 2022) can help tailor support services to different student populations, such as non-STEM students or specific age groups. For educators, understanding AI anxiety is essential to maintain student engagement. Students experiencing high anxiety may disengage or resist AI tools, reducing the effectiveness of these technologies. Educators can ease this anxiety by gradually integrating AI tools, explaining how they work, and emphasizing that AI complements, not replaces, human instruction. AI developers play a key role by designing user-friendly, transparent, and supportive systems that address common concerns like data privacy and decision-making opacity(Heike Felzmann, 2020). Collaboration between educators and developers can lead to AI tools that enhance learning while minimizing anxiety. From a policy perspective, the findings underscore the need for AI literacy programs in educational curricula. These programs would demystify AI, reduce student anxiety, and promote effective engagement with AI-powered tools. Policymakers should prioritize AI literacy and the ethical use of AI in education to foster a more positive relationship between students and AI technologies, ultimately improving the educational outcomes of AI integration.

AI in Education: A Historical Overview

The use of artificial intelligence (AI) in education has evolved significantly over the past few decades, beginning with basic automation tools and progressing to sophisticated systems capable of personalized learning. Early educational technologies, developed in the 1960s and 1970s, focused primarily on computer-assisted instruction (CAI), offering programmed learning and simple drill exercises aimed at reinforcing foundational skills. These early systems were limited in scope and lacked the adaptive capabilities present in modern AI technologies. By the 1990s, advancements in computational power and algorithms paved the way for intelligent tutoring systems (ITS), which provided more interactive learning experiences by simulating the decision-making processes of human tutors. These systems allowed for more personalized education, adjusting content delivery based on a student's performance and learning pace(An, 2021). The 21st century brought about the integration of machine learning and natural language processing into education, enabling more complex applications such as AI-based grading systems, virtual teaching assistants, and adaptive learning platforms. Today, AI is used not only to support personalized learning experiences but also to assist in administrative tasks, track student performance, and offer predictive analytics that help educators identify students at risk of falling behind. As AI continues to evolve, its role in education is becoming more pronounced, with emerging technologies such as learning analytics and AI-driven assessments promising to revolutionize how students learn and how educators teach.

Psychological Impacts of Technology in Education

The increasing use of technology in education has had profound psychological effects on both students and teachers. On one hand, technology has enhanced learning by providing greater access to educational resources, enabling more interactive learning environments, and fostering collaboration among students. Digital platforms and tools, such as virtual classrooms, online learning portals, and educational apps, have made it easier for students to learn at their own pace and access information from anywhere in the world. However, alongside these benefits, technology has also introduced psychological challenges, such as increased anxiety, cognitive overload, and a sense of depersonalization in the learning process. Students, particularly those who struggle with technology, may experience anxiety when navigating complex digital platforms or using unfamiliar tools. The constant influx of information and the need to multitask can lead to cognitive overload, reducing the effectiveness of learning and contributing to stress. Additionally, the shift from face-to-face interaction to technology-mediated communication can create feelings of isolation, as students may miss the personal connection with their teachers and peers. Teachers, too, face psychological pressures from the increasing demand to integrate technology into their teaching practices, often without adequate training or support. This can lead to resistance or burnout as they attempt to balance traditional teaching methods with new technological requirements. The psychological impacts of technology in education are multifaceted, requiring careful consideration of how best to support both students and teachers in this evolving landscape.

The Concept of AI Anxiety in Educational Settings

AI anxiety refers to the fear, discomfort, or unease that individuals experience when interacting with artificial intelligence systems, particularly in contexts where they feel their roles or abilities may be supplanted by machines(Yu-Min Wang, 2022). In educational settings, AI anxiety has emerged as a significant concern, especially as AI tools become more prevalent in classrooms, universities, and online learning environments. The concept of AI anxiety is rooted in a broader fear of technological advancement, where students and educators alike worry about the implications of relying on machines for tasks traditionally performed by humans. For students, AI anxiety may be triggered by concerns about data privacy, the accuracy of AI-driven assessments, or the fear that AI will eventually replace human teachers. This anxiety is often exacerbated by a lack of understanding of how AI systems work, leading to mistrust and resistance to using these tools(Artur Klingbeil, 2024). Instructors, on the other hand, may experience AI anxiety due to fears that their professional roles could be diminished or even replaced by AI technologies capable of automating instructional tasks such as grading or content delivery. Additionally, the perceived impersonal nature of AI, which lacks the empathy and emotional intelligence of human educators, can contribute to a sense of alienation among students, further fuelling their anxiety. Understanding the root causes of AI anxiety is critical for addressing this issue, as it can hinder the effective adoption and utilization of AI technologies in

education". By addressing these concerns, educators and AI developers can work towards creating more transparent, accessible, and supportive AI systems that alleviate anxiety and foster positive educational outcomes.

REVIEW OF LITERATURE

The table above summarizes recent studies exploring the impact of AI tools in education across various contexts. These studies reveal diverse perspectives on the adoption, perception, and effects of AI technologies on both students and educators. Common themes include AI's potential to enhance motivation, autonomy, and personalized learning experiences, as well as concerns related to creativity constraints, anxiety, and over-reliance on AI tools. Collectively, these findings underscore the need for informed decision-making, institutional support, and ethical considerations when integrating AI into educational settings.

Student Perceptions of AI: Opportunities and Challenges

Students' perceptions of AI in education are shaped by both the opportunities these technologies present and the challenges they introduce. "On the one hand, many students recognize the potential of AI to enhance their learning experience. AI-powered tools can offer personalized learning pathways, providing real-time feedback and adapting content based on individual performance. This can lead to more efficient learning, as students can focus on areas where they need improvement while progressing faster through subjects they excel in. AI can also facilitate access to education for students in remote or underserved areas, offering virtual tutors, AI-driven assessments, and automated content delivery systems that make learning more accessible. However, these opportunities are counterbalanced by significant challenges. Many students' express concerns about the role of AI in education, particularly regarding the replacement of human teachers with AI-driven systems(Firuz Kamalov, 2023). The lack of human interaction and empathy in AI tools is a major concern for students, who may feel that AI cannot provide the emotional support and understanding that a human teacher can offer(Clugston, 2024). Additionally, issues related to data privacy and security are prominent in students' perceptions of AI, as they worry about how their personal information and academic performance data may be used or misused by these technologies. The potential for algorithmic bias in AI systems, where automated assessments or recommendations may unfairly disadvantage certain groups of students, is another concern. These challenges highlight the complex relationship between students and AI in education, where the benefits of personalized, efficient learning are often tempered by concerns about the broader implications of AI integration.

Emergence of AI Anxiety in Educational Contexts

Definition of AI Anxiety

AI anxiety refers to the feelings of apprehension, discomfort, or fear that individuals may experience when interacting with artificial intelligence systems. Accordingly, AI anxiety refers to an overall affective response of anxiety or fear and feelings of agitation about out-of-control AI that inhibits an individual from interacting with AI (Johnson & Verdicchio, 2017). In educational settings, this anxiety can stem from several factors. For many students, a lack of understanding about how AI technologies work can create a sense of unease, especially when these tools are used to monitor performance or deliver feedback without human involvement. There is often a fear that AI may replace traditional human roles in education, such as teachers and instructors, which can lead to concerns about the quality of learning experiences. The idea of being evaluated or taught by a machine may feel impersonal and intimidating to students, exacerbating their anxiety. Additionally, some may worry about the potential misuse of AI in terms of privacy violations, where the data collected by these systems could be exploited without their consent. All of these concerns contribute to the overall experience of AI anxiety, which can hinder students from fully embracing the educational technologies meant to support their learning journey.

Psychological Reactions to AI

Despite the intended benefits of AI tools in education, such as improving learning efficiency and providing personalized support, many students experience psychological discomfort when interacting with these technologies.

Key contributors to AI anxiety include concerns over data privacy, security, and the potential for surveillance(Kyoungwon Seo, 2021). Students may fear that their personal information, learning habits, or academic performance data could be improperly accessed or misused by the AI systems that track their progress. The perceived lack of empathy in AI, as compared to human teachers, can also cause discomfort, as students may feel that AI lacks the emotional intelligence necessary to understand and respond to their individual needs. Additionally, the potential for algorithmic bias in AI-driven assessments or recommendations can further increase anxiety, as students may worry about being unfairly evaluated by systems that are not entirely impartial. Another major factor exacerbating AI anxiety is the depersonalization of education, where the human interaction that typically characterizes the learning process is replaced by automated systems. This shift can lead to feelings of isolation or alienation, particularly among students who value the human elements of teaching and learning.

Role of AI Anxiety in Adoption

AI anxiety plays a significant role in shaping how students perceive, adopt, and engage with AI-powered educational tools. Research indicates that students who experience higher levels of anxiety toward AI are less likely to use these technologies, even when they are designed to enhance learning outcomes(Fangchen Wen, 2024). This avoidance behavior can diminish the effectiveness of AI systems, as students may not take full advantage of personalized feedback, adaptive learning plans, or other features designed to improve academic performance. The reluctance to engage with AI tools can create barriers to the broader adoption of these technologies, as educational institutions may struggle to integrate AI into learning environments if students are resistant or fearful(Cecilia Ka Yuk Chan, 2023). Addressing AI anxiety is therefore crucial for maximizing the potential benefits of AI in education. By understanding the emotional responses that contribute to this anxiety, educators and developers can implement strategies to ease concerns and promote greater acceptance. This could involve increasing transparency around how AI systems work, offering training to help students become more familiar with these tools, and ensuring that AI complements rather than replaces human teachers. By reducing anxiety, institutions can create a more supportive environment that encourages students to embrace AI as an integral part of their educational experience.

METHODOLOGY

This study employs a quantitative research design, utilizing a structured Likert-scale questionnaire to gather data from university students (N=200) across various academic disciplines. The survey captures student's perceptions of AI-powered learning tools and measures levels of AI anxiety. Stratified random sampling ensures diversity in gender, age, and field of study. Data analysis involves descriptive statistics to summarize responses and explore patterns of agreement or disagreement, while correlation analysis identifies relationships between demographic variables and AI anxiety levels". This approach provides insights into how different student groups perceive and respond to AI tools in educational settings.

Data analysis

Demographics

The study sample consisted of 200 participants, with 43% identifying as male and 57% as female. "The age distribution showed that 42% of the respondents were between 18-21 years old, 33% were aged 22-25, 8% were in the 26-30 age group, and 17% were above 30. In terms of academic background, 38% of the participants were from STEM fields (Science, Technology, Engineering, Mathematics), 29% from Humanities, 18% from Social Sciences, and 15% from other fields of study. The year of study was also diverse, with 27% in their first year, 28% in their second year, 24% in their third year, and 21% in their final year. This distribution provides a balanced representation across gender, age, academic discipline, and year of study, ensuring comprehensive insights into the perceptions of AI-powered learning tools.

Section 2: Perceptions of AI in Education

The survey on the perceptions of AI-powered learning tools showed mixed views on their effectiveness. 24% of respondents believed that AI-powered tools improved the overall learning experience, while 29% agreed that they helped them learn more efficiently by providing personalized content. Trust in AI systems was reflected in 32% of respondents who trusted the feedback and assessments provided by AI-powered learning systems. 35% of students felt comfortable using AI tools to assist them in their studies, while 21% disagreed and 19% strongly disagreed. 36.5% agreed that AI tools provided timely feedback that helped improve academic performance", while fewer disagreed or strongly disagreed. "Finally, 37% agreed that AI-powered tools made learning more accessible to them, while 18% disagreed and 9.5% strongly disagreed.

Section 3: AI Anxiety among students

The study reveals a significant divide among participants regarding concerns and anxieties about AI-powered learning tools. Concerns were expressed about the amount of personal data collected by AI systems during studies, the potential replacement of human teachers in the future, and the anxiety of being evaluated by a machine. Concerns were also expressed about AI-driven assessments and the unease of AI tools making decisions about academic progress. The lack of empathy in AI systems was also a concern, with 37% of respondents agreeing and 14% strongly agreeing. A significant number of students experienced heightened anxiety when using AI tools, with 38% agreeing and 17.5% strongly agreeing. These results highlight that despite the benefits of AI tools, many students still have concerns about privacy, decision-making, and the emotional disconnect associated with AI in education. The study highlights the need for further research and understanding to better understand the complexities of AI in education.

Correlational Analysis

A Pearson product moment correlation was performed to find out the relationships between the variables in the study table above. The correlation analysis indicates a strong positive relationship between perceptions of AI in education and AI anxiety, with a Pearson correlation coefficient of 0.78. The significance value($p = 0.026$) confirms that this relationship is statistically significant, suggesting that increased perceptions of AI are associated with higher levels of AI anxiety among students. The present study demonstrates consistency with the findings of Zhang and Dafoe (2019) who reported a similar positive correlation between perceptions of AI and AI-related anxiety, particularly in educational and professional settings. Their research indicated that individuals with a greater understanding of AI's capabilities were more inclined to experience anxiety over its potential consequences, such as concerns about loss of autonomy and ethical implications. Another study by Holstein et al. (2020)found that while AI-based tools can be advantageous in education, they may also generate psychological obstacles for students. Students who view AI as a substitute for human instructors reported heightened levels of anxiety due to worries about the fairness, transparency, and personalization of these AI systems.

CONCLUSION

The paper emphasizes the difficulties of bringing AI-powered learning tools into education as well as their transforming capacity. These instruments raise questions about data privacy, trust in machine-driven evaluations, and the lack of human empathy even if they offer great benefits such tailored learning experiences, effective feedback, and more accessibility. The noted relationship between good opinions of artificial intelligence and increased worry emphasizes the complex and even contradictory sentiments students have about these technologies.While AI can offer valuable support in education, concerns around issues like privacy, job displacement, and the lack of human interaction must be carefully addressed. Students from disadvantaged backgrounds may face digital divides, limiting their access to AI-powered educational tools, ultimately widening existing inequalities(Milad Shahvaroughi Farahani, 2024). Ongoing efforts are needed to train AI models responsibly and monitor them to mitigate bias and ensure fairness (Mello et al., 2023a) (Mello et al., 2023b).

Further, the potential clash between using AI for data-informed decision-making and upholding moral values requires thoughtful consideration by educational leaders . Safeguarding student privacy, promoting equal access, ensuring model explain ability, and fostering ethical AI practices are crucial steps in harnessing the potential of AI in education while mitigating associated worries. As AI becomes more prevalent, continuous monitoring and proactive efforts to address these concerns will be vital in creating an inclusive, equitable, and ethically responsible AI-powered education system. These results highlight the need of focused interventions including open data policies, thorough AI literacy classes, and support mechanisms to properly handle student concerns. Developers and educational institutions must provide a human-centred approach top priority for integrating artificial intelligence into balance between innovation and student comfort and involvement. Reducing these psychological obstacles will help the industry to fully utilize artificial intelligence and provide conditions fit for education and personal development.

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Table: 1 Review of literature

Year	Authors	Title	Main Focus	Methodology	Findings
2013	*David D. Luxton*	Artificial Intelligence in Psychological Practice: Current and Future Applications and	This article reviews developments in artificial intelligence (AI) technologies and their current and prospective	Qualitative analysis	The advancement of AI capabilities and their integration into psychological practice have significant implications that are

		Implications	applications in clinical psychological practice.		poised to reshape the mental health care landscape. (APA PsycINFO Database Record (c) 2016 APA, all rights reserved)
2019	*Baobao Zhang&Allan Dafoe*	Artificial Intelligence: American Attitudes and Trends	American attitudes and trends towards AI	Quantitative survey	Their research indicated that individuals with a greater understanding of AI's capabilities were more inclined to experience anxiety over its potential consequences, such as concerns about loss of autonomy and ethical implications.
2020	Ella Glikson & Anita Williams Woolley	Human Trust in Artificial Intelligence : review of empirical research	This review examines how AI diverges from other technologies and reviews the empirical research on factors influencing human trust in AI, which has been conducted across various disciplines over the past two decades.	Literature Review	This review offers several key insights into the factors that shape emotional trust across diverse AI representations. While existing studies have primarily examined emotional trust in relation to robotic and virtual AI, there is a dearth of research on emotional trust in embedded AI systems.
2023	Filipec & Woithe	Programme of Study: international management	Adoption, Perception, and impact of ChatGPT in higher education.	Constructivist-interpretivist approach, semi-structured interviews.	Highlights the need for informed decision-making and a balanced approach to AI in education
2023	Irfan et al.	Insights into Student Perceptions: Investigating AI Tool Usability in Irish Higher Education	Examines students' perceptions of AI tools at the University of Limerick.	Quantitative survey, 120 students	Identified strengths and shortcomings of AI tools in education, with students expressing hope and fear towards AI.
2023	Moybeka et al.	Artificial Intelligence and English Classroom: The Implications of AI Toward EFL Students' Motivation	Impact of AI on motivation among EFL students in AI-driven learning environments.	Mixed-methods: quantitative surveys, qualitative literature analysis	Revealed AI enhances intrinsic motivation, self-efficacy, and provides personalized learning experiences.

2023	Phan	Students' Perceptions of the AI Technology Application in English Writing Classes	Investigates students' perceptions of AI tools in English writing classes at Vietnam National University.	Quantitative study involving 100 students	Found AI writing tools accessible and adaptable, though challenges like technology anxiety were noted.
2023	Mursyid	Integrating AI-based Writing Tools to Enhance Students' Learning Process in Digital Writing	Investigated AI tools for improving academic writing	Case study and qualitative feedback from students	AI-based tools helped students with motivation and new learning experiences, but tools were underdeveloped for certain stages of writing.
2024	Huang et al.	Modelling Generative AI Acceptance, Perceived Teachers' Enthusiasm and Self-Efficacy	Examines the impact of AI acceptance, teachers' enthusiasm, and self-efficacy on EFL learners' well-being.	Quantitative modeling	Found that AI acceptance and teachers' enthusiasm positively predict well-being; self-efficacy mediates the effect.
2024	Kalra	Exploring Teachers' Perceptions Toward the Integration of AI Tools in the Language Classroom	Investigates English instructors' perceptions of AI integration in classrooms.	Qualitative interviews	Found widespread adoption of AI, but concerns over excessive reliance on AI tools were noted.
2024	Lin & Chen	AI-Integrated Educational Applications and College Students' Creativity and Academic Emotions	Impact of AI on students' creativity and academic emotions.	Survey-based study involving both students and teachers	Found that AI can constrain creativity and increase performance anxiety, but also stimulate engagement and creativity.
2024	Mambile & Mwogosi	Transforming Higher Education in Tanzania	Explores AI's potential in transforming higher education in Tanzania.	Qualitative analysis	Highlights ethical considerations and challenges to AI's successful implementation in education.
2024	Mohamed et al.	Empowering the Faculty of Education Students: Applying AI's Potential for Motivating Learning	Investigates the impact of AI on students' intrinsic motivation in education.	Mixed-methods research	Found that AI enhances autonomy and critical thinking but does not affect academic level.

2024	Muthmainnah	AI-CiciBot as Conversational Partners in EFL Education	Explores the use of AI-CiciBot to reduce speaking anxiety in Indonesian EFL students.	Quantitative analysis	Showed significant improvement in speaking skills and reduced anxiety.
2024	Ofosu-Ampong	Beyond the Hype: Exploring Faculty Perceptions and Acceptability of AI	Investigates lecturers' acceptance of AI in teaching practices.	Survey-based research	Found that 84% of lecturers are willing to use AI, with experience and institutional support influencing acceptance.
2024	Almohesh	AI Application (ChatGPT) and Saudi Arabian Primary School Students' Autonomy	Examines the impact of ChatGPT on Saudi Arabian primary students' autonomy in online classes.	Mixed-methods approach	Found that AI applications significantly influence student autonomy, with some potential negative consequences.
2024	Yetişensoy & Karaduman	The Effect of AI-Powered Chatbots in Social Studies Education	Explores the use of AI-powered chatbots in social studies education for 6th graders.	Experimental research with 78 students	Found higher post-test and permanency scores in the experimental group, but AI tools need further improvements.
2024	Saqr, R.R., Al-Somali, S.A., Sarhan, M.Y.	Exploring the Acceptance and User Satisfaction of AI-Driven e-Learning Platforms	Examined user acceptance of AI-driven e-learning platforms	Cross-sectional survey of Saudi university students	Significant influence of AI-based social learning networks on user satisfaction; perceived usefulness significantly impacted satisfaction.
2024	Usman Abubakar	AI in Pedagogical Practices: Challenges and Opportunities	Focused on student awareness and AI adoption challenges in education	Descriptive survey research design	Highlighted the need for improved AI awareness, training, and privacy concerns; moderate awareness of AI benefits.
2024	Slamet, Joko	Potential of ChatGPT as a Digital Language Learning Assistant: EFL Teachers' and Students' Perceptions	Investigated perceptions of EFL teachers and students using ChatGPT	Cross-sectional survey in East Java, Indonesia	Found benefits in personalized learning but noted concerns over accuracy and reliance on technology.
2024	Abubakar, U., Onasanya, S.A., Ibrahim, H.A.	Student Perspectives and Impact of AI Integration in Pedagogical Practices in Nigerian Tertiary Institutions	Evaluated AI integration in Nigerian universities	Survey of 421 undergraduate students	Moderate awareness of AI; significant benefits in learning but noted technical challenges and privacy concerns.

2024	Guo, Y., & Wang, Y.	Effectiveness of AI-powered Tools in EFL Learning	Assessed AI tools like Google Classroom for EFL learning	Mixed methods: surveys, interviews, observation of online classes	AI tools improved English proficiency, especially speaking skills, but challenges included technical issues and reduced human interaction.
2024	Biswas & Murray	The Influence of Education and Self-Perceived Tech Savviness on AI Reliance	Explores the role of education and tech-savviness in individual reliance on AI.	Quantitative analysis	Highlights the complex interplay between trust, convenience, and concerns about autonomy.

Table: 2 Demographics

Gender					
		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	Male	86	43.0	43.0	43.0
	Female	114	57.0	57.0	100.0
Age					
Valid	18-21	84	42.0	42.0	42.0
	22-25	66	33.0	33.0	75.0
	26-30	16	8.0	8.0	83.0
	Above 30	34	17.0	17.0	100.0
Field of Study					
Valid	STEM (Science, Technology, Engineering, Mathematics)	76	38.0	38.0	38.0
	Humanities	58	29.0	29.0	67.0
	Social Sciences	36	18.0	18.0	85.0
	Other	30	15.0	15.0	100.0
Year of Study					
Valid	First Year	54	27.0	27.0	27.0
	Second Year	56	28.0	28.0	55.0
	Third Year	48	24.0	24.0	79.0
	Final Year	42	21.0	21.0	100.0

Table: 3 Perceptions of AI in Education

Statement	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
I believe that AI-powered learning tools improve the overall learning experience.	40	36	38	48	38
AI tools help me learn more efficiently by providing personalized content.	42	50	24	58	26
I trust the feedback and assessments provided by AI-powered learning systems.	34	44	32	64	26
I feel comfortable using AI tools to assist me in my studies.	38	42	34	70	16
AI tools provide timely feedback that helps me improve my academic performance.	38	24	36	73	29

AI-powered tools make learning more accessible to me.	19	36	34	74	37

Table: 4 AI Anxiety among students

Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am concerned about the amount of personal data AI systems collect during my studies.	44	40	26	52	38
I worry that AI tools may replace human teachers in the future.	43	54	26	51	26
The use of AI in education makes me feel anxious about my performance being evaluated by a machine.	54	27	27	53	39
I feel uneasy about AI tools making decisions about my academic progress.	56	41	27	38	38
AI systems lack the empathy and understanding that human teachers offer.	38	24	36	74	28
I feel more anxious using AI-powered learning tools than I do in a traditional classroom setting.	21	34	34	76	35

Table:5 Correlational Analysis

Pearson Product Moment Correlation			
		Perceptions of AI in Education	AI Anxiety
Perceptions of AI in Education	Pearson Correlation	1	.78
AI Anxiety	Pearson Correlation	.78	1

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RESEARCH ARTICLE

Cleaning of Cache Files of Mobile Devices

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ABSTRACT

Developers creating Android applications employ data caching to boost app performance. Caching entails storing data temporarily, allowing faster retrieval for future access. When a mobile device experiences low activity, cached data, including potentially sensitive information, may persist on the device for an extended duration. This situation introduces a security vulnerability, especially when developers neglect to apply crucial security measures to protect users' sensitive data. While both the Android operating system and third-party tools offer methods to clear application caches, these often require manual action from the user. This document proposes a dynamic cache cleaning approach that actively eliminates idle cached data while also exploring alternative strategies to optimize cache management efficiency.

Keywords: Android, cache, efficiency, protection, storage

INTRODUCTION

While the functionalities of smartphones and tablets continue to evolve, society increasingly relies on them. Businesses frequently adapt their software programs to operate on mobile platforms such as iOS, Android, and Windows Mobile [1]. Several enterprises even depend entirely on mobile technology for day-to-day operations. However, as the user base expands and device capabilities improve, so do the associated risks. Numerous security experts have anticipated significant security breaches and privacy violations due to the vulnerabilities inherent in mobile devices. Using these devices for emailing, online transactions using credit cards, and the vulnerability of loss or theft container expose classified information to unauthorized access. This study focuses regarding Android

operating system to illustrate aloofness threat associated with mobile apps and their storage approaches. Although the Android API provides assured future features innovators integrate into their set of symbols, there is no ensure that developers willad here to secure programming practices. Moreover, the issue arises of whether application developers should be accountable for user privacy. Cache serves as a tool to store data transparently, facilitating quicker access for future requests. Subsequent data requests are swiftly met by retrieving information from the solicitation cache split up, obviating the necessity to establish network connections or access distant servers to satisfy the entreaty. fleeting housing data in the local cache significantly enhances the attainment of Android applications, preventing the unnecessary retrieval of recently accessed information. during the time advantages of caching are evident, challenges stemming from improperly managed caches can indeed a device's efficiency, memory usage, and security. Although the Android operating system might automatically remove When internal storage space is limited, removing files from application caches, developers must still manage their application's cached files responsibly. Users [Source: https://www.linkedin.com/posts/tanue-quddus-741b04266_what-is-a-cache-system-in-telecommunications -activity-7193924013964902401-XI8G] may find that many of their applications exceed this recommended cache size when checking their Android mobile device's storage allocation for cached files. Notably, certain resource-intensive applications like web browsers are anticipated to exceed the recommended cache storage limit because of their frequent usage and versatility. The constitutional storage measurement of mobile devices, although continuously expanding, still pales in comparison to that of desktops or laptops. Consequently, internal storage is considered valuable and limited. Additionally, as cached files accumulate and occupy the already limited space within the device, it negatively affects the device's overall performance.

THREAT MODELS

As smartphones and tablets continue to advance, society's reliance on them grows. Companies often modify their software to run on mobile platforms like iOS, Android, and Windows Mobile, with some businesses fully dependent on mobile technology for daily operations. However, as the user base expands and devices become more capable, the associated risks also rise. Security experts have long predicted significant breaches and privacy issues due to vulnerabilities in mobile devices. Activities like emailing, conducting online transactions with credit cards, and the risk of loss or theft can expose sensitive information to unauthorized access. This study examines the Android operating system to highlight the data security risks related to mobile applications and their storage techniques. While the Android API offers features designed for future integration, it cannot guarantee that developers will always follow secure coding practices. Additionally, the question arises of whether application developers should bear responsibility for safeguarding user privacy. Caching is a technique used to store data locally, enabling faster access for future requests. When subsequent data requests occur, information is retrieved directly from the cache, eliminating the need for network connections or accessing remote servers. Temporarily storing data in the local cache can significantly improve the performance of Android applications by preventing redundant retrieval of frequently accessed information. Though the benefits of caching are clear, poor cache management can impact a device's efficiency, memory use, and security. While the Android operating system can automatically clear cached files when internal storage is low, developers are still responsible for managing their app's cache properly. Users often find that many apps exceed the recommended cache size when reviewing their device's storage usage. Resource-intensive apps, such as web browsers, are particularly prone to exceeding cache limits due to their frequent use and versatility. Despite continuous improvements in mobile device storage capacity, it still lags behind that of desktops and laptops. As a result, internal storage remains a scarce resource. When cached files accumulate excessively, occupying this limited space, the device’s overall performance can degrade.

RELATED WORK

Numerous cache cleaning applications are accessible on Google's Play Store, simplifying the process of clearing app caches for users. These tools typically display a list of apps storing cached data, along with the corresponding storage space occupied on the device's internal memory. Clearing cached data through these applications can be done in two ways: by individually removing the cache for a specific app or by deleting all cached data across all apps with a single action. Although this cache cleaning approach provides a convenient method for users to free up storage more

quickly than using the default Android application manager, it still depends entirely on user interaction. While the Android operating system can automatically delete older cached files when internal storage becomes limited, outdated and possibly sensitive cached data may remain on devices with low activity. This occurs even with basic cache cleaners, which do not manage cached data without manual user involvement. Cache Cleaning T1, T2 takes 20 minutes interval shows percentage of memory usage by Machine MC1, MC2, MC3, MC4. Though asking users to clear caches with a single tap might seem simple for maintaining device performance, many smartphone users are unfamiliar with Android's technical aspects, including how cache clearing benefits device efficiency. Some cache cleaning apps, like App Cache Cleaner, offer automated cache clearing without direct user involvement. However, such tools often require users to set fixed intervals for cache deletion across all apps rather than dynamically determining when to clear cache on an app-by-app basis.

Dynamic Cache Cleaner Model

The idea behind a dynamic cache cleaner is to automatically delete outdated cached files without requiring user involvement. This method helps free up internal storage by operating as a background service, which enhances device performance. Additionally, it improves security by promptly and effectively removing potentially sensitive data. A dynamic cache cleaner evaluates two key factors: the device's idle time and application usage, recording relevant events for analysis. This section will explore these metrics and explain how they are used to determine the optimal moment for clearing an app's cache. Dynamic Cache Cleaning T1, T2 takes 20 minutes interval shows percentage of memory usage by Machine MC1, MC2, MC3, MC4.: Rather than a gradual process, cache cleaning is executed abruptly. When both the device and an application remain idle for a predefined period, the app's entire cache is removed from the device.

Device Idle Time

There are multiple techniques for monitoring an Android device's idle state. This model uses CPU load tracking to assess device activity. Other methods, such as monitoring the screen status (on or off), can interfere with additional dynamic components, which will be addressed later. By measuring CPU load, the system accounts for minor tasks like checking the time or reading an email or text message, allowing the dynamic cache cleaner to interpret the device as idle during such activities. This behavior improves cache cleaning efficiency, as constantly resetting the idle time tracker due to minor actions would reduce the cleaner's ability to clear application caches effectively. A device is considered in use when CPU usage exceeds 10%. However, most mobile devices can experience CPU spikes of up to 40% due to background processes running while the device is idle or when the screen is simply turned on. These brief spikes are ignored when surrounded by lower CPU activity, preserving the device's idle status. If a continuous CPU load above 15% is detected, short dips below this threshold do not change the device's active state. Additionally, balancing peaks during idle times and valleys during active use helps prevent the cache cleaner from overusing CPU resources. Though transitioning between idle and active states can create significant overhead, the background service monitoring device idle time operates with efficiency similar to Android's default alarm clock application.

METHODOLOGICAL ASPECTS

Figure 2 demonstrates the process followed by the dynamic cache cleaner concerning app usage and cache removal. The principle is simple: when an app with cached data is closed, the dynamic cache cleaner records the event. From there, one of two outcomes occurs: either the app is reopened, which prevents its cache from being cleared, or the app remains unused beyond its expiration period, triggering cache removal by the cleaner. The length of time an app can stay inactive before its cache is cleared depends on two key factors. The first is the device's idle time. If the device remains in active use, clearing an app’s cache will take longer, even if the app itself has not been recently accessed. However, when the device enters an idle state—indicated by CPU usage dropping below 10%—the countdown for cache clearance begins to accelerate. A device idle for eight hours or longer will clear caches more aggressively compared to one that has only been idle for a short period. The second factor is the memory consumed by an app’s

cache. Apps with larger cached data will be cleared sooner, as they are more likely to hold sensitive information. In contrast, apps with smaller caches may not be cleared as quickly since their minimal storage impact is unlikely to affect the device's performance.

Memory Consumption

The dynamic cache cleaner has minimal impact when the device is heavily used. Under such conditions, with all tested applications actively running, the available internal storage after four hours measured 2.65GB—just 0.29GB lower than the control scenario. This slight difference could be due to the cache cleaner's operation or random user activity. However, in the control scenario, setting the device aside and returning to it later, regardless of the time elapsed, showed cached storage remaining stable at 1.26GB. In contrast, with the dynamic cache cleaner active, application caches were fully cleared after 24 hours (the default idle setting). Figure 3 illustrates memory usage under heavy activity for four hours followed by ten hours of idle time. The dynamic cache cleaner effectively maintains lower cache levels compared to the control scenario, even during usage, emphasizing the importance of monitoring app-specific activity. If a particular app remains inactive for an extended period, its cache is automatically cleared. The cleaner's impact becomes even more noticeable during idle periods. Unlike the control setup where stale cache data remains until the device actively needs additional space, the dynamic cache cleaner continues clearing cache files during inactivity, making it more efficient. Figure 4 emphasizes the cleaner's core purpose during idle phases: removing unnecessary cached data that consumes storage, affects performance, and could potentially expose sensitive information.

Performance Impact

The size of cached data directly affects device performance. When an app's cache is empty, data retrieval from a web server takes longer. However, excessive cache accumulation can also degrade performance. Performance testing was conducted using Linpack for Android on single-threaded tasks. When no apps stored cached data, both scenarios averaged 2.28 seconds over 100 tests, indicating the cleaner's background services don't affect performance when idle. However, differences emerged after heavy use followed by idle time. As the cleaner began clearing cached data, the impact of excessive caching on performance became evident. With a total cache size of 0.5GB, performance improved compared to an empty cache. However, with 1GB of cached data, performance degraded, with average single-thread execution rising to 2.35 seconds. At 1.25GB, it increased further to 2.52 seconds, and at 1.83GB (the maximum cache size reached due to Android's automatic cleaning), the process took 3.09 seconds.

Similar patterns occurred during heavy usage with the dynamic cache cleaner running. However, after the device remained idle, performance improved as the cleaner removed caches, eventually restoring the single-thread test time to 2.28 seconds.

Security

The dynamic cache cleaner plays a significant role in maintaining device integrity. When an application caches sensitive information—generally discouraged as a programming practice—this data can persist on the device for extended periods, potentially even days, without an active cleaning mechanism. To evaluate the effectiveness of the dynamic cache cleaner, a test application was created to cache user-entered data. In the control experiment, this cached file remained on the device until Android's garbage collection cleared it to free up internal storage when necessary. Since Android uses a least-recently-used (LRU) algorithm, the file would only be deleted after all older cached files were removed. Under optimal conditions, where the sensitive file was the first cached and the device was heavily used, the file could be deleted in as little as 2 hours and 43 minutes. Comparable results were observed when the dynamic cleaner was enabled. However, if the device remained idle with the sensitive file cached and no dynamic cleaning mechanism was in place, the data could persist indefinitely until manually cleared by the user. With the dynamic cache cleaner active, the file would be deleted within 24 hours of idle time, provided the device remained powered on.

CONCLUSION

While caching undeniably benefits device performance, excessive caching can lead to significantly high memory consumption, which can negatively impact overall device efficiency. Furthermore, poor programming practices can sometimes result in the storage of sensitive information within cached data. In cases where neither the application nor the Android operating system actively clears such data, it can remain on the device for extended periods. Mobile caches have increasingly become targets for malicious attacks, leaving any sensitive data stored within an app's cache vulnerable to exploitation. The dynamic cache cleaner addresses these risks by enforcing a more proactive and efficient approach to garbage collection, ensuring stale cached files are removed more effectively.

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Table-1: Cache cleaning Memory usage

	T1	T2	T3		T11	T12	T13
MC1	20	40	49	----	52	53	52
MC2	20	45	55	-----	55	54	55
MC3	18	48	51	-----	57	57	55
MC4	20	45	52	-----	52	51	50
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Table-2: Dynamic Cache cleaning Memory usage

	T1	T2	T3		T11	T12	T13
MC1	20	40	49	----	30	25	20
MC2	20	45	55	-----	32	25	22
MC3	18	48	51	-----	35	27	21
MC4	20	45	52	-----	33	30	22
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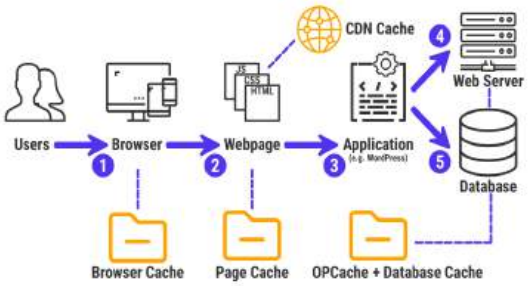


Figure 1:Process Control Flow

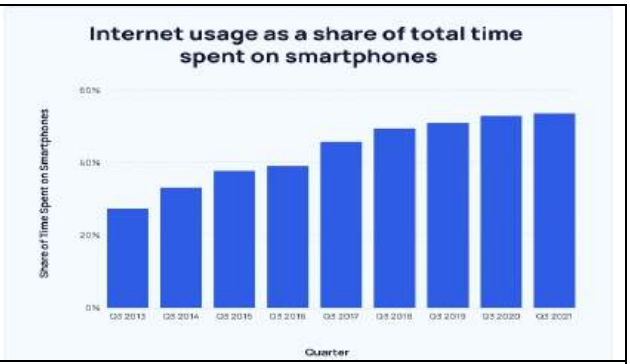


Figure 2: Usage stat

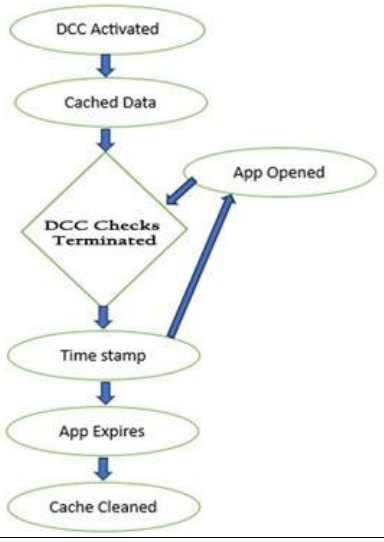


Figure 3: Flowchart of Dynamic Cache Cleaning

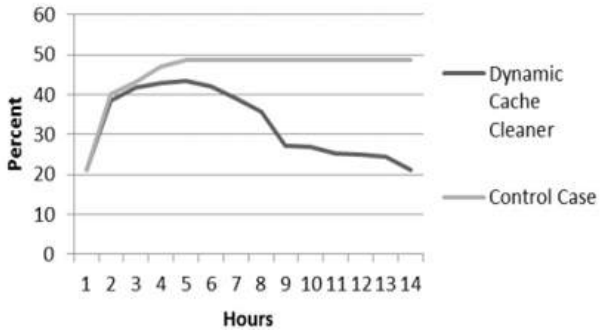


Figure 4 : Memory consumption after 4 hours of heavy use

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RESEARCH ARTICLE

Identification of Misconceptions among Prospective Science Teachers in Relation to Life Science Concepts at Secondary Level

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ABSTRACT

To ensure that science concepts which comes under life sciences is of the highest quality, the misconceptions held by those entrusted with its delivery must be identified and addressed. Prospective science teachers, in the pursuit of their educational and professional journey, encounter a wide array of scientific concepts, some of which are intricate and counter-intuitive. It is not uncommon for these individuals to develop misconceptions, which are often rooted in their prior learning experiences, cultural influences, or incomplete understanding of complex topics. Unfortunately, if left unaddressed, these misconceptions can persist, leading to sub-optimal teaching practices and potentially influencing wrong concepts in the next generation's understanding of science. Eysenck in 1982 described misconceptions as "beliefs that are immune to counter-evidence." This definition highlights the persistent nature of misconceptions. Even when individuals are presented with information that contradicts their misconceptions, they may continue to hold onto their erroneous beliefs. Eysenck's perspective underscores the challenge of addressing and correcting misconceptions, as they can be resistant to change. By addressing misconceptions in the prospective science teachers, we can better equip them to provide accurate, engaging, and effective instruction in life science.

Keywords: This definition highlights the persistent nature of misconceptions.

NEED AND SIGNIFICANCE

The National Research Council (1997) said that misunderstandings are primarily a barrier to science education for pupils because they frequently prevent them from developing the accurate concepts that serve as the foundation for more advanced learning. This is comparable to King's (2010) revelation that misconceptions in the Earth Science textbook affect students' comprehension of scientific texts, making it harder for them to understand further information or knowledge as readers. Additionally, instructors may have misconceptions when teaching biology,

chemistry, or physics, which in turn causes misconceptions in the minds of the students (Bektas, 2017; Moodley & Gaigher, 2019). Misconceptions held by science teachers can hinder their effectiveness in the classroom which leads to the transfer of misconceptions. By identifying and rectifying these misconceptions early in their education and training, we can help break the cycle of inaccurate information being passed down to secondary-level students which will lead to more effective teaching methods, ultimately benefiting students' learning experiences and improving or enhancing the quality of science education.

OPERATIONAL DEFINITIONS OF KEY TERMS

Misconceptions

In the context of this study, misconceptions refer to inaccurate or incomplete beliefs held by prospective science teachers regarding specific concepts within physical science and life science taught at the secondary level. These misconceptions may arise from misunderstandings, prior learning experiences, or cultural factors.

Prospective Science Teachers

Prospective science teachers are individuals who are currently enrolled in teacher education programs with the intent of becoming secondary-level science educators.

Life Science Concepts

Life science concepts include biological and ecological principles and topics taught at the secondary level. This category encompasses subjects like genetics, ecology, physiology, evolution, and the structure and function of living organisms.

Secondary Level

The term "secondary level" refers to the educational stage typically attended by students comprising in grades 6 to 12, which is often high school or its equivalent in various educational systems worldwide. This study focuses on the misconceptions related to physical science and life science concepts within Secondary educational stage.

RESEARCH QUESTIONS

1. What are the common misconceptions held by prospective science teachers in the fields of life science at the secondary level?
2. What are the key factors or reasons contributing to the development and persistence of these misconceptions among prospective science teachers?
3. What effective remedies and strategies can be recommended for the removal of misconceptions among prospective science teachers to enhance their understanding and teaching of science concepts?

OBJECTIVES

1. To identify common misconceptions held by prospective science teachers in both life science
2. To find out reasons or factors of misconceptions among prospective life science teachers in secondary level
3. To suggest the remedies for the removal of misconceptions among prospective life science teachers in secondary level

REVIEW OF LITERATURE

Science teachers competence and knowledge have a significance impact on the education landscape, particularly those preparing students at the secondary level. Identifying and correcting prospective science teachers misconceptions is an important aspect of effective science education. This literature review examines existing research into the identification of misconceptions among prospective science teachers with a focus on the complex relationship between these misconceptions and concepts in life sciences. Kumandaş, B., Ateskan, A., & Lane, J. (2019)

said that biology misconceptions in the classroom should be recognized by teachers, and they should know how to correct them. In response, scientists and science educators have proposed and investigated practical strategies to stop and correct misconceptions. A thorough analysis of the literature helps determine which issues to address and why by providing researchers and educators with insights into trends, practices, and gaps in the research on misconceptions. The current study describes how Turkish researchers use a form to perform a content analysis of published research on misconceptions in Turkey. The investigation produced a meta-synthesis, or thematic content analysis, which listed and contrasted the goals, techniques, tools for gathering data, and conclusions of the chosen publications. By using this instrument and study techniques to discover trends and patterns in research on misconceptions, biology educators worldwide can improve the quality of instruction in their classrooms. In addition to being able to recognize biology misconceptions that have not received enough attention and require more research, researchers will acquire knowledge about successful techniques that have been employed to investigate misconceptions. (Ouch & Widiyatmoko, 2023) said Students' misconceptions are one of the things that make science teaching and learning challenging. The persistent misconceptions hinder the learning process for the students. Research on students' misconceptions has been conducted in large quantities, but it appears that the body of knowledge is still incomplete. Through a clear explanation of its position, drawback, and benefits for science teaching and learning, this review paper aims to contribute to a concise knowledge of students' misconceptions.

The article specifically tries to address the role of students' misconceptions in science teaching and learning as well as the major difficulties in incorporating students' misconceptions into teaching strategies, based on papers published in the 1990s. The results demonstrate how students' misconceptions impede their ability to learn as well as useful teaching techniques for dispelling them. Mufit et al. (2023) evaluate the Cognitive Conflict-Based Learning (CCBL) model's effectiveness in remediating misconceptions in physics. By activating preconceptions, presenting cognitive conflict, fostering collaborative exploration, and encouraging reflection, the CCBL model stimulates conceptual dissatisfaction and enhances students' confidence and knowledge in physics concepts. Das (2020) examines misconceptions in the use of brackets in arithmetic expressions among secondary-level students. Through document-based analysis, Das highlights the challenges associated with correctly utilizing brackets and emphasizes the importance of effective teaching strategies and curricula in addressing these misconceptions. Ageng Prayitno & Hidayati (2022) analyze students' misconceptions regarding general biology concepts using the Four-Tier Diagnostic Test (FTDT). The findings reveal prevalent misconceptions among students, underscoring the need for accurate information and effective learning models to prevent misconceptions in biology education. Behera (2019) investigates misconceptions in the shape of molecules among ninth-grade science students. Through action research, Behera identifies areas of difficulty and suggests strategies for addressing misconceptions, emphasizing the importance of deep learning and effective classroom evaluations. Karakaya et al. (2021) examine pre-service science teachers' conceptual perceptions and misconceptions about photosynthesis. Through focus groups and structured interviews, the study reveals significant misunderstandings among pre-service teachers, highlighting the need for improved science teacher education.

METHODOLOGY

This descriptive Survey study was done on students/prospective teachers/ pupil teachers who have science as a major teaching subject at Sharda University and Modern College of Professional Studies. Purposive cluster Sample selection process is used to select sample for this study which is B.Sc. B.Ed. and B.Ed. Students who are currently enrolled in 5th year of integrated programme and 2nd year of B.Ed. programme. The sample size(N) = 115 and FGD taken from 45 teachers in Delhi NCR

Tools

- Questionnaire will be developed to identify misconceptions on topics of biology.
- FOCUS GROUP discussion

Analysis and interpretation

When science classes in high schools fail to engage students, it is often because the instructors themselves have misconceptions. Misunderstandings like these can cause students a lot of trouble in the classroom. In order to address this critical issue, this data analysis section makes use of a survey administered to prospective science instructors. Through data analysis, we want to identify specific misunderstandings held by these prospective secondary school teachers regarding the core concepts taught in the life sciences. In order to guarantee that these future educators fully comprehend the scientific principles they will be instructing, our research will identify the specific areas of confusion and provide valuable recommendations for targeted treatments.

Biotic Factor in an Ecosystem

Soil pH is incorrectly identified as a biotic factor by the largest group (35.3%). Predators are correctly identified as a biotic factor by 29.3% of respondents. Temperature and water availability are abiotic factors but are incorrectly identified as biotic by 21.6% and 13.8% of respondents, respectively.

Abiotic Factor in an Ecosystem

Soil nutrients are correctly identified as an abiotic factor by the largest group (44.8%).
Predators, which are a biotic factor, are incorrectly identified as abiotic by 21.6% of respondents.
Producers and decomposers, both biotic factors, are incorrectly identified as abiotic by 17.2% and 16.4% of respondents, respectively.

Process of Nutrient and Energy Transfer in an Ecosystem

Energy pyramid is correctly identified as the term describing the process by which nutrients and energy are transferred from one trophic level to another by the largest group (41.4%). Decomposition (24.1%) and biomass (20.7%) are related concepts but do not directly describe the trophic transfer process. Trophic cascade (13.8%) is a related ecological concept but not the correct term for the process in question.

Movement of Molecules from High to Low Concentration

Diffusion is correctly identified as the term describing the movement of molecules from an area of high concentration to an area of low concentration by the largest group (33.6%).Osmosis, which is a specific type of diffusion through a semipermeable membrane, is incorrectly identified as the general term by 23.3% of respondents. Active transport (31.0%) and transpiration (12.1%) are related biological processes but do not describe the passive movement of molecules from high to low concentration. In conclusion, the charts indicate a mixed understanding of ecological and biological concepts among the respondents. While there is a correct identification of abiotic factors such as soil nutrients and the energy pyramid as a model for nutrient and energy transfer, there is also confusion between biotic and abiotic factors, as well as between different biological processes such as diffusion and osmosis. This suggests a need for clearer education on these topics to avoid misconceptions. The first chart asks, "What term describes the process by which plants lose water vapor through small openings in their leaves?" The majority of responses (47.4%) correctly identify "Transpiration" as the process. Other responses include "Osmosis" (25.0%), "Photosynthesis" (19.8%), and "Absorption" (7.8%). The second chart asks, "In plant biology, what structure is primarily responsible for the transport of water and nutrients from roots to leaves?" The correct answer, "Xylem," is chosen by the majority (50.9%). Other responses are "Phloem" (29.3%), "Stomata" (15.5%), and "Epidermis" (4.3%). The third chart asks, "What is the primary mechanism responsible for the movement of water molecules across a semipermeable membrane?" The responses are more varied, with "Diffusion" leading at 36.2%, followed by "Osmosis" (31.0%), "Active transport" (20.7%), and "Filtration" (12.1%). The correct answer is "Osmosis." The fourth chart asks, "Which of the following is a function of the human reproductive system?" The majority of responses correctly identify "Producing gametes" (64.7%) as a function. Other responses include "Maintaining" (14.7%), "Transporting nutrients to" (11.2%), and "Regulating body" (9.5%). In conclusion, the pie charts indicate that for the first and second questions, the majority of respondents correctly identified "Transpiration" and "Xylem" as the answers. For the third question, "Osmosis" should be the leading response, but "Diffusion" has the highest percentage. For the fourth question, the majority correctly identified "Producing gametes" as a function of the human reproductive system. The

first pie chart is titled "Count of In the human reproductive system, what structure serves as the site of fertilization?" The chart shows the following distribution of answers:
Fallopian tube: 50.0%
Uterus: 21.6%
Ovary: 17.2%
Cervix: 11.2%
From this chart, we can summarize that the majority of respondents (50%) correctly identified the Fallopian tube as the site of fertilization in the human reproductive system. The other options received significantly fewer selections, with the uterus being the second most common incorrect answer.
The second pie chart is titled "Count of Which of the following is an example of an adaptation in plants?" The chart shows the following distribution of answers:
Growing long, sharp: 58.6%
Developing a thicker: 15.5%
Shedding leaves to: 13.8%
Migrating to a warmer: 12.1%
The summary for this chart is that the majority of respondents (58.6%) chose "Growing long, sharp" as an example of an adaptation in plants. It's not clear what the full context of each answer choice is due to the text being cut off, but based on the available information, "Growing long, sharp" was the most popular choice, indicating that respondents may associate this characteristic with plant adaptation. The other options were less frequently selected.
In conclusion, for the first chart, the Fallopian tube is correctly recognized as the site of fertilization by half of the respondents. For the second chart, "Growing long, sharp" is the predominant choice for an adaptation in plants, but without the full context of the answers, it's difficult to assess the accuracy of this response

Focus Group Discussion

The focus group comprised forty five educators in two sessions of 25 and 20 with diverse backgrounds and teaching experiences in secondary level science education.

Prevalence of Misconceptions

The majority of participants agreed that misconceptions are indeed common in fundamental principles of physical and natural sciences. They highlighted that misconceptions often stem from students' prior knowledge, limited exposure to accurate scientific information, and reliance on intuitive reasoning rather than scientific principles.

Removing Misconceptions

Participants emphasized the crucial role of teachers in identifying and addressing misconceptions. Strategies discussed included:

- Providing hands-on activities and experiments to engage students actively in the learning process.
- Encouraging critical thinking and inquiry-based learning to challenge and correct misconceptions.
- Utilizing multimedia resources and visual aids to illustrate complex concepts and promote deeper understanding.
- Incorporating formative assessments to gauge students' understanding and address misconceptions promptly.

Methodology for Removing Misconceptions

Regarding methodology for removing misconceptions, participants suggested the following approaches:

- Engaging students in collaborative learning activities such as group discussions and peer teaching to encourage knowledge sharing and collaborative problem-solving.
- Incorporating real-life examples and analogies to bridge the gap between abstract concepts and students' everyday experiences.
- Providing timely and constructive feedback to students to correct misconceptions and guide their learning effectively.

- Encouraging reflection and metacognitive awareness to help students recognize and rectify their own misconceptions.

Addressing Misconceptions in Biology

In biology, misconceptions regarding processes like osmosis, photosynthesis, and reproduction were noted, and educators emphasized the importance of fostering a deeper understanding through inquiry-based learning and practical demonstrations

MAJOR FINDINGS OF THE STUDY

Ecological and Biological Concepts: Biotic and Abiotic Factors: Respondents demonstrated confusion between biotic and abiotic factors in ecosystems, as well as misconceptions regarding their definitions. Energy Transfer in Ecosystems: While there was a good understanding of the term "energy pyramid," there were misconceptions regarding other aspects of nutrient and energy transfer in ecosystems. Molecular Movement and Reproductive Systems: While some respondents correctly identified concepts such as diffusion and the function of the human reproductive system, there were also misconceptions observed in these areas. Botanical and Physiological Concepts: Plant Physiology: Respondents generally showed a good understanding of concepts such as transpiration and xylem function, although there were some misconceptions observed. Biological Processes: While there were correct responses regarding biological processes like osmosis and gamete production, there were also misconceptions and incomplete understandings observed in these areas. Overall, the findings suggest a mixed understanding of scientific, electrical, chemical, ecological, biological, botanical, and physiological concepts among the respondents. While some concepts were well-understood by the majority, others showed a need for clearer education and remediation to address misconceptions and gaps in understanding.

Reasons for Misconceptions

Misconceptions may arise due to inadequate education, unclear presentation of concepts, or misunderstandings perpetuated by common misconceptions in society. In some cases, respondents may have been influenced by incomplete or ambiguous answer choices, leading them to select options that do not fully represent their understanding. Lack of reinforcement or exposure to accurate information, especially in complex scientific topics, can also contribute to misconceptions.

Remedies for Addressing Misconceptions

Clear and comprehensive education on scientific concepts is essential. This includes providing accurate information, addressing common misconceptions explicitly, and using varied teaching methods to accommodate different learning styles. Incorporating interactive activities, such as hands-on experiments, demonstrations, and discussions, can help reinforce understanding and clarify misconceptions. Teachers and educators should be trained to recognize and address misconceptions effectively. This may involve targeted interventions, such as diagnostic assessments, tailored instruction, and follow-up assessments to monitor progress. Providing ample opportunities for student engagement and feedback can foster a supportive learning environment where misconceptions can be addressed openly and constructively. Encouraging critical thinking and inquiry-based learning can empower students to question their own understanding, seek clarification, and refine their knowledge over time. Differentiated instruction, active learning will remove misconception.

CONCLUSION

By delving into both primary survey data and the wealth of knowledge gleaned from secondary sources, this research sheds light on the specific misconceptions that prospective science teachers grapple with in relation to fundamental physical and life science concepts. Analyzing these misconceptions through a dual lens proves to be particularly insightful. The survey data offers a direct window into the understanding of these future educators, pinpointing areas where their grasp of scientific principles might be shakyBy addressing these misconceptions head-

on, teacher education programs can be strategically designed to equip future educators with a rock-solid foundation in scientific knowledge. This not only empowers them to confidently and accurately transmit scientific understanding to their students but also equips them with the pedagogical tools to effectively identify and rectify prevalent misconceptions in the classroom. The focus group discussion shed light on the prevalence of misconceptions in fundamental principles of natural sciences among students and the critical role of educators in addressing these misconceptions. By employing effective teaching strategies, incorporating engaging activities, and providing targeted support, educators can facilitate meaningful learning experiences and promote accurate understanding of scientific concepts.

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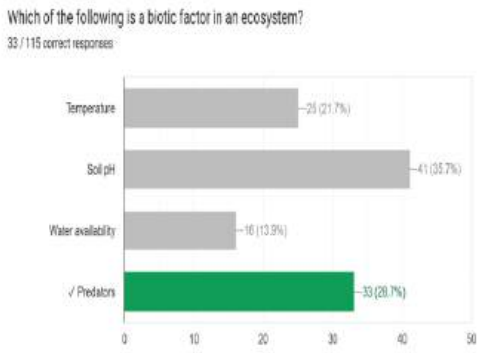


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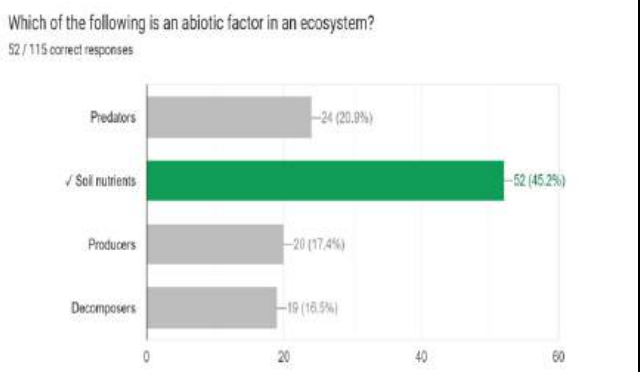


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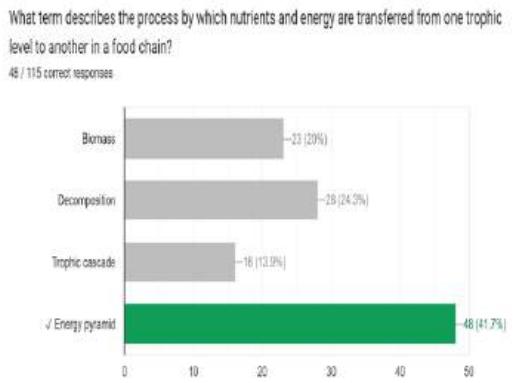


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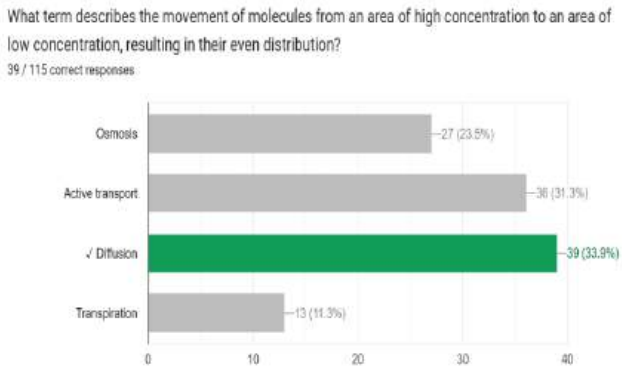


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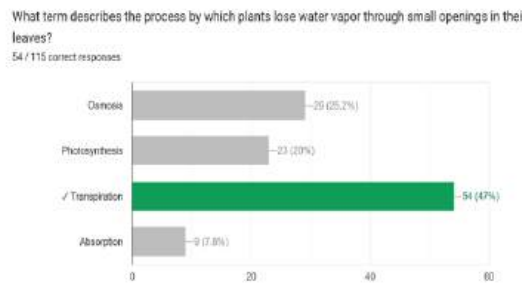


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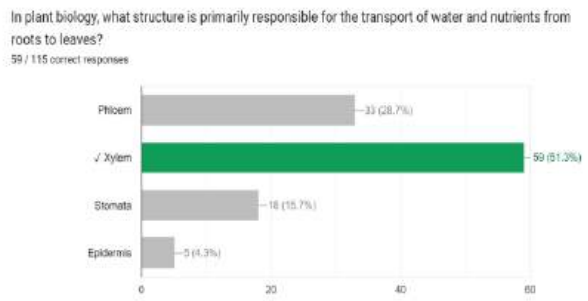


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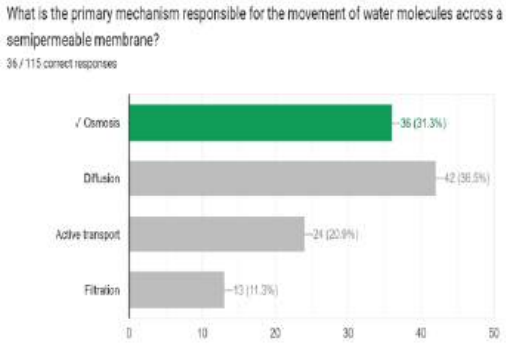


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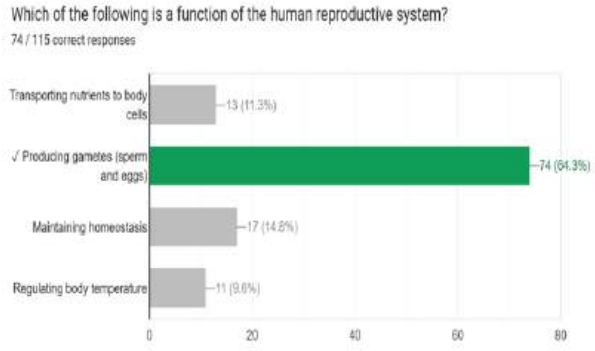


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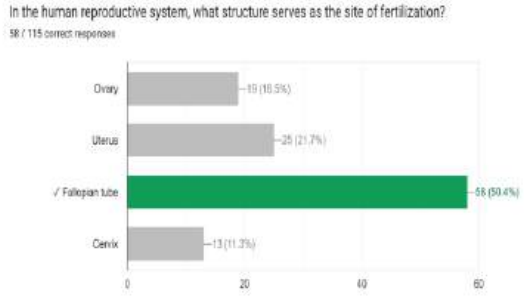


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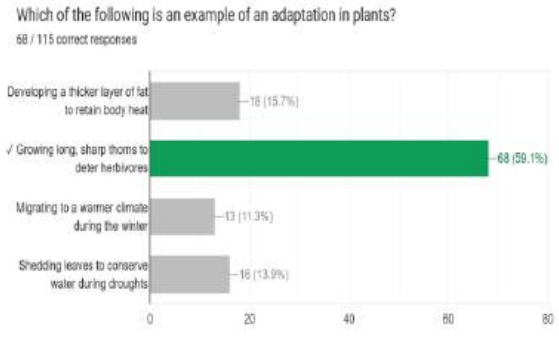


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RESEARCH ARTICLE

Relationship between Digital Screen Time, Sleep Duration and Musculoskeletal Issues in Adults: A Cross-sectional Study in South Gujarat

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ABSTRACT

Prolonged digital screen time and inadequate sleep duration have been linked to musculoskeletal discomfort. This study investigates the association between digital screen usage, sleep patterns, and associated health complaints in a sample of adults. A cross-sectional survey was conducted among 118 adults using a structured questionnaire designed to capture detailed information on digital device usage, complains of the musculoskeletal discomfort, and psychological status. Data were analyzed descriptively, focusing on the frequency of complaints related to musculoskeletal pain, psychological stress, and sleep disturbances. Correlation analysis and cluster analysis were applied to find out if there were any significant correlations between different variables. The study revealed that 96.61% of participants used mobile phones as their primary device, with 42.37% spending 2–4 hours per day on screens. Common complaints included neck pain (67.80%) and fatigue (51.69%). Screen use was reported to affect psychological health in 48.31% of participants and physical health in 47.46%. Significant positive correlations were found between screen time and neck pain ($r = 0.43$), fatigue ($r = 0.51$), and psychological distress ($r = 0.35$). Sleep duration was negatively correlated with neck pain ($r = -0.29$), fatigue ($r = -0.41$), and wrist pain ($r = -0.36$). Prolonged digital screen time and inadequate sleep duration are associated with increased musculoskeletal discomfort and psychological distress. Balancing screen time and sleep is crucial for promoting overall well-being. These findings highlight the need for public health interventions to mitigate the negative effects of excessive screen time.

Keywords: Correlation, digital, health, mental, musculoskeletal, pain, psychological, screens.

INTRODUCTION

The rapid advancement and widespread adoption of digital devices have revolutionized communication, entertainment, and information access. The widespread use of digital devices has led to a significant increase in sedentary behaviour and prolonged screen time. While these devices have become integral to daily life, there is growing concern about the potential negative health impacts associated with prolonged screen exposure. Previous studies have linked extended screen time to a variety of adverse outcomes, including musculoskeletal pain, disrupted sleep patterns, and increased psychological stress [1-3]. Digital devices, such as smartphones, laptops, and tablets, often require prolonged periods of static posture, which can lead to musculoskeletal discomfort, particularly in the neck, shoulders, and back. Moreover, exposure to blue light emitted by screens has been shown to interfere with circadian rhythms, thereby affecting sleep quality[4, 5]. Additionally, the overuse of digital devices has been associated with increased psychological stress, irritability, and mental fatigue [6-9]. Understanding the interrelationships between digital screen usage time, sleep patterns, and musculoskeletal discomfort is essential for developing effective prevention and intervention strategies.

RESEARCH QUESTIONS

- Is there a correlation between digital screen time and musculoskeletal discomfort?
- Is sleep duration associated with musculoskeletal discomfort?
- Can cluster analysis identify distinct groups based on screen time and sleep duration? This study aims to explore the relationship between digital screen use and its impact on sleep, physical health, and psychological well-being among a sample population. Understanding these associations is expected to provide critical information for developing guidelines to reduce screen-related health risks.

METHODS

An online cross-sectional survey was conducted to explore digital screen usage patterns among participants using Google Forms platform. A convenience sample of 118 adults (mean age: 32.6 ± 8.1 years) participated in the study. Participants were invited and included for the study if they were between age of 18-65 years, had been using any digital device regularly for >2 hours/day, and were able to provide informed consent. They were excluded if they had any pre-existing musculoskeletal conditions or sleep disorders unrelated to digital device usage, or were suffering from chronic medical disease or disorders which may affect participant's capacity to participate. A pre-validated structured online questionnaire was used to collect data on the following variables:

- Types of Digital Devices Used: Participants reported on their use of mobile phones, tablets, laptops, computers, televisions, and other devices.
- Average Daily Screen Time: Participants were asked to estimate their daily screen time over the past seven days, categorized as <2 hours, 2–4 hours, 4–6 hours, or >6 hours.
- Sleep Patterns: Data on average daily sleep over the past seven days were collected, with participants reporting sleep duration in hours.
- Perceived Effects of Digital Screen Use: Participants were asked to describe the perceived impact of screen use on their sleep, psychological health, and physical health.
- Common Physical Complaints: Participants reported physical complaints related to screen use, including pain in the neck, shoulders, upper back, lower back, wrists, and hands, as well as symptoms of tingling, numbness, and fatigue.
- Psychological Status: Participants were asked about their psychological well-being, with options including "normal," "fatigued," "irritated," "frustrated," and "sleepy." Surveys were distributed via email and social media; and included detailed description of study followed by informed consent. The survey responses were accepted over 6 weeks' duration.

Data were analysed using Jamovi version 2.3.28 for Windows and Microsoft Office Excel for Windows. Descriptive statistics summarized demographic and survey data. Correlation analysis (Pearson's r) examined relationships between variables. Cluster analysis (K-means) identified distinct groups based on screen time and sleep duration [10].

RESULTS AND DISCUSSION

The study included 118 participants with mean age 32.6 ± 8.1 years. Following is the description of findings based upon descriptive statistics of the data received from survey (table-1). The findings of this study highlight the significant relationships between digital screen time, sleep duration, and musculoskeletal discomfort and psychological distress. The positive correlations between screen time and neck pain, fatigue, and psychological distress suggest that prolonged screen time may contribute to increased prevalence levels of these health outcomes. Here, we have discussed individual relationship in details as per the need based upon available literary evidence. Most of the participants reported using mobile phones (96.61%), making them the most frequently used device, followed by laptops (52.54%), tablets (8.47%) and televisions (3.39%). This finding reflects the increasing dominance of mobile technology in daily life.42.37% participants reported spending 2–4 hours per day on digital screens. However, 23.73% of participants reported using screens for more than 6 hours daily. The most frequently reported average sleep duration was 7 hours (40.68%), followed by 6 hours (22.88%). A small percentage of participants (3.39%) reported sleeping more than 8 hours per night. Participants reported that digital screen use negatively impacted their sleep (32.20%), psychological health (48.31%), and physical health (47.46%). The most common physical complaint was pain and aches, reported by 55.93% of participants. Fatigue was also prevalent, affecting 51.69% of participants. Numbness and tingling were less commonly reported but were still notable symptoms, particularly among those with higher screen times. Musculoskeletal complaints were common among participants, with the neck (67.80%) and hand/thumb/fingers (37.29%) being the most frequently affected areas. Table 2 shows the correlation analysis for the variables of interest. It shows strong positive correlation of screen time with neck pain (r=0.43), and fatigue (r=0.51). A moderate positive correlation (r=0.35) was reported between screen time and psychological status. Also, sleep duration demonstrated moderate negative correlation with screen time (r=-0.31), neck pain (r =-0.29), and strong negative correlation (r = -0.41) with fatigue.

Fatigue was found to have strong positive correlation with neck pain (r = 0.63), and psychological status (r = 0.58). The association between screen time and musculoskeletal discomfort is consistent with previous studies[1, 11-13]. Prolonged screen time often involves prolonged sitting, poor posture, and repetitive movements, increasing the risk of musculoskeletal injuries [1, 12, 14]. The high prevalence of neck pain (67.8%) and hand/thumb/finger pain (37.3%) in our sample supports this finding. Impact of screen type on physical and psychological health has been studies previously. The researchers have concluded that majority of times, use of mobile devices was found to be associated with increased risk of neck pain, thumb pain, and eye strain due to prolonged texting, browsing, and gaming [1, 15]. While studying computer users, it was reported that sedentary behaviour and decreased physical activity were associated with secondary development of obesity and cardiovascular disease [16]. In a few studies usage of tablets was reported to cause poor posture, shoulder pain, and decreased physical activity [11, 17]. Psychological effects were significant, with 28.81% of participants reporting feeling fatigued or tired, 19.49% reporting feelings of irritation, and 14.41% reporting feelings of sleepiness. The negative correlations between sleep duration and neck pain, fatigue, and wrist pain suggest that adequate sleep is essential for mitigating musculoskeletal discomfort. Sleep plays a crucial role in muscle recovery and repair. Exposure to screens before bedtime suppresses melatonin production, leading to delayed sleep onset, reduced sleep duration, and poor sleep quality. Increased screen time can also increase alertness and arousal, interfere with sleep-wake cycle, and lead to sleep fragmentation. Inadequate sleep duration may exacerbate muscle fatigue, leading to increased pain sensitivity. Additionally, poor sleep quality can contribute to mood disturbances, anxiety, and depression, further impacting overall well-being. The positive correlation of screen time with fatigue and psychological health was reported in this study. Eye strain, sedentary behaviour and sleep disturbances have been reported to significantly affecting the psychological health in previous

studies. Few studies have reported that higher screen usage can lead to anxiety and depression, social isolation and decreased social skills, cyber bullying and online harassment, addiction, and decreased attention span.

K-means clustering was done to identify patterns in the data. Table 3 depicts the clusters which emerged along with the characteristics. The cluster analysis revealed three distinct groups:

- **Cluster 1 (High Screen Time/Low Sleep):** This group reported higher levels of musculoskeletal discomfort, fatigue, and psychological distress.
- **Cluster 2 (Moderate Screen Time/Moderate Sleep):** This group demonstrated moderate levels of musculoskeletal discomfort and fatigue.
- **Cluster 3 (Low Screen Time/High Sleep):** This group reported lower levels of musculoskeletal discomfort and fatigue.

Limitations of present study include: limited causal inference due to cross-sectional design; risk of subject bias due to self-reported data; and limited ability to generalize the findings due to study's focus on a specific population. Beyond the findings presented in the study, it is important to consider the broader implications of these results. The increasing prevalence of digital device usage, particularly among young people, highlights the need for comprehensive strategies to address the potential negative health consequences. Educational campaigns for raising awareness about the potential health risks associated with excessive screen time and promoting healthy screen usage habits; workplace policies that encourage regular breaks, limit screen time during work hours, and promote ergonomic practices; school-based programs for educating students about the importance of balanced digital device usage, providing opportunities for physical activity, and promoting healthy sleep habits; community-based initiatives, such as organizing events and activities to encourage physical activity, limit screen time, and promote healthy lifestyle choices; and technological solutions like development of tools and apps that help individuals track and manage their screen time and sleep patterns can help to address the issues discussed above. While considering research implications for future, longitudinal studies to investigate the long-term effects of digital screen usage on health outcomes, including the development of chronic diseases; randomized controlled trials to evaluate the effectiveness of interventions aimed at reducing screen time and improving sleep habits, particularly in vulnerable populations (e.g., children, adolescents, older adults); studies exploring the impact of different types of digital devices (e.g., smart phones, tablets, computers) on health outcomes; and research on the role of blue light emitted from screens in disrupting sleep patterns and affecting mood are a few suggestions to advance the knowledge and enhance evidence database for broader applications.

CONCLUSION

In conclusion, this study provides valuable insights into the relationship between digital screen usage, inadequate sleep duration, and increased musculoskeletal discomfort and psychological distress. The findings emphasize the importance of balancing screen time and sleep to promote overall well-being. Further research and public health interventions are needed to address the growing health challenges associated with excessive digital device usage. Healthcare professionals should emphasize responsible digital device usage, physical activity, and sleep hygiene practices to promote overall well-being.

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Table 1: Descriptive Statistics for Demographics & Survey Data

Description		Frequency (n)	Frequency (%)
Types of Digital Devices Used	Mobile Phone	114	96.61
	Tablet	10	8.47
	Laptop	62	52.54
	Computer	18	15.25
	TV	4	3.39
	Others	1	0.85
Average Daily Digital Screen Time in Past 7 Days	> 6 hours	28	23.73
	4-6 hours	29	24.58
	2-4 hours	50	42.37

	< 2 hours	8	6.78
Average daily sleep in past 7 days	4 hours	1	0.85
	5 hours	10	8.47
	6 hours	27	22.88
	7 hours	48	40.68
	8 hours	26	22.03
	> 8 hours	4	3.39
Perceived effect of use of digital screen	On sleep during night times	38	32.20
	On psychological health	57	48.31
	On physical health	56	47.46
Areas of the body affected	Neck	80	67.80
	Shoulder	33	27.97
	Upper Back	37	31.36
	Lower Back	15	12.71
	Wrist	25	21.19
	Hand, Thumb & Fingers	44	37.29
	None	15	12.71
	Others	13	11.02
Common Complaints	Pain and aches	66	55.93
	Fatigue	61	51.69
	Tingling	12	10.17
	Numbness	17	14.41
	Other	11	9.32
Psychological Status	Normal	71	60.17
	Fatigued/Tired	34	28.81
	Irritated	23	19.49
	Frustrated	8	6.78
	Sleepy	17	14.41
	Other	0	0.00

Table 2: Correlation Analysis

Variable	Screen Time	Sleep Duration	Neck Pain	Fatigue	Psychological Status
Screen Time	1	-0.31*	0.43**	0.51**	0.35*
Sleep Duration	-0.31*	1	-0.29*	-0.41**	-0.23
Neck Pain	0.43**	-0.29*	1	0.63**	0.39**
Fatigue	0.51**	-0.41**	0.63**	1	0.58**
Psychological Status	0.35*	-0.23	0.39**	0.58**	1

Correlation Coefficients:

- *: Correlation coefficient between 0.2 and 0.4 (moderate correlation)
- **: Correlation coefficient between 0.4 and 0.7 (strong correlation)

Table 3: Details of the Clusters

Cluster No.	Frequency (n)	Name of the Cluster	Characteristics
1	40	High screen time/low sleep	• High screen time (>6 hours) • Low sleep duration (<7 hours) • High neck pain • High fatigue • Poor psychological status
2	30	Moderate screen time/moderate sleep	• Moderate screen time (4-6 hours) • Moderate sleep duration (7-8 hours) • Low neck pain • Low fatigue • Normal psychological status
3	20	Low screen time/high sleep	• Low screen time (<4 hours) • High sleep duration (>8 hours) • Low neck pain • Low fatigue • Good psychological status

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RESEARCH ARTICLE

Competition to Collabortion : Comparing Service Quality and Patient Satisfaction of Multi Specialty Hospitals in Coimbatore

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ABSTRACT

Quality is a multidimensional concept with patient satisfaction as one of the most important facets which mirrors the quality of services in a hospital setting. This study helps the hospitals to measure, monitor, and improve the quality of healthcare services in order to accomplish patient satisfaction. Patients' opinions of "how well" services meet their needs and expectations are also considered as a valid indicator to measure service quality. This will able to alert management to consider the perception of patients. This study helps to identify specific areas of excellence and weaknesses. This helps to prioritize areas of service weaknesses. Apart from intra organisational learning, If the hospitals know their competitors, it will help them to gain competitive advantage. When patient search for hospitals for medical treatment, they may have confusions like which hospital is best for what in terms of various service quality dimensions. Comparative study of hospitals may beneficial to patients to understand the hospital services in a better way. Thus, the researcher chose five multi specialty hospitals for study. Descriptive research design was used. Convenient sampling technique was used. Sample consists of 390 patients. Questionnaire was used for data collection.

Keywords: Quality of healthcare services, Service quality dimensions, Patient perception, Convenient sampling, Hospital comparison

INTRODUCTION

Quality is associated to personal ethics and anticipations and there is no common definition for quality in the healthcare industry. In healthcare industry, service quality and patient satisfaction is receiving significant focus and this subject is considered in their deliberate forecasting process. Patients' perceptions about the services offered by particular health care organizations influence the reflection and success of the hospital and it also notably affects the patient behaviour in terms of their reliability and word-of-mouth. Quality of healthcare services is evidently necessary element of the healthcare industry as it straight deals with human being health and bears liability for their lives. Cost of poor quality is significantly higher within the healthcare industry. Quality in health care is not easy like any other service. Result of healthcare service depends not only on healthcare service providers but also on patients' support and their conformity to treatments. Service quality is primarily focused on meeting the customer's requirements and also how good the service delivered satisfies the customer's anticipation of it. Quality service is the important factor needed for a victorious business. In this consumer driven world, where competition is becoming tough day by day and crucial deadlines are common, one cannot imagine of business expansion without extraordinary consumer service. Quality customer service can promote business in numerous ways and by observing the significance of customer service can take way to offer consumers with an encouraging experience. Patient satisfaction is a most preferred outcome of health care and may even be an aspect of health status itself. A patient's feel of satisfaction or dissatisfaction is a result of quality hospital care in all of its dimensions. Whatever its strengths and limitations, patient satisfaction is an indicator that should be indispensable to the measurement of the quality of care in hospitals. Patient satisfaction is the patient reaction to his or her service experience. Patients do not appear to be suffered by morbidity and mortality statistics but more by personal stories of care. Patient perception of quality is evaluated through dimensions of what is personally valued and often they do not distinguish between the provider of the service and the service received. Being treated with respect and dignity and involvement in treatment decisions are intangible issues of patient satisfaction that are paramount issues for patients.

STATEMENT OF THE PROBLEM

Coimbatore is developing as a major healthcare hub in the nation and is expect to grow remarkably from what it is today. The annual growth rate would go up to a whopping Rs. 5,000 crores from Rs. 750 crores today, in a couple of years' time. There are around 750 hospitals in the city with an in-patient capacity of 5,000 beds having the highest concentration of private hospitals in the State, next to Chennai. Large number of patients from other parts of the country and abroad as well prefer Coimbatore as their destination for health care. As the city boasts of specialisation in multiple fields, they come for a variety of surgeries and procedures ranging from heart operations to orthopaedic treatment. When patient prefers Coimbatore as their choice of medical treatment, they may have confusions like which hospital is best for what in terms of various service quality dimensions. If patient process knowledge over the quality of care rendered by different hospitals, they take better decision regarding their choice of health care. It is important for the hospitals to attract and retain their patients to utilize the maximum market potential. A patient would be satisfied if Hospitals are able to convince the patient of how the provided service is the optimal solution to the patient needs. However, this can be done only when the Hospital itself is sure of what the patient wants, which is possible by conducting research. Apart from intra-organizational learning, if the hospitals know their competitors, it will help them to gain competitive advantage. Since Coimbatore is a hospital saturated city, knowledge about the competitors would also be helpful for the hospitals to be a preferred hospital among the patients. Hence the researcher is interested to find out the service quality of chosen Multi specialty hospitals in Coimbatore to understand the quality of service offered in these hospitals and satisfaction of patients towards various factors in hospital.

OBJECTIVES OF THE STUDY

- To measure the service quality and patient satisfaction at Multi-Specialty Hospitals in Coimbatore City.
- To identify the factors which influence the level of patient satisfaction towards service provided by Multi-Specialty Hospitals in Coimbatore city.

- To rank the hospitals based on service quality dimensions

REVIEW OF LITERATURE

Review literature shows service Quality and patients satisfaction are influenced by individualized care, communication, waiting time, pain management, spending time with patient, professional competence, interpersonal aspects, physical and social environment, natural dimension, quality of rivals and every service quality dimension. Ramachandran. K. K assessed the relevance of service quality dimensions with passenger's satisfaction. Descriptive research design was used for the study and the primary data was collected by using convenience sampling method. The sample size for the study is 578. The collected data was analysed using ANOVA-1 "f" test. Results reveal a significant difference in passengers' perception of tangibles of different domestic airline companies in India. EmineKol, FatmaArıkan, Emineİlaslan, Muhammed AliAkıncı, Mehmet CumaKoçak (2017)determined the patient satisfaction levels as a quality indicator for the assessment of nursing care. This study was designed as a descriptive study with a sample size of 400 patients. 'The skilfulness of nurses' and respect for the patients' privacy' were recorded as the highest satisfaction items. the Efforts by nurses to make the patients feel at their home was given lowest scores. and 'the way the nurse comforted your relatives and friends'. Hui-PengLiew, Talbot Brooks (2017)conducted a study on satisfaction towards different attributes of inpatient care among Indonesian men and women's and how the ratings differ across clusters of individuals. Respondents are responsive to the type, cost, quality, and location of the inpatient care, though individuals in diverse groups connect different significance to the diverse attributes linked inpatient care. AppalayMeesala, Justin Paul (November 2016)revealed that reliability and responsiveness (not empathy, tangibility, and assurance) impact patients' satisfaction. Patient's satisfaction was directly related to patients' loyalty to the hospital. Marital status and age had no impact on the regression weights of the variables analyzed; however, it was found that to some extent gender does. Mien Li, Emily N K Angdnurs, Yionghuak Chan, Hong Guhe, KatriVehvilainen, Julkunen (2016)exposed that there was a high level of patient satisfaction linked with, pain management, waiting time and communication and advice given. RezartaKalaja, RediMyshketa, FrancescoScalera (2016) assessed the service quality in the regional hospitals of public sector. Patients are the key people in evaluating the quality. This study is based on a questionnaire completed by 200 hospitalized patients. The findings in specific reveal positive results towards quality services without significant differences between expectations and actual perceptions of patients.

RESEARCH FRAMEWORK

The study aims at describing the perception and satisfaction which prevails in the minds of the patients. Thus, Descriptive research design is used. The target population includes patients who were admitted in the selected hospitals as inpatients. Only multi-specialty hospitals which got NABH certification or applied for the same are selected for the study. According to the Sample size Calculator, the adequate sample required for the study is 385. With rounding off, the researcher has taken 390 samples. The actual number of patients available to respond is also infinite. So, non-probability convenient Sampling was used for the study. The data collected is Primary data through the questionnaire prepared by the researcher.

ANALYSIS AND INTERPRETATION

The study variables are examined using simple mean and standard deviation. The summated scores were obtained on the items that constitute each factor and level of mean and the standard deviation were used to study the service quality factors and overall service quality and patient satisfaction across the chosen hospitals in Coimbatore city. The results are presented in this part. To calculate mean and standard deviation, Values are allocated in SPSS as follows.

1 - Always/Strongly Agree/Highly Satisfied

2 – Usually/Agree/Satisfied

3 – Often/ Neutral

4 – Rarely/Disagree/Dissatisfied
5 – Never/Strongly Disagree/Highly Dissatisfied
Hence lower mean score indicates better-quality perception of a particular factor.

INFERENCE
Ramakrishna hospital was perceived top in all services quality dimensions except Assurance dimension. In Assurance dimension, GKNM was perceived top. KG hospital was perceived low in all service quality dimensions except Responsiveness. KMCH was perceived low in Responsiveness.

INFERENCE
GKNM is perceived best for General Medicine and cardiology, PSG is for Paediatrics, KG is for Respiratory medicine and Orthopaedics, KMCH is for Gastroenterology and Ramakrishna is for Obstetrics & Gynaecology.

INFERENCE
Ramakrishna hospital was perceived better by respondents followed by GKNM, PSG, KMCH and KG based on overall service quality dimension.

INFERENCE
Among seven chosen specialities, respondents are highly satisfied with paediatrician (comparison among specialities within their hospital) at GKNM, KMCH, PSG and Ramakrishna. Respondents are highly satisfied with orthopaedist at KG.

INFERENCE
Based on overall experience of respondents', respondents are highly satisfied with GKNM followed by Ramakrishna, PSG, KMCH and KG Hospitals.

INFERENCE
The above table shows the reasons why the respondents have chosen a particular hospital. The reasons are listed from highest to lowest based on the preference of respondents'. Reference given by the friends and relative is top reason to choose a hospital and Service provided by employees is least reason to choose a hospital. H_o: There is no significant relationship between hospital and reliable factors. H_a :There is significant relationship between hospital and reliable factors

INFERENCE
The above 4.2.1 indicates, p value is less than 0.05 (at 5% significance level) for the factors Doctor makes right diagnosis, Doctor is prescribing only necessary investigation and medicine, Doctor spends enough time to examine the patients and Hospital maintain patients' investigations reports and records accurately. So Null Hypothesis is rejected. It is concluded that, there is a significant association between Hospitals and the opinion of respondents to all above mentioned factors. p value is greater than 0.05 (at 5% significance level) for the factors Patients are attended according to appointment/scheduled time, Hospital delivery prompt service. So Null Hypothesis is accepted and it is concluded that there is no significant association between Hospitals and the opinion of respondents for these two factors.

INFERENCE
Table 4.8 indicates, all Assurance factors' p value is less than 0.05 (at 5% significance level). So Null Hypothesis is rejected. It is concluded that, there is a significant association between Hospitals and the opinion of respondents to all factors of Assurance dimension.

INFERENCE

Table 4.9 indicates, all Tangible factors' p value is less than 0.05 (at 5% significance level). So Null Hypothesis is rejected. It is concluded that, there is a significant association between Hospitals and the opinion of respondents to all factors of Tangibility dimension. Table 4.10 indicates, all Empathy factors' p value is less than 0.05 (at 5% significance level) except for the factor "quality of service and cost of service are consistent with patient requirements. So, it is concluded that, there is a no significant association between hospitals and the opinion of respondents for the factor quality of service and cost of service are consistent with patient requirements, and there is significant association between Hospitals and opinion of respondents to other factors of Empathy dimension. Table 4.11 indicates, all Responsiveness factors' p value is less than 0.05 (at 5% significance level). So Null Hypothesis is rejected. It is concluded that, there is a significant association between Hospitals and the opinion of respondents to all factors of Responsiveness dimension.

DISCUSSION AND SUGGESTION

- Though all service quality dimensions and patient satisfaction factors got positive responses, the low positive responses are recorded for cost aspects. This may be because, almost 3/4 of respondents of this study spent medical expenses out of their pocket. So, health care professionals and government can upgrade the insurance schemes which cover every individual for all necessary ailments in more appropriate way. (Present Government insurance schemes are utilised by only a specific cater of people. So, measures can be taken to utilise insurance schemes by all cater of people.)Affordable treatment helps for sustainable development.
- All the hospitals are perceived highest in tangible dimension and least in empathy and responsiveness dimension. Empathy and responsiveness are most important factors for service industry particularly to hospitals. But hospitals concentrate more on tangible dimension of hospitals (Building, equipment and etc.). Hospitals should take all possible efforts to improve these dimensions. Development does not only mean physical development. Development has to be present in human aspects as well for sustainability.
- In almost all the hospitals, respondents are highly satisfied with paediatric doctors. So in Coimbatore, paediatricians' services are appreciable. All other specialty doctors can also adopt some unique approach to satisfy their patients.
- Though tangibility was perceived better in hospital, when it comes to reason to choose the hospital, only reference given by friends and relatives, Availability of doctors and goodwill of the hospital are the top reasons. Reasons related tangibility not recorded in top reasons. So hospitals need to concentrate in these areas to satisfy their customers.
- Hospitals can adopt collaborative approach rather competitive approach to serve better for their patients. Coimbatore is the preferred location for medical treatment next to Chennai in Tamil Nadu. So, each hospital can choose few specialities where they can super specialise in all aspects of service without any duplication with other hospitals. It will help patients to visit an appropriate hospital and get treatment without any further referrals. At the same time hospitals are also get benefits getting patients without spending much on marketing.This helps for sustainable development of all hospitals without disturbing their competitors.
- Almost all aspects of patient care GKNM and Ramakrishna hospital was perceived top among chosen hospitals. These two hospitals should be careful to maintain the same in an increasing competition and ever-changing expectation of patients.

CONCLUSION

Hospital is highly scientific and highly sensitive place. From this study, it is understanding hospitals focused much on tangibility dimension and less on Empathy and responsiveness dimension. Apart from medicines and machines, empathetic approach and responsiveness towards patients are of high importance in hospitals. Hospitals ultimate aim is to satisfy the patients. For satisfy the patients, hospitals should understand the exact requirement of patients. Patient satisfaction tactics are not easy, unless everyone in the hospital understand the requirements of patients and

internalise the same. So, necessary arrangements should be done to satisfy the patients' requirements. This can be possibly done by approaching patients with simple human touch. Human aspects are necessary for sustainable development of hospitals.

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Table 1 - Service Quality Dimension Mean Scores of Chosen Hospitals

S.No	Service Quality Dimension	Hospital	Mean
1	Reliability	GKNM	1.794
		KG	2.138
		KMCH	2.103
		PSG	1.865
		Ramakrishna	**1.700**

2	Assurance	**GKNM**	**1.757**
		KG	2.109
		KMCH	2.108
		PSG	1.944
		Ramakrishna	1.940
3	Tangibility	GKNM	1.653
		KG	2.085
		KMCH	1.792
		PSG	1.818
		Ramakrishna	**1.579**
4	Empathy	GKNM	1.974
		KG	2.406
		KMCH	2.252
		PSG	1.980
		Ramakrishna	**1.841**
5	Responsiveness	GKNM	1.943
		KG	2.308
		KMCH	2.242
		PSG	2.764
		Ramakrishna	**1.900**

Table 2 - Specialty * Hospital based on Service Quality Dimension Mean Scores

S.No	Specialty	Hospital	Mean
1	General Medicine	**GKNM**	**1.701**
		KG	2.339
		KMCH	2.101
		PSG	2.144
		Ramakrishna	1.833
2	Paediatrics	GKNM	1.676
		KG	2.167
		KMCH	1.949
		PSG	**1.604**
		Ramakrishna	1.633
3	Cardiology	**GKNM**	**1.653**
		KG	2.287
		KMCH	2.328
		PSG	1.730
		Ramakrishna	1.934
4	Respiratory Medicine	GKNM	2.330
		KG	**2.074**
		KMCH	2.301
		PSG	2.218
		Ramakrishna	2.245
5	Gastroenterology	GKNM	2.029
		KG	2.526
		KMCH	**1.657**
		PSG	1.859

		Ramakrishna	1.782
6	Obstetrics & Gynaecology	GKNM	1.686
		KG	2.675
		KMCH	2.032
		PSG	1.784
		Ramakrishna	**1.531**
7	Orthopaedics	GKNM	1.695
		KG	**1.308**
		KMCH	2.328
		PSG	2.075
		Ramakrishna	1.586

Table 3 - Overall Service Quality Scores for Chosen Hospitals

S.NO	Hospital	Mean
1	GKNM	1.824
2	KG	2.200
3	KMCH	2.099
4	PSG	2.070
5	Ramakrishna	**1.792**

Table .4 Specialty wise Mean Score for Doctor Consultation of chosen Hospitals

PS01 - Explanation of Present Conditions and Treatment by Doctors
PS02 - Confidentiality and Privacy maintained during consultation
PS03 - Attitude and behaviour of doctors
PS04 - Treatment given by the Doctor

Hospital	Specialty	PS01	PS02	PS03	PS04	
GKNM	General Medicine	1.60	1.60	1.60	1.45	1.56
	Paediatrics	1.50	1.50	1.67	1.50	**1.54**
	Cardiology	1.69	1.54	1.69	1.38	1.58
	Respiratory Medicine	2.56	2.44	2.56	2.56	2.53
	Gastroenterology	2.33	1.89	2.11	2.22	2.14
	O & G	1.83	1.50	1.58	1.75	1.67
	Orthopaedics	1.64	1.91	1.64	1.64	1.71
	Total	1.84	1.74	1.79	1.72	1.77
KG	General Medicine	2.16	2.00	2.37	2.37	2.23
	Paediatrics	2.67	2.67	2.67	2.67	2.67
	Cardiology	2.21	2.36	2.29	2.14	2.25
	Respiratory Medicine	2.33	2.17	2.25	2.25	2.25
	Gastroenterology	2.40	2.40	2.80	2.60	2.55
	O & G	2.00	2.00	2.33	2.33	2.17
	Orthopaedics	1.25	1.50	1.50	1.25	**1.38**
	Total	2.18	2.15	2.32	2.25	2.23

KMCH	General Medicine	2.26	2.32	1.84	2.16	2.15
	Paediatrics	1.33	1.50	1.50	1.83	**1.54**
	Cardiology	2.29	2.00	2.43	2.57	2.32
	Respiratory Medicine	2.08	2.17	2.25	2.17	2.17
	Gastroenterology	2.00	1.50	1.50	1.75	1.69
	O & G	2.33	2.44	2.00	2.22	2.25
	Orthopaedics	2.33	2.50	2.72	2.61	2.54
	Total	2.17	2.21	2.15	2.27	2.20
PSG	General Medicine	2.35	1.95	2.05	2.25	2.15
	Paediatrics	1.56	1.56	1.56	1.56	**1.56**
	Cardiology	1.64	2.09	1.45	1.55	1.68
	Respiratory Medicine	2.38	2.23	2.15	2.46	2.31
	Gastroenterology	1.50	2.19	1.56	1.69	1.74
	O & G	2.00	1.69	1.69	1.75	1.78
	Orthopaedics	2.45	2.55	2.27	2.36	2.41
	Total	2.01	2.03	1.83	1.97	2.17
Ramakrishna	General Medicine	1.82	1.59	1.45	1.73	1.65
	Paediatrics	1.38	1.38	1.13	1.25	**1.29**
	Cardiology	1.75	2.25	1.88	2.13	2.00
	Respiratory Medicine	2.12	2.41	1.94	2.24	2.18
	Gastroenterology	1.25	1.50	1.88	1.38	1.50
	O & G	1.78	1.44	1.22	1.33	1.44
	Orthopaedics	1.86	2.14	1.86	1.86	1.93
	Total	1.77	1.84	1.62	1.76	1.74

Table .5 - Overall Experience Mean Score for Chosen Hospitals

Hospital	Mean	N	Std. Deviation
GKNM	2.06	80	.817
KG	2.55	60	.964
KMCH	2.48	75	.950
PSG	2.16	96	.875
Ramakrishna	2.08	79	.844
Total	2.24	390	.904

Table .6 - Reasons for Choosing a Hospital

S.No	Reasons	No of Responses	Mean
1	Reference given by friends and Relatives	95	0.243
2	Availability of Doctors	80	0.205
3	Goodwill of the Hospital	79	0.202
4	Many services and service under one roof	72	0.184

5	Referred by other doctors	65	0.166
6	Accessibility	47	0.120
7	State of the art technology and equipment	42	0.107
8	Cost of treatment	38	0.097
9	Service provided by employees	28	0.071

Table: 7 Chi – Square Analysis to find the association between Hospital and Reliable Factors

S.No	Factors		Value	Df	Asymp. Sig (2 sided)
1	Doctor makes right diagnosis	Pearson Chi-Square Likelihood RatioLinear-by Linear Association No of valid cases	29.726[a] 28.122 .147 390	16 16 1	.019 .031 .701
	a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is .15.				
2	Doctor is prescribing only necessary investigations and medicines	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	29.041[a] 30.574 .291 390	16 16 1	.024 .015 .590
	a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is .62.				
3	Patients are attended according to appointment/scheduled time	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	20.547[a] 22.212 1.360 390	16 16 1	.197 .136 .243
	a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is .92.				
4	Doctor spends enough time to examine the patient	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	29.813[a] 31.676 .009 390	16 16 1	.019 .011 .923
	a. 5 cells (20.0%) have expected count less than 5. The minimum expected count is .46.				
5	Hospital Deliver prompt service	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	22.518[a] 23.267 .764 390	16 16 1	.127 .107 .382
	a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 1.08.				
0	Hospital maintain patients' investigation reports and records accurately	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	40.675[a] 40.491 1.226 390	16 16 1	.001 .001 .268
	a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is .15.				

Table .8 Chi – Square Analysis to find the association between Hospital and Assurance Factors

S.No	Factors		Value	Df	Asymp. Sig (2 sided)
1	Family members are kept informed about patient conditions and treatment methods	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	29.533[a] 31.720 .015 390	16 16 1	.021 .011 .901
	a. 9 cells (36.0%) have expected count less than 5. The minimum expected count is .62.				
2	Post treatment conditions are as informed	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	31.565[a] 30.954 4.486 390	16 16 1	.011 .014 .034
	a. 9 cells (36.0%) have expected count less than 5. The minimum expected count is .62.				
3	Hospital has good reputation	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	30.658[a] 30.890 .001 390	16 16 1	.015 .014 .980
	a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is .62.				
4	Technicians use technology quickly and skilfully	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	31.807[a] 29.704 3.216 390	12 12 1	.001 .003 .073
	5 cells (25.0%) have expected count less than 5. The minimum expected count is 2.92				
5	Health care professional maintains confidentiality of patients	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	46.088[a] 48.916 .582 390	16 16 1	.000 .000 .445
	a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is .77.				
6	Hospital takes care of the infection control aspects while providing treatment	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	27.443[a] 28.514 .140 390	16 16 1	.037 .027 .709
	a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is .92.				

Table: 9. Chi – Square Analysis to find the association between Hospital and Tangibility Factors

S.No	Factors		Value	Df	Asymp. Sig (2 sided)
1	Hospital maintains clean and hygienic environment	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	30.527[a] 30.836 2.545 390	16 16 1	.015 .014 .111
	a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is .15.				
2	Drinking water, toilet and waiting facilities are adequately available	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	21.726[a] 23.094 3.549 390	12 12 1	.041 .027 .060
	a. 5 cells (25.0%) have expected count less than 5. The minimum expected count is 1.54.				
3	Pharmacy, Radiology and Laboratory are appropriate	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	36.024[a] 38.612 1.233 390	16 16 1	.003 .001 .267
	a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is .31.				
4	Room/Ward is clean and comfortable	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	42.111[a] 38.512 2.662 390	16 16 1	.000 .001 .103
	a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is .15.				
5	Hospital provides safety measures as required	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	35.719[a] 35.602 .001 390	12 12 1	.000 .000 .973
	a. 5 cells (25.0%) have expected count less than 5. The minimum expected count is 1.54.				
6	Parking facilities are convenient and adequate	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	44.384[a] 40.476 .781 390	16 16 1	.000 .001 .377
	a. 9 cells (36.0%) have expected count less than 5. The minimum expected count is .15.				

Table: 10. Chi – Square Analysis to find the association between Hospital and Empathy Factors

S.No	Factors		Value	Df	Asymp. Sig (2 sided)
1	Doctors understand patients' specific needs and give individual attention	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	30.688[a] 32.263 3.057 390	16 16 1	.015 .009 .080
	a. 5 cells (20.0%) have expected count less than 5. The minimum expected count is .62.				
2	Nurses care their patients	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	30.179[a] 33.430 8.261 390	16 16 1	.017 .006 .004
	a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is .46.				
3	Support staff are polite with patients	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	29.122[a] 31.280 .812 390	16 16 1	.023 .012 .368
	a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is .46.				
4	Quality of service and cost of service are consistent with patient requirements	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	25.783[a] 25.907 1.568 390	16 16 1	.057 .055 .210
	a. 5 cells (20.0%) have expected count less than 5. The minimum expected count is 2.31.				
5	Patients treated with dignity and respect	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	30.522[a] 31.434 .309 390	16 16 1	.015 .012 .578
	a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is .46.				
6	Patients' psychological, economic and social aspects taken into consideration	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	29.912[a] 31.582 .015 390	16 16 1	.018 .011 .902
	a. 5 cells (20.0%) have expected count less than 5. The minimum expected count is 1.23.				

Table.11 Chi – Square Analysis to find the association between Hospital and Responsiveness Factors

S.No	Factors		Value	Df	Asymp. Sig (2 sided)
1	Nurses provide timely attention whenever necessary	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	32.568[a] 37.013 1.765 390	16 16 1	.008 .002 .184
	a. 7 cells (28.0%) have expected count less than 5. The minimum expected count is 1.54.				
2	Hospital shows sincere interest in solving patient problems	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	32.221[a] 33.340 1.462 390	16 16 1	.009 .007 .227
	a. 5 cells (20.0%) have expected count less than 5. The minimum expected count is .92.				
3	Patients are informed about actual service time in advance	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	36.011[a] 36.482 .276 390	16 16 1	.003 .002 .599
	a. 5 cells (20.0%) have expected count less than 5. The minimum expected count is .46.				
4	Treatment plan and consent forms are explained clearly	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	39.490[a] 41.839 .474 390	16 16 1	.001 .000 .491
	a. 10 cells (40.0%) have expected count less than 5. The minimum expected count is 1.23.				
5	Doctors are responding efficiently to patient queries	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	32.909[a] 30.636 2.002 390	16 16 1	.008 .015 .157
	a. 9 cells (36.0%) have expected count less than 5. The minimum expected count is 1.54.				
6	Patients are explained about the admission and discharge process clearly	Pearson Chi-Square Likelihood Ratio Linear-by Linear Association No of valid cases	29.939[a] 30.615 .001 390	16 16 1	.018 .015 .971
	a. 6 cells (24.0%) have expected count less than 5. The minimum expected count is 3.08.				

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RESEARCH ARTICLE

Pharmaceutical Study of Tamra Bhasma Prepared by using Modern Instruments

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ABSTRACT

Bhasma, a traditional Ayurvedic medicinal preparation, has been used for centuries to treat various ailments. Since metals and minerals are not bio-assimilable in their raw form, they are converted into Bhasma through a series of traditional Ayurvedic procedures. These procedures include Shodhana (purification), Bhavana (levigation), and Marana (incineration). The Puta method comprises preparation Bhavana, Chakrika (pellet) preparation, Sarava Samputa, and Putikarana. Traditionally, this process is carried out using heat generated by burning Gomaya (cow dung cakes). However, in this study, modern instruments such as Wet grinder, Muffle furnace, and pyrometer are employed. The primary objective of this study is to prepare Tamra Bhasma using modern equipment and pharmaceutical techniques**.** The preparation of Tamra Bhasma involves a series of procedures, starting from the procurement of raw materials to Shodhana, Bhavana, and Marana. The Bhavana process is facilitated using a Wet grinder, while the Marana process is carried out using a horizontal Muffle furnace. A Pyrometer is utilized to determine the temperature during the Marana process. The Bhasma prepared by using modern equipment like Wet Grinder, Muffle furnace have rendered the Bhasma sidhi lakshanas after three puta maintained at 500℃ each time. The present study demonstrates the preparation of Tamra Bhasma using

modern equipment such as a Wet grinder, Muffle furnace, and Pyrometer. This study highlights the potential of integrating traditional Ayurvedic practices with modern technology to produce high-quality Bhasma.

Keywords: Tamra, Wet grinder, Muffle furnace, Bhasma pareeksha

INTRODUCTION

Bhasma, a Sanskrit term meaning "ash" or "calcined powder," refers to a unique Ayurvedic medicinal preparation derived from metals, minerals, and gemstones. With a rich history spanning thousands of years, Bhasma has been an integral part of Ayurvedic therapeutics, offering a distinct approach to healthcare by harnessing the bioactive potential of inorganic substances. Through a complex process of purification, calcination, and transformation, Bhasma preparations are believed to acquire enhanced bioavailability, safety, and efficacy, making them a valuable adjunct to conventional Ayurvedic treatments. This ancient yet innovative paradigm has garnered significant attention in recent years, sparking scientific interest in exploring the pharmacological and therapeutic properties of Bhasma. The conversion of metals to Bhasma involves a series of pharmaceutical procedures, including Shodhana, Bhavana, and Marana. Traditionally, this process is carried out using the Puta method, which employs Gomaya(cow dung) as fuel. However, due to limitations such as the unavailability of Gomaya, labor-intensive processes, and difficulties in maintaining consistent temperatures, modern equipment has been adopted to overcome these challenges. This article aims to describe the preparation of Tamra Bhasma using modern equipment. Specifically, a wet grinder is employed for the Bhavana Samskara process, a horizontal muffle furnace is used for Marana, and a pyrometer is utilized to accurately determine the temperature.[1]

MATERIALS & METHODS

Materials[2]

Tamra Patra (copper sheets) were procured from a local market. Similarly, all the necessary ingredients required for the processes of Shodhana (purification) and Marana (incineration) were also sourced from the local market. The Tamra Patra were analyzed for their characteristic features (Grahya lakshanas) as described in classical Ayurvedic texts. These features included Ghanaghata-saha (The ability to withstand impact without breaking when struck with a hard object), Sachikkana (A smooth and glossy appearance), Vimala (Cleanliness), Japa-suma-prabha (A reddish hue reminiscent of hibiscus flowers), Mrudu (Softness)

Samanya Shodhana of Tamra[3]

Equipment/Requirements

- Tamrapatra - 250gms
- TilaTaila - Q.S
- Takra - Q.S
- Gomutra - Q.S
- Aranala - Q.S
- Kulathakwatha - Q.S
- Gas stove
- Iron laddle
- Iron vessel

Procedure of samanya Shodhana

1. This process was carried out through Nirvapa Samskara. The specified quantity of Tamra Patra was taken in an iron vessel and heated over fire until it turned red hot. Once it changed color, it was quenched in **TilaTaila** (sesame oil) seven times.
2. The Tamra Patra was taken in an iron vessel and heated over fire until it turned red hot. Once it changed color, it was quenched in **Takra** (buttermilk) seven times.
3. The Tamra Patra was taken in an iron vessel and heated over fire until it turned red hot. Once it changed color, it was quenched in **Gomutra** (cow urine) seven times.

Kanji:[4]

Equipment/Requirements

- Rice - 1 part
- Water - 10 parts
- Steel vessel
- Iron Laddle
- Gas stove

Sandhana Paatradhupana

The Paatra (vessel) selected for the kanji preparation is cleaned properly and dried. Later ghritalepana is done all over the vessel. Then dhupana (fumigation) process is carried out using the drugs like guggulu, agaru and other krimighnadravyas.

Method of preparation of kanji

One part of rice was taken with 10 parts of water in a vessel and boiled until the rice was cooked well and became soft. Then, it was poured into the Sandhana Patra and fermented for 5 days before being used for Shodhana.

4. The Tamra Patra was taken in an iron vessel and heated over fire until it turned red hot. Once it changed color, it was quenched in fresh **Kanji** (fermented rice water) seven times.
5. The Tamra Patra was taken in an iron vessel and heated over fire until it turned red hot. Once it changed color, it was quenched in fresh **Kulatha Kwatha** seven times. **Note:** Fresh liquid was used each time for the quenching process

Visheshashodhana of tamra[5]

Equipment /Requirements

- Tamrapatra (which has undergone samanya shodhana)
- Gomutra
- Gas stove
- Vessel
- Iron laddle

Procedure of Visheshashodhana

Once the Samanya Shodhana of Tamra was completed, it was taken in a large vessel and a sufficient quantity of Gomutra (cow urine) was poured into it. The boiling process was then continued for 1 Yama (3 hours). Later, the Shodhita Tamra was collected.

Marana of tamra:[6]

Preparation of kajjali:[7]

Equal quantities of Shuddha Parada and Shuddha Gandhaka were taken in a clean Khalva Yantra and triturated until the Kajjali Siddha Lakshanas were obtained.

Procedure of Marana

1. The required amount of Shodhita Tamra was taken in a wet grinder and mixed with an equal quantity of Kajjali and the required amount of Nimbu Swarasa. The mixture was then ground for 45 minutes (attained a semi-solid consistency).
2. The ground material was made into Chakrikas (pellets) and left to dry. Once the pellets were dry, they were placed in a silica crucible, which was then covered with lid.
3. The crucible was placed in an electrical muffle furnace, maintaining a temperature of 500°C for one hour. A pyrometer was inserted into the muffle furnace to determine the temperature inside, and the gradual decrease in temperature was noted once the process was completed.
4. After Swangashita (self-cooling) the crucible was removed from the muffle furnace, carefully de-sealed, and the Bhasma was weighed. The color, taste, texture, and other characteristics of the Bhasma were observed and noted.
5. Two additional Puta (incineration) processes were performed, following the same procedure as mentioned above, with the temperature maintained at 500°C.
6. After the process of Marana, the TamraBhasma is taken into khalva yantra and pounded to make it into a fine powder.

RESULTS

Bhasma Sidhalakshanas: (After 3rd puta)

BhasmaPareeksha

1. **Nischandratva:[8]**
   Nischandratva is a specific parameter for Tamra Bhashma. A portion of the prepared Tamra Bhasma was rubbed between fingers and thumb, and the rubbed portion was examined in sunlight. The prepared samples of TamraB hasma (Fig. 17) were found to be Nischandra (Absence of shining particle).
2. **Rekha Poornatha:[9]**
   This test indicates the fineness of a Bhasma. The Bhasma was rubbed between the thumb and index finger. The particles of the Bhasma attained a state where they could settle in the ridges of the fingers. The prepared samples of Tamra Bhasma (Fig. 18) were found to be Rekha Poornatha.
3. **Nirdhoomatva: [10]**
   This test was performed to check for moisture, organic content, or sulfur in the Bhasma. A small quantity of the Bhasma was taken in a silica crucible and ignited. The ignition of the Bhasma was observed carefully, and the observations were noted. The prepared samples of Tamra Bhasma (Fig. 18) did not produce any fumes and were found to be Nirdhooma.
4. **Varitaratva:[11]**
   This test checks the lightness of the Bhasma. A small amount of the Bhasma was put over the jar containing water and observed. The prepared samples of Tamra Bhasma (Fig. 19) floated on the water and were found to be Varitara.
5. **Amla Dadhi Pareeksha:[12]**
   This test checks for the maturity of the Bhasma. The Bhasma was put over Dadhi and observed for color. There was absence of color in the curd (Fig. 20) even after 12hrs suggesting Pakwa Bhasma.
6. **Avami Pareeksha: [13]**
   This test is specific to Tamra Bhasma. The pinch Bhasma was consumed and observed for 1 hour. In The prepared sample of Tamra Bhasma there (Fig. 21) was absence of nausea and vomiting sensation. Graph: Showing observations regarding temperature during Marana samskara of Tamra Bhasma.

DISCUSSION

Samanya Shodhana of Tamra

The process of Shodhana was not carried out merely to remove impurities but also to perform 35 iterations of Nirvapa Samskara. This process transformed the Tamra into a brittle state, facilitating further processing.

Vishesha Shodhana of Tamra

VisheshaShodhana was performed through Pachana Samskara for 1 Yama (3 hours) using Gomutra. Although the exact quantity of Gomutra required was not specified, more than 700 ml was utilized during the process. As Gomutra evaporated during Pachana, additional quantities were added.

Marana of ShuddhaTamra

Following the Shodhana of Tamra Patra, it was obtained in the form of a coarse powder. To convert it into a fine powder, it was ground in a wet grinder by adding an equal quantity of Kajjali and the required amount of Nimbu Swarasa. Grinding was completed in approximately 45 minutes, resulting in a semi-solid like consistency. This indicated that the process was highly beneficial in preparing the Bhasma. The wet grinder also facilitated rapid conversion of the coarse powder into a paste-like form, compared to using a Khalva Yantra. As per classical texts, Gajaputa is recommended for Tamra Bhasma preparation. However, to avoid Adhika Paka (excessive heat), the temperature in the muffle furnace was maintained at 500°C. After administering three Puta at 500°C, the Bhasma was subjected to Bhasma Pareeksha to assess the Bhasma Siddhi Lakshanas. Throughout the procedure, the temperature was monitored using a pyrometer inserted into the muffle furnace. Temperature patterns were recorded from the beginning of the process until the peak temperature of 500°C was reached. After switching off the muffle furnace, the gradual decrease in temperature until it reached 30°C was also noted.

CONCLUSION

The present study demonstrates the preparation of Tamra Bhasma using modern equipment such as a Wet grinder, Muffle furnace, and Pyrometer (To determine temperature). The results obtained from the Bhasma Pareeksha confirmed that the prepared Tamra Bhasma possessed the desired characteristics and properties. In the preparation of Bhasma, the emphasis lies not on the number of Puta administered or the amount of Gomaya utilized, but rather on achieving the desired quality and Bhasma Siddhi Lakshanas. Our study demonstrates that identical Bhasma Siddhi Lakshanas can be obtained using modern instruments with just three Puta (as mentioned in the classics) at the temperature of 500℃, thereby instilling confidence in the adoption of contemporary approaches for Bhasma preparation in the present era.

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Table 1: Showing Observations and Results after complete Shodhana of Tamra

Initial weight	Final weight	Weight loss	Changes after Process
250 gms	190gms	60gms	Tamrapatra turned into black color, some of it turned into coarse powder

Table 2: Showing Quantitative Observations during process of preparation of Tamra Bhasma

No. of puta	Weight of Tamra (gm)		Weight of kajjali added(gm)	Amt of nimbuswarasa added(ml)	Duration of lavigation (min)	Max temp of puta(℃)	Wt. gain
	Before Puta	After Puta					
1	190	260	190	QS	45	500℃	70
2	260	280	190	QS	45	500℃	20
3	280	300	190	QS	45	500℃	20

Table 3: Showing Organoleptic characteristics of Tamra Bhasma

Varna (color)	Dull Black
Sparsha (touch)	Soft
Rasa (taste)	-
Gandha (smell)	-
Shabda (sound)	-

Table 4: Showing Merits and demerits of using Wet grinder for preparation of Tamra Bhasma

Merits	Demerits
• Time-efficient: Grinding is done faster than with the khalva yantra.	• Dependence on electricity
• Uniform pressure: Through out the grinding, uniform pressure is maintained.	
• It turns into fine powder easily because of the pressure and weight of the stone in the grinder.	

Table 5: Showing Merits and demerits of using Muffle furnace for preparation of Tamra Bhasma

Merits	Demerits
• Time-efficient: The preparation process is faster compared to traditional methods.	• Dependence on electricity
• Easy to replicate: The study provides a clear and reproducible method for preparing Tamra Bhasma.	
• Equivalent to traditional methods: The study shows that modern methods can produce Bhasma Siddhi Lakshanas identical to traditional methods.	



Fig. 1 Tamra Patra



Fig. 2 Heating - Tamra Patra



Fig. 3 Taila Nirvapa



Fig. 4 Takra Nirvapa



Fig. 5 Gomutra Nirvapa



Fig. 6 Preparation of kanji



Fig. 7 Preparation of kanji



Fig. 8 Kanji Nirvapa



Fig. 9 Kulathakwatha Nirvapa



Fig. 10 Visheshashodhana of tamra



Fig. 11 & 12 Bhavana of ShodithaTamra



Fig. 13 Chakrika preparation



Fig. 14 & 15 Crucibles placed in the muffle furnace



Fig. 16 After Marana - Pounded



Fig. 17 Nischandratva Pareeksha



Fig. 18 Rekha poornatha Pareeksha



Fig. 19 Nirdhooma Pareeksha



Fig. 20 Amladadhi Pareeksha



Fig. 21 Varitara pareeksha

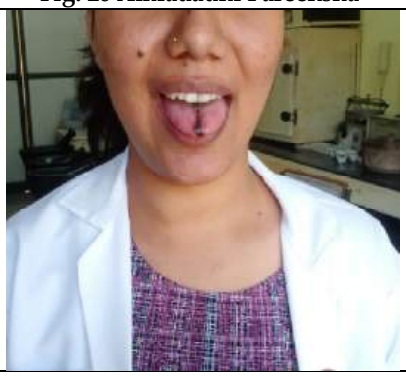
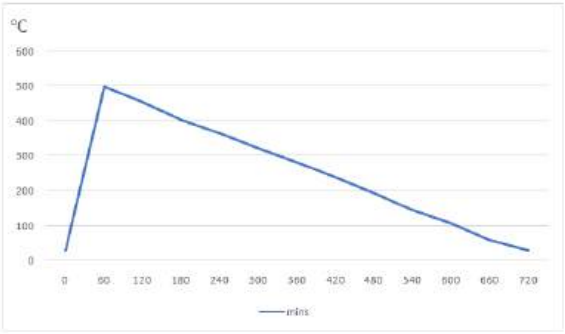


Fig. 22 Avami pareeksha



Graph: Showing observations regarding temperature during Marana samskara of Tamra Bhasma.

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RESEARCH ARTICLE

Investigating Core Influences: Key Factors Affecting the Foundational Literacy and Numeracy Skills

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ABSTRACT

Foundational Literacy and Numeracy (FLN) skills are the rudiments for learning. A special emphasis has been given in NEP 2020 for developing these skills. These skills are very significant for fulfilling the learning gaps of the children which otherwise can hinder their progress. According to the studies and official reports, a large no. of students doesn't have these basic skills and it is highlighted as the main reason of the poor performance of the children in higher grades. For enhancing these skills so many changes are expected to be done and out of them curricular changes are of the utmost importance. There is a need to adopt those assessment methods which can portray the real picture of the child and can track the progress of child continuously. The demand of the time is that teachers should adopt the teaching methods which can promote the joyful learning so that children can learn mathematical skills without any fear. There is also a need of reviewing the curriculum so that we can figure out the gaps that are preventing children from learning these skills. Training of teachers is also the major issue in this regard. This paper aims to explore all the significant factors that impact the FLN skills of the children and curricular expectations that are needed for developing the essential FLN skills among children.

Keywords: Assessment Methods, Basic Requirement, Curricular Expectations, Joyful Learning, Learning Gaps

INTRODUCTION

The early childhood experiences are responsible for shaping the overall personality of the individual. The skills they acquire in the childhood period help them in their future learning. The experiences of young children are determined by the quality of inputs and instructions that they receive (OECD, 2015). The renowned philosopher Rousseau has defined the importance of teachers and educators in shaping the childhood experiences by stating that "Everything is good as it comes from the hand of the maker of the world but degenerates once it gets into the hands of man". This notion of Rousseau reflects that young children are capable of acquiring all the skills and knowledge but it is the responsibility of society (parents, teachers and administrators) to provide opportunities and rich environment to the children (Gianoutos, 2006). The positive interactions and experiences in the early childhood becomes stimulation for the advancement of significant early development areas such as Foundational literacy and numeracy (OECD, 2015). The early childhood education or preschool education is the Key tool for strengthening the experiences of the children and for the smooth transition into the formal schooling (Slaby et al.,). Early childhood education is viewed as a "magic bullet" for the social and economic development of the country (Farquhar & White, 2014). Foundational literacy not only refers to the acquisition of basic skills of reading and writing but it is also the ability to read, write and listen with comprehension and to identify, decode, produce and convey by utilizing printed material (Litster, 2013). According to Qadiri and Manhas (2009) the children literacy, numeracy skills and communication skills are largely determined by the quality of preschool education.

Foundational numeracy skills means the children should have basic competency in mathematics like they should be able to identify and discriminate between numbers, solve basic addition, subtraction and multiplication problems and they should be able to solve word problems by the end of grade third (Kumar & Behera 2022 and NIPUN BHARAT, 2O21). It is important to have these skills because it will help children to not only excel in academics but also in real life situations. These skills are the basis of all future learning as it provides strong base for it (Duncan et al., 2007 and UNESCO, The state of global learning poverty, 2022). These skills can help the individual in making decisions in a variety of situations and in solving practical problems. NEP 2020 has also emphasized the role of foundational numeracy and mathematical skills in child's lifelong learning and it is recommended by NEP 2020 to achieve this goal by 2025. It has also become a national mission. Some modifications are required to achieve this mission. There should not only be book learning but children should know how and where to apply the facts that are learnt from books. We can take an example, if one knows four multiplied by two is equals to eight but he doesn't know how to apply these concepts while he or she is solving real life problems. Then what is the benefit of this kind of learning. Here play way methods of teaching and other creative methods of teaching can play an important role. We need to teach mathematical skills to children by igniting their critical thinking and problem solving ability so that they can learn joyfully. Learning mathematical skills will also reduce the dropout rate because when one is not competent in these basic skills, it will affect their further learning and this also becomes a reason of drop out. So enhancing or improving the foundational numeracy and mathematical skills of children is very important as we know we all should have the knowledge of 3 R's. This is the foundation that gives the shape to the future achievements of the child and hence it should be achieved.

Importance of Strengthening the Foundational Skills

Early childhood is a very crucial stage of life (Yadav, 2021). It is the stage where maximum development takes place. At this stage child's learning takes place at a very faster speed and whatever children learn at this stage impacts their lifelong learning. The studies have reported that 85% of child intellect, personality and skill develop by age five, so children should be given opportunities to develop the rudimentary skills like literacy and numeracy in the early years of life (UNICEF Global report 2019 and NEP 2020). The failure in early childhood learning restricts children's futures by depriving them of the chance to realise their full potential and also widens learning disparities in the long run (UNICEF Global report 2019) We all know that a weak foundation can damage the whole building likewise a weak foundation of child's learning can damage the brain structure. Only learning of these skills is not enough but we should ensure that children must get mastery of these skills. It was found by ASER (Annual status of education

report 2019) that those who were better at cognitive tasks and mathematical skills are more likely to be better at other tasks as well. So it is thus very important to develop these skills of the child.

Objectives

For the present study, following objectives have been framed:

1. To discuss the factors that affects the FLN skills
2. To give some recommendations for developing the basic literacy and numeracy skills.

Factors that Affects the Foundational Literacy and Numeracy Skills

Foundational numeracy helps the children in various situations. It strengthens the critical thinking of the child which further helps him or her in various aspects of life. It helps the child to analyze everything from different perspectives. Present world demands good problem solvers and analytical thinkers. So it is very significant to strengthen the basic numeracy skills of the children. Likewise, foundational literacy helps the children to learn and understand all the subjects efficiently including mathematics and to achieve mastery over the content of higher grades. But there are various factors which become barriers in the way of development of these skills.

1. **Large Pupil Teacher Ratio:** It is also the major factor that impacts these essential skills. Generally in classrooms where a single teacher have to deal with large no. of students specially when students belongs to socioeconomically disadvantaged groups, then it becomes difficult for the teacher to teach mathematical skills with examples and activities. Then he or she just tries to tell students that are written in the book. This is the reason why children have weak numeracy skills (NEP 2020 and Report on state of foundational literacy and numeracy in India, 2021)
2. **Rote Memorization:** Rote learning especially in case of mathematics is very harmful. If the teacher only assess that whether students are able to recall the tables and words or not. Then he or she will never get to know about the real mathematical skills of children because only recalling the facts will not guarantee that students can solve real life problems. The present evaluation system predominantly focuses to assess the knowledge and facts memorized by an individual. Thus, the present evaluation system also encourages the rote memorization among individuals. There is a need to adopt the assessment methods that can measure the learning of the individuals instead of facts that they have memorized (Yadav, 2021).
3. **Poor Health:** Good health is the basic factor on which our learning depends. If children are malnourished or physically weak, then they will not be able to learn any kind of skills properly (UNESCO, Education for All Global Monitoring Report 2007).
4. **Teacher Training:** The kind of input teacher gives to students accordingly he or she will get the output. If teachers teach mathematical skills through creative methods or by real life examples, then it will become easy for students to grasp the concepts. But it requires using multiple methods of teaching on the part of the teacher. If teachers have to tell students that six multiplied by two is equals to twelve. They should demonstrate this with the proper illustration. So, it requires to train teachers according to the demand of present scenario (National curriculum framework for foundational stage ,2022 Wimberly et al., 1978)
5. **Less Importance Given To Pre-Primary Stage of Education:** previously pre primary stage was the most ignored stage of education. It was not considered as an important stage. So no attention was paid on numeracy and mathematical skills of lower grades students. But yes NEP 2020 has considered it as a very important stage (NEP 2020).
6. **Not teaching through their local language:** we all know that children understand better when they are being taught through their first language or mother tongue. But in classrooms teachers generally use English or Hindi for teaching. Teachers should have the knowledge of local language where he or she is teaching so that he\she can make the learning more effective (Institute for competitiveness, Foundational literacy and numeracy report, 2023).
7. **Mathematical anxiety:** When teachers use complex methods of teaching especially at the foundational stage of child's learning, it can create mathematical anxiety among them. This is also the reason of weak foundational skills of the children (Pantoja et al., 2020).

8. **Poverty:** Due to poverty a large no. of children are unable to fulfill even their basic requirements, so it is difficult for them to achieve foundational numeracy and mathematical skills. Poverty affects the child in numerous ways and it is also the reason of malnourishment among children. So there should be some provisions for helping these children (Rao et al., 2021).
9. **Migration:** Migration is a major factor that affects child's learning. Due to migration a large no. of children are unable to complete their elementary education, consequently they lack in foundational skills (Nortvedt & Wiese, 2020).

Recommendations for developing the basic literacy and numeracy skills

Improving foundational literacy and numeracy skills in children is crucial for their overall academic success and lifelong learning. Here are some suggestions to help achieve this goal:

1. **Early Childhood Education:** Early childhood education serves as the foundation for a child's lifelong learning journey. Research highlights that high-quality preschool programs significantly impact children's school readiness, equipping them with essential cognitive and social skills. A well-structured early education program should emphasize interactive learning experiences that foster language development, numeracy, and problem-solving abilities. Instead of rote memorization, young learners benefit from hands-on activities, storytelling, music, and play-based learning that enhance their cognitive flexibility and creativity. Moreover, early childhood education plays a crucial role in bridging learning gaps, particularly for children from disadvantaged backgrounds. A nurturing preschool environment provides a level playing field, helping all children develop the skills necessary for academic success. Trained educators should focus on fostering curiosity, encouraging questions, and guiding children toward independent thinking. Parental involvement is equally crucial in early childhood education. When parents actively participate in their child's learning process—through reading together, engaging in interactive play, or reinforcing concepts at home—children tend to show improved language proficiency and cognitive growth. Additionally, modern educational technologies, such as interactive digital platforms, can complement traditional teaching methods by making learning more engaging. By ensuring that early education is high-quality, inclusive, and stimulating, educators and policymakers can enhance children's preparedness for primary school. Investing in well-structured early childhood programs ultimately leads to better academic outcomes, reduced dropout rates, and long-term cognitive benefits.
2. **Quality Teachers:** Teachers are the backbone of a strong education system, playing an instrumental role in shaping young minds and imparting foundational literacy and numeracy skills. Investing in well-trained, motivated, and skilled teachers is essential for ensuring high-quality education. Effective teaching goes beyond delivering lessons; it involves understanding diverse learning needs, implementing innovative instructional strategies, and fostering a positive classroom environment that encourages critical thinking and creativity. For teachers to be effective, continuous professional development is crucial. Training programs should equip educators with evidence-based pedagogical techniques, classroom management skills, and methods to engage students with different learning styles. Furthermore, mentorship programs and peer collaboration can help teachers refine their teaching approaches and stay updated with emerging educational trends. In addition to training, teacher motivation significantly impacts student learning outcomes. Competitive salaries, career growth opportunities, and a supportive school environment contribute to job satisfaction and enhance teacher performance. Recognizing and rewarding exceptional teachers through incentives or awards can further boost morale and commitment. Technology also plays a role in enhancing teacher effectiveness. Digital tools, such as interactive whiteboards, online teaching resources, and student performance tracking systems, can support teachers in designing personalized learning experiences. By integrating technology into teaching, educators can cater to diverse student needs more effectively. Ultimately, ensuring that teachers are well-prepared, adequately supported, and continuously trained leads to improved student engagement, better academic performance, and a stronger education system overall. High-quality teachers are not only facilitators of knowledge but also mentors who inspire a lifelong love for learning among students.
3. **Individualized Learning:** Every child is unique, possessing different learning styles, strengths, and challenges. A one-size-fits-all approach to education often fails to address the diverse needs of students. Instead, individualized learning, which tailors instruction to each child's pace and abilities, ensures that all learners

receive the support they need to succeed. By recognizing that children learn differently—some through visual aids, others through auditory explanations, and some through hands-on experiences—educators can design more effective teaching strategies. A key aspect of individualized learning is differentiated instruction, where teachers modify lesson plans, assignments, and activities to accommodate varying learning needs. For instance, small group activities allow educators to provide focused attention to students who require additional support, while more advanced learners can be challenged with higher-order thinking tasks. One-on-one tutoring or mentorship sessions further enhance personalized learning experiences by addressing specific gaps in understanding. Technology plays a pivotal role in facilitating individualized learning. Adaptive learning software and AI-driven educational platforms analyze students' progress and provide customized lessons suited to their proficiency levels. These tools help teachers monitor student development, identify weak areas, and adjust teaching strategies accordingly. Additionally, fostering a classroom culture that encourages self-paced learning empowers students to take ownership of their education. Allowing children to explore subjects at their comfort level reduces academic stress and boosts confidence. Schools should also involve parents in this process, ensuring learning continues beyond the classroom. By embracing individualized learning, educators can maximize student potential, promote deeper understanding, and create an inclusive environment where every child thrives. This approach not only enhances academic outcomes but also nurtures critical thinking, problem-solving skills, and a lifelong love for learning.

4. **Interactive Learning:** Interactive learning is a dynamic approach to education that actively engages students in the learning process rather than relying on passive instruction. It involves the use of hands-on activities, real-world applications, and digital tools to make learning more immersive and effective. When students participate actively—whether through experiments, role-playing, discussions, or educational games—they retain knowledge more effectively and develop essential problem-solving and critical-thinking skills. One of the most effective ways to implement interactive learning is through Gamification, where educational content is transformed into engaging challenges, quizzes, and simulations. Games like puzzles and storytelling activities reinforce key concepts while keeping children motivated. Digital learning platforms, such as interactive e-books and educational apps, further enhance engagement by providing audiovisual content that caters to different learning styles. Collaborative learning also plays a significant role in interactive education. Group activities, peer discussions, and project-based assignments encourage students to exchange ideas, learn from one another, and develop communication and teamwork skills. Encouraging inquiry-based learning—where students explore topics through questioning and investigation—fosters curiosity and deeper understanding. Moreover, interactive learning can be integrated into traditional classrooms by using hands-on teaching aids, such as models, flashcards, and manipulatives. Virtual reality (VR) and augmented reality (AR) technologies also offer immersive experiences that bring abstract concepts to life, making complex subjects easier to understand. By making learning an engaging, participatory process, interactive education enhances retention, boosts motivation, and fosters creativity. When students are actively involved in their learning journey, they develop a sense of ownership over their education, leading to improved academic performance and long-term success.
5. **Phonics and Reading Programs:** A strong foundation in reading is critical for academic success, and phonics-based reading programs are among the most effective methods for developing literacy skills in young learners. Phonics instruction focuses on teaching children the relationship between letters and sounds, enabling them to decode words systematically. This method helps students recognize patterns in language, improving their ability to read fluently and comprehend texts accurately. Phonics instruction should be structured, sequential, and interactive. It begins with teaching letter-sound correspondences, followed by blending sounds to form words and eventually reading complete sentences. Multi-sensory techniques, such as singing phonics songs, using flashcards, and engaging in word-building activities, enhance retention and make learning more enjoyable. Early exposure to phonics-based reading programs significantly improves vocabulary, spelling, and comprehension skills. Research indicates that children who receive systematic phonics instruction in their formative years demonstrate higher reading proficiency compared to those who rely solely on sight-word memorization. Schools should integrate phonics instruction into daily lessons to ensure consistent reinforcement of reading skills. Technology can further support phonics learning through interactive reading apps, digital storybooks, and AI-driven platforms that provide personalized reading exercises. These tools offer

instant feedback, helping children correct mistakes and build confidence in their reading abilities. Parental involvement is equally crucial in reinforcing phonics skills at home. Reading aloud, encouraging storytelling, and practicing phonics games create a literacy-rich environment that nurtures a love for reading. By implementing strong phonics and reading programs, educators can lay a solid literacy foundation; ensuring children develop essential reading skills that will support their academic growth and lifelong learning journey.

6. **Storytelling: A Powerful Tool for Language Development:** Storytelling plays a crucial role in early childhood education, fostering both language development and cognitive skills. Encouraging reading and storytelling from a young age helps children build vocabulary, improve comprehension, and develop critical thinking abilities. When parents or educators read aloud to children, they expose them to new words, sentence structures, and storytelling techniques, which enrich their language skills. Additionally, when children are encouraged to narrate their own stories, they learn how to organize their thoughts, sequence events logically, and express emotions effectively. This practice also enhances their listening skills, as they pay close attention to details in order to recall and retell stories accurately. Beyond linguistic benefits, storytelling nurtures creativity and imagination. It allows children to explore different perspectives and understand the nuances of human emotions. Engaging stories introduce moral values, cultural traditions, and historical contexts, making learning a more holistic experience. Teachers and parents can use interactive storytelling methods, such as role-playing or puppet shows, to make stories more engaging. Encouraging children to create their own stories also boosts their confidence in communication. Furthermore, storytelling strengthens the bond between children and their caregivers. Reading together creates meaningful interactions that foster a love for books and lifelong learning. Digital storytelling tools, audiobooks, and visual storyboards can also enhance the experience, catering to different learning styles. In classrooms, integrating storytelling into subjects like science or history makes lessons more relatable and memorable. By making storytelling a regular activity, educators and parents can significantly enhance a child's linguistic and cognitive development, ultimately contributing to academic success.
7. **Math Manipulative: Enhancing Conceptual Understanding through Hands-On Learning:** Math manipulative are physical objects that help children grasp mathematical concepts through interactive, hands-on learning. These tools, such as counting beads, base-ten blocks, fraction tiles, and geometric shapes, provide a concrete representation of abstract mathematical ideas. Young learners often struggle with numerical concepts when taught through traditional rote memorization. Using manipulative bridges this gap by allowing children to visualize and physically manipulate numbers, making math more tangible and comprehensible. For example, counting beads help children understand basic arithmetic operations like addition and subtraction. Base-ten blocks illustrate place value concepts; while fraction tiles help students compare and contrast different fractions. Similarly, geometric shapes allow learners to explore spatial relationships, symmetry, and measurement. Through active engagement, children develop problem-solving skills and logical reasoning, essential components of mathematical proficiency. Math manipulative are beneficial for all learners, especially those who struggle with conventional teaching methods. By incorporating tactile learning, they cater to kinesthetic learners who grasp concepts more effectively through movement and hands-on experience. Furthermore, manipulative encourage exploration and discovery, allowing children to develop their own strategies for solving problems. This fosters a deeper understanding of mathematical principles rather than mere memorization of formulas. Teachers can integrate math manipulative into daily lessons by designing engaging activities that encourage collaboration and critical thinking. For instance, group tasks involving manipulative promote peer learning and discussion, enhancing mathematical communication skills. At home, parents can support their children's learning by using simple household items like buttons, sticks, or coins to practice math concepts in an enjoyable way. Overall, math manipulative serve as powerful educational tools that make mathematics accessible, engaging, and meaningful for young learners, laying a strong foundation for future success in the subject.
8. **Regular Assessments: A Key to Effective Learning and Timely Intervention:** Regular assessments play a vital role in ensuring students' academic progress by identifying their strengths and areas of difficulty. Assessments help educators track learning outcomes, adjust teaching strategies, and provide timely interventions for struggling students. When assessments are conducted periodically, teachers can pinpoint specific concepts that require reinforcement, ensuring that no child falls behind in their educational journey. There are various forms

of assessments, including formative and summative evaluations. Formative assessments, such as quizzes, observations, and informal discussions, provide ongoing feedback to both teachers and students. These assessments help educators adjust their instructional methods in real time, making learning more responsive to students' needs. Summative assessments, such as standardized tests and end-of-term exams, evaluate overall learning progress and determine whether students have achieved the desired learning outcomes. Both types of assessments are essential for developing a comprehensive understanding of a child's academic development. One of the key benefits of regular assessments is the early detection of learning difficulties. When educators identify gaps in understanding at an early stage, they can implement targeted interventions, such as personalized tutoring, peer support, or differentiated instruction. This proactive approach prevents learning gaps from widening over time. Additionally, regular assessments foster a growth mindset among students, encouraging them to view challenges as opportunities for improvement rather than failures. Parents also play a crucial role in assessment-driven learning. Schools should communicate assessment results with parents and provide guidance on how they can support their children's learning at home. When assessments are used as tools for learning rather than merely for grading, they create an environment of continuous improvement. By integrating regular assessments into the educational framework, schools can enhance student learning, boost confidence, and ensure academic success.

9. **Parental Involvement: A Foundation for Lifelong Learning:** Parental involvement is a critical factor in a child's academic success, as it fosters a supportive learning environment beyond the classroom. When parents actively engage in their children's education, they reinforce learning, boost motivation, and help build confidence. Research has consistently shown that children with involved parents tend to perform better academically, exhibit positive behavior, and develop a stronger love for learning. One of the most effective ways to enhance parental involvement is by providing parents with the necessary resources and guidance to support their children's education at home. Schools can organize workshops, send newsletters, or provide digital platforms that offer instructional materials, literacy activities, and educational games. Parents can assist with homework, engage in daily reading sessions, and encourage discussions about school topics, reinforcing classroom learning in a home setting. Beyond academics, parental involvement fosters emotional and social development. When children see their parents take an interest in their education, they develop a sense of responsibility and accountability toward their studies. Regular communication between parents and teachers helps create a cohesive learning experience, ensuring that children receive consistent support in both settings. Schools can encourage parental engagement through volunteer opportunities, parent-teacher conferences, and involvement in school activities. Technology also plays a role in enhancing parental involvement. Digital tools, such as educational apps and school communication platforms, allow parents to monitor their child's progress and stay informed about school events. By fostering strong parent-teacher partnerships, schools create a collaborative educational environment that benefits children's overall development. Encouraging active parental participation in learning builds a strong foundation for lifelong educational success.
10. **Peer Tutoring: Strengthening Learning through Collaboration:** Peer tutoring is an effective educational strategy in which students help each other learn by sharing knowledge and explaining concepts. This approach benefits both the tutor and the learner, as teaching reinforces understanding while receiving peer support builds confidence and motivation. When older or more advanced students assist their peers, they engage in deeper learning, develop communication skills, and strengthen their mastery of academic concepts. One of the major advantages of peer tutoring is that students often relate better to their peers than to teachers. A peer tutor can explain difficult concepts in a way that feels more accessible and relatable, making learning less intimidating. This method also creates a supportive and collaborative learning environment, where students feel comfortable asking questions without the fear of judgment. Additionally, struggling students benefit from receiving one-on-one attention, which may not always be possible in a large classroom setting. Teachers can structure peer tutoring programs in various ways, such as cross-age tutoring (where older students help younger ones) or same-age tutoring (where students of similar ages assist each other). Group-based peer tutoring also fosters teamwork and collective problem-solving skills. To ensure effectiveness, teachers should provide guidelines, set clear objectives, and monitor progress. Beyond academics, peer tutoring nurtures essential life skills such as leadership, empathy, and patience. Tutors gain confidence in their abilities as they

help others, while learners develop resilience and a positive attitude toward learning. Schools and educators should encourage peer tutoring as a structured practice, making it an integral part of the learning process. By fostering a culture of shared learning, peer tutoring enhances academic achievement while promoting collaboration and mutual respect among students.

11. **Cross-Curricular Integration:** Cross-curricular integration is an effective approach to strengthening both literacy and numeracy skills by highlighting their interconnectedness. By embedding literacy into numeracy lessons and vice versa, students can develop a holistic understanding of these essential skills. For instance, reading a story that involves counting or mathematical problem-solving can enhance both comprehension and numerical abilities. A teacher can introduce a book about measuring ingredients in a recipe, prompting students to engage in hands-on math while practicing reading skills. Similarly, word problems in mathematics encourage students to interpret text, analyze numerical relationships, and apply reasoning to find solutions. This approach makes learning more meaningful and applicable to real-world situations. Additionally, cross-curricular integration can be expanded beyond reading and math to include science, social studies, and art. For example, a history lesson about trade routes can incorporate mathematical concepts such as distance, time, and cost calculations. When students recognize that literacy and numeracy are not isolated subjects but are deeply connected, their engagement and retention of knowledge improve. This method also promotes critical thinking and problem-solving, as students learn to apply multiple skill sets simultaneously. Teachers can use project-based learning and interdisciplinary activities to reinforce these connections, ensuring students see the practical value of literacy and numeracy across different subjects.
12. **Technology Integration:** The integration of technology in education offers numerous opportunities to enhance literacy and numeracy, but it must be used strategically to maximize its effectiveness. Digital tools such as interactive educational apps, online games, and virtual simulations can engage students and reinforce core skills. However, the use of technology should be purposeful, ensuring that digital resources align with clear learning objectives rather than serving as mere distractions. For example, adaptive learning platforms can personalize instruction, identifying students' strengths and weaknesses and providing tailored exercises to support their development. Similarly, e-books with interactive features can help young readers develop comprehension skills, while math apps can provide instant feedback on problem-solving. Teachers should integrate technology in moderation, balancing digital and traditional methods to prevent over-reliance on screens. Furthermore, technology can facilitate collaborative learning, allowing students to work together on projects, conduct research, and share ideas through online discussion platforms. Blended learning models, which combine in-person instruction with digital resources, can enhance student engagement and provide flexible learning opportunities. Additionally, teachers should be trained to evaluate and implement effective digital tools, ensuring they align with curriculum standards and pedagogical best practices. By leveraging technology wisely, educators can create dynamic learning experiences that support literacy and numeracy development while fostering digital literacy skills essential for the 21st century.
13. **Community Involvement:** Community involvement plays a crucial role in fostering literacy and numeracy development by expanding learning beyond the classroom. When local organizations, businesses, libraries, and families actively participate in education, students gain access to additional resources and support systems that enhance their learning experiences. Public libraries, for instance, can offer literacy programs, storytelling sessions, and book clubs that encourage children to develop reading habits. Similarly, local businesses can contribute by organizing financial literacy workshops or supporting numeracy-based activities such as budgeting exercises. Schools can collaborate with community centers to create mentorship programs where professionals guide students in real-world applications of math and literacy. Engaging families in educational initiatives, such as reading challenges and math-focused game nights, reinforces learning at home and strengthens the parent-child learning dynamic. Furthermore, community-led initiatives, such as volunteer tutoring programs and literacy festivals, provide students with diverse learning experiences that cater to different interests and abilities. Schools can also invite guest speakers from various fields to demonstrate how literacy and numeracy are essential in different careers, inspiring students to see the relevance of these skills in everyday life. Encouraging community engagement in education fosters a sense of collective responsibility,

making learning more accessible and culturally relevant. By integrating community support into literacy and numeracy programs, educators can create a more enriching and holistic learning environment for students.

14. **Teacher Professional Development:** Investing in teacher professional development is essential for ensuring high-quality instruction in literacy and numeracy. As educational practices evolve, teachers must continuously update their knowledge and skills to incorporate the latest research-based teaching strategies and technological advancements. Professional development programs equip educators with effective methodologies, such as differentiated instruction, data-driven decision-making and innovative assessment techniques, to address diverse student needs. Workshops, online courses, and peer collaboration opportunities allow teachers to refine their instructional approaches and integrate best practices into their classrooms. For example, training in phonics-based reading instruction can enhance literacy teaching, while hands-on workshops on problem-solving strategies can improve numeracy instruction. Additionally, professional development enables teachers to stay informed about emerging educational technologies, ensuring they use digital tools effectively to enhance student learning. Mentorship programs and collaborative learning communities within schools also provide teachers with ongoing support and opportunities to exchange ideas. When educators engage in continuous learning, they become more effective in adapting to curriculum changes, addressing student challenges, and fostering an engaging learning environment. School administrators should prioritize professional development by allocating time and resources for training sessions, ensuring that teachers remain confident and competent in their instructional practices. Ultimately, investing in teacher development leads to improved student outcomes, as well-trained educators are better equipped to nurture strong literacy and numeracy skills in their students.
15. **Flexible Learning Environments:** Creating flexible learning environments is essential to accommodate diverse learning styles and needs, ensuring that all students can effectively develop literacy and numeracy skills. A flexible learning environment goes beyond traditional classroom structures by incorporating various teaching methods, seating arrangements, and instructional materials that cater to different learners. For instance, some students may benefit from hands-on activities, while others may prefer visual or auditory learning strategies. Allowing students to engage with content in ways that suit their strengths enhances comprehension and retention. Flexible learning also includes incorporating movement into lessons, using group work, and providing quiet spaces for individual study. In literacy instruction, this might involve offering multiple formats of texts, such as audiobooks, graphic novels, and interactive reading materials, to accommodate different reading preferences. In numeracy education, manipulatives, digital tools, and real-world problem-solving tasks can provide varied approaches to understanding mathematical concepts. Technology also plays a role in creating adaptable learning environments, enabling personalized learning paths through digital platforms. Additionally, flexibility in assessment methods—such as allowing students to demonstrate understanding through presentations, projects, or written responses—ensures that diverse learners can showcase their knowledge effectively. Schools should also consider flexible scheduling options, such as blended learning or extended learning time, to support students who need additional help. By fostering a responsive and inclusive learning environment, educators can support all students in developing strong literacy and numeracy skills while promoting engagement and confidence in their learning journey.
16. **Inclusive Education:** Inclusive education ensures that all children, regardless of their abilities or learning differences, receive equal opportunities to access quality education. This approach acknowledges that students have diverse needs and learning styles, making it necessary to create adaptable and flexible teaching methods. Schools should provide individualized support systems, such as special educators, assistive technologies, and modified curricula, to accommodate students with disabilities or learning difficulties. Teacher training is crucial in equipping educators with the skills to recognize and address the unique needs of students. Moreover, fostering an inclusive classroom environment where students support each other can reduce stigma and encourage peer learning. Inclusive education benefits not only students with special needs but also their peers, as it promotes empathy, collaboration, and a broader understanding of different abilities. Governments and educational institutions must ensure the implementation of policies that uphold the rights of all children to receive education in mainstream schools whenever possible. In addition to infrastructural modifications, such as accessible classrooms and learning resources, schools should foster a culture of acceptance. Encouraging parental involvement and community participation in inclusive education initiatives can further strengthen the

learning experience. Ultimately, ensuring inclusivity in education leads to a more equitable society, where every child is given the opportunity to thrive academically and socially.

17. **Monitoring and Accountability:** A robust education system requires well-defined standards, continuous monitoring, and accountability mechanisms to ensure students receive a high-quality education. Schools, teachers, and policymakers must be held accountable for student performance through data-driven evaluations and transparent reporting. Regular assessments, both formative and summative, help track student progress and identify areas for improvement. Governments and education departments should establish independent monitoring bodies that assess schools' adherence to educational standards. Teacher evaluations should be conducted periodically, ensuring that educators are following best practices and implementing effective teaching strategies. Professional development programs should be in place to support teachers in areas where improvement is needed. Furthermore, parental engagement in school accountability can enhance oversight and encourage schools to maintain high standards. Technology can also play a role in monitoring student progress through digital assessments and data analytics, enabling educators to make informed decisions. A strong accountability framework should balance evaluation with support mechanisms, ensuring that teachers and schools receive the necessary resources to improve. Incentivizing good performance and addressing deficiencies proactively can lead to sustainable improvements. Public reporting of school performance can also drive healthy competition and encourage institutions to enhance their educational offerings. Ultimately, monitoring and accountability ensure that education systems remain dynamic, responsive, and committed to student success.
18. **Support for Struggling Students:** Students who struggle with foundational literacy and numeracy skills require timely and targeted support to prevent long-term academic difficulties. Early identification of learning gaps is crucial in addressing the needs of struggling students before they fall too far behind. Schools should implement intervention programs that provide additional instruction, tutoring, or mentoring to help students improve their skills. Teachers should be trained to recognize signs of learning difficulties and employ differentiated instruction techniques that cater to diverse learning needs. Personalized learning plans, which adapt teaching strategies to the specific needs of each student, can be effective in ensuring progress. Small-group instruction, peer tutoring, and remedial classes are additional strategies that can support struggling students. Emotional and psychological support is equally important, as students who struggle academically often experience low self-esteem or disengagement. Encouraging a positive learning environment that rewards effort rather than just outcomes can motivate students to persist in their studies. Schools should also involve parents in the support process by providing guidance on how to reinforce learning at home. Utilizing educational technology, such as adaptive learning platforms and interactive software, can help struggling students engage with subjects in a more personalized and accessible way. By prioritizing support for struggling students, education systems can reduce dropout rates, close achievement gaps, and ensure that all learners reach their full potential.
19. **Cultural Sensitivity:** Education systems should embrace and respect cultural and linguistic diversity to ensure an inclusive and meaningful learning experience for all students. Cultural sensitivity in education involves recognizing students' diverse backgrounds and incorporating their cultural experiences into the teaching process. Literacy and numeracy programs should be designed in ways that acknowledge and respect cultural differences, making learning relatable and engaging for students from various backgrounds. This can be achieved by using locally relevant examples, multilingual instruction, and culturally diverse teaching materials. Teachers should receive training on cultural competence to foster an inclusive classroom where all students feel valued and respected. Encouraging students to share their cultural experiences can enrich the learning environment and promote mutual understanding. Additionally, involving parents and community members in the educational process can help bridge cultural gaps and enhance student learning. Schools should also celebrate cultural festivals, traditions, and histories, allowing students to develop a sense of pride in their heritage. Language policies should support bilingual or multilingual education, especially in regions where multiple languages are spoken. Ensuring cultural sensitivity in education contributes to a more equitable system where all students, regardless of their cultural background, feel included and empowered to learn. Ultimately, a culturally responsive education fosters social cohesion and prepares students to thrive in a diverse world.

20. **Continuous Improvement:** Education systems must embrace a culture of continuous improvement to keep up with evolving learning needs, pedagogical advancements, and societal changes. Regular evaluation of teaching methods, curriculum, and learning materials ensures that students receive the best possible education. Schools and policymakers should use research-based approaches to refine instructional strategies, incorporating best practices from educational research. Feedback from teachers, students, and parents should be actively sought to identify areas for improvement. Professional development programs should be an ongoing effort, equipping educators with updated teaching techniques and skills. The integration of technology and innovative teaching tools should be regularly assessed to ensure they effectively enhance learning outcomes. Data-driven decision-making can help schools tailor instruction to student needs, making education more efficient and impactful. Continuous improvement also involves curriculum revisions that align with current educational and workforce demands, ensuring students acquire relevant skills. Collaboration between educators, researchers, and policymakers can accelerate the adoption of effective teaching strategies. Encouraging a mindset of lifelong learning among teachers and students fosters an adaptive and forward-thinking education system. Schools should also invest in infrastructure and resources that support evolving educational needs. Ultimately, continuous improvement in education leads to higher-quality instruction, better student outcomes, and a more resilient and future-ready education system. Improving foundational literacy and numeracy skills is a long-term endeavor, but it's one that has a profound impact on a child's future success. It requires the collaboration of educators, parents, communities, and policymakers.

CONCLUSION

At last we can say that enhancing a child's foundational literacy and numeracy skills is essential for their long-term academic success and overall learning development. These fundamental abilities serve as the building blocks for more advanced knowledge and skills, making early mastery crucial. However, achieving this objective requires a collaborative effort from all stakeholders involved in the child's education. This includes not only teachers but also parents, policymakers, community leaders, and educational institutions. Each has a role to play in creating a conducive environment that supports the child's learning journey. Additionally, there is a pressing need to rethink and reform various elements of the teaching and learning process to make it more effective. This includes updating pedagogical approaches, teaching methods, curriculum design, and assessment strategies. Traditional models may no longer suffice in addressing the diverse learning needs of children in today's rapidly evolving world. A more holistic and flexible approach is required to meet the unique needs of every learner. The National Education Policy (NEP) 2020 has put significant emphasis on Early Childhood Care and Education (ECCE) and provides a framework for improving foundational literacy and numeracy skills in children. The policy outlines several recommendations aimed at achieving these goals, ranging from curriculum reforms to improved teacher training. For these recommendations to make a tangible difference, they must be implemented effectively and comprehensively across the educational landscape. Only through a concerted and united effort will we be able to ensure that every child develops the foundational skills necessary for lifelong learning and success.

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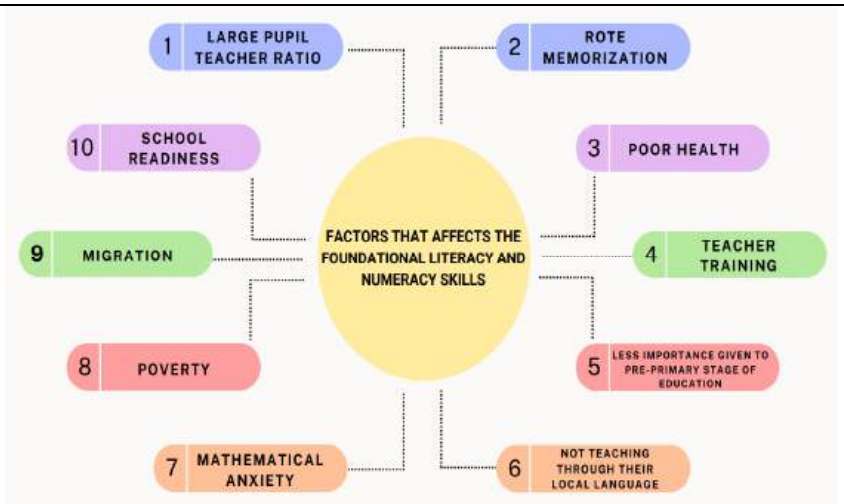


Figure 1: Factors affecting the FLN skills

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RESEARCH ARTICLE

Studies on Thermally Evaporated p-ZnTe/n-CdSe Heterojunction Diodes

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ABSTRACT

This paper reports the fabrication and characterization of thermally evaporated p-ZnTe/n-CdSe heterojunction diode. The heterojunction was characterized by current-voltage (I-V) and capacitance-voltage (C-V) measurements with the aid of digital microvoltmeter, picoammeter and digital LCR meter.The presence of high density recombination sites in the space charge region is confirmed by the ideality diode factor, which is predicted to be approximately 3.12. For the C-V characteristic curve, the barrier heights are found to be 1.07 eV, and for the I-V characteristic curve, they are 0.516 eV. The C-V curve shows that there are $1.3x10^{13}$ cm^{-3} interface states and that the built-in potential is 1 V.

Keywords: ZnTe; CdSe; heterojunction; barrier height; built-in-potential

INTRODUCTION

ZnTe presents itself as a potentially attractive material for a visible light-emitting diode due to its wide band gap of 2.26 eV [1]. Heteroepitaxy technology is useful in the creation of ZnTe junction devices since it is difficult to convert ZnTe into an n-type. The contact between ZnTe and CdSe can offer unique electronic features in a heterojunction diode due to its tiny lattice misfit [2], direct bandgap, and high absorption coefficient in the visible region for the constituent materials. A few applications for these properties include photodetectors, photovoltaics, and light-emitting diodes (LEDs) [3]. Different types of heterojunctions, including those utilising p-type ZnTe and n-type CdSe [4], CdS [5], ZnS and ZnSe [6], can also be made with II-VI compounds. Among the II-VI heterostructures, ZnTe/CdSe structure is unique in that it achieves a lattice match between two binary compounds in which there is no

commonality between the cation and the anion [7]. These findings implied that these materials could form a heterojunction, and this structure has been used as a window layer and absorber in opto-electronic devices. According to earlier research [8-11] on ZnTe/CdSe devices, appropriate deposition parameter controls are necessary to create customized CdSe and ZnTe films for devices. I-V, C-V, and spectral response measurements were used to characterize the p-n junctions that Kimmerle et al. [12] created using vacuum evaporation and wide bandgap II-VI compounds. An amorphous p-n junction made of doped amorphous silicon has been reported by Spear et al. [13] and Carlson and Wronkski [14]. Moore et al. [15] demonstrated that ZnTe and ZnSe can form a rectifying junction, but they were unable to determine the current mechanisms at play at the time. ZnTe-CdTe heterojunctions were fabricated by Pal et al. [16] using the hot wall method, and the photoelectrical properties, direct and reverse currents were examined. Atomic rearrangement at ZnTe/CdSe interfaces was investigated by Kemner et al. [17] using transmission electron microscopy, X-ray absorption fine-structure spectroscopy, and X-ray diffraction. This paper focuses on the I-V and C-V properties of the ZnTe/CdSe heterojunction structure that is thermally evaporated on glass substrates using aluminium electrodes.

Experimental Details

The p-ZnTe/n-CdSe heterojunction structures were formed on glass substrates with aluminium (Al) electrodes. Al (99.999% pure) obtained from Aldrich chemicals, USA, was evaporated at a pressure of 10-5 Torr from a helical tungsten filament to form the lower electrode. Zinc telluride (99.99% pure) obtained from Aldrich chemicals, USA was evaporated by the method of thermal evaporation. The powder of ZnTe placed in the molybdenum boat (200 amps) and gets heated with high current by energizing transformer. The transformer capable of supplying 150 amperes at 20 volts is used to provide the necessary current for heating the molybdenum source. Prior to evaporation, the evaporant material was carefully degassed at a lower temperature for about thirty minutes with the shutter closed. Deposition of the material (1500 Å thickness) over aluminium electrode was achieved by slowly varying the current under the pressure of about 10-5 Torr. A constant rate of evaporation 1Å/sec was maintained throughout the film preparation. A rotary drive was employed to maintain uniformity in film thickness. Thickness of the films was measured through quartz crystal monitor and verified by multiple beam interferometer (MBI) technique by forming Fizeau fringes. Cadmium Selenide (99.99 % pure, Aldrich chemicals, USA) film (1500 Å) was deposited over the ZnTe layer using the same method. Finally top aluminium electrode was deposited over CdSe layer to form p-n junction diodes with the structure Al/p-ZnTe/n-CdSe/Al. The I-V and C-V characteristics were obtained by making measurements with the aid of digital microvoltmeter, picoammeter and digital LCR meter.

RESULTS AND DISCUSSION

Current-Voltage (I-V) analysis

Fig. 1 shows the I-V characteristics of a ZnTe/CdSe heterojunction structure at room temperature. It is seen that its characteristics have a distinctly diode feature. I-V curve demonstrates that it is a rectifying device, which means that current flows through it more readily in one direction than the other. The heterojunction is a good diode because the forward current is significantly greater than the reverse current. In the forward bias region, the current increases exponentially with voltage. This is because the potential barrier at the p-n junction is lowered, allowing more charge carriers to flow across the junction. In the reverse bias region, the current is very small and remains relatively constant with voltage. This is because the potential barrier at the p-n junction is raised, preventing most charge carriers from flowing across the junction. For practical diodes, the current density – voltage relation is represented by the following equation [18],

$$J = J_O \, exp\left(\frac{qV}{nkT}\right)\left\{1 - exp\left(\frac{-qV}{kT}\right)\right\} \text{ ----- (1)}$$

where the ideality factor 'n' is roughly independent of voltage and greater than unity. The simpler version of equation (1) can be used for values of V greater than 3kT/q.

$$J = J_o \, exp\left(\frac{qV}{nkT}\right) \qquad \text{----- (2)}$$

Fig. 2 shows the variation of Ln J Vs Voltage plot for ZnTe/CdSe heterojunction in the forward direction. The ZnTe/CdSe heterojunction is a type II heterojunction, which means that the conduction band of the ZnTe is lower than the conduction band of the CdSe. When a voltage is applied to the heterojunction, the electrons in the ZnTe are excited into the conduction band of the CdSe. This creates an electron accumulation layer at the interface between the two materials. The electron accumulation layer increases the current density through the heterojunction. The inverse of the slope of the curve at forward bias gives the ideality factor (n). The ideality factor is a measure of how closely the heterojunction behaves to an ideal diode. The ideality factor for this heterojunction is calculated as 3.12 for room temperature. Similar value was obtained for ZnTe-CdS and Ge-GaAs heterojunctions [19,20]. This value indicates that the recombination generation in the depletion region. This ideality factor value indicates the prevailing in the current flow of emission-recombination mechanism in the Schockley-Noyce-Sah model [21]. According to this model when the direct bias is applied to p-n junction the charge carrier concentration in the space charge region is high also the junction has a high density of recombination centers, where p ≈ n is considerable [22]. The intercept on the y-axis can be used to determine the saturation current (J0) of the ZnTe/CdSe heterojunction. The saturation current is the current that flows through the heterojunction when the voltage is zero. Although the simple thermionic emission model is not strictly applicable to situations in which *n* is much larger than unity, it is used here for its intuitive value with the barrier height

$$\varphi_b = \left(\frac{kT}{q}\right) ln\left(\frac{J_o}{A^* T^2}\right) \qquad \text{----- (3)}$$

The height of ZnTe/CdSe barrier can be calculated by substituting the value of *Jo* in equation (3). The barrier height, determined from the saturation current in this heterojunction is 0.52 eV.

Capacitance – Voltage (C-V) analysis

Capacitance - Voltage measurements were made in order to study the characteristics of the ZnTe/CdSe junction. The capacitance of a reverse biased Schottky diode in a p-type semiconductor can be written as [23]

$$\frac{1}{C^2} = \left(\frac{2}{\varepsilon q N S^2}\right)(V_b - V - kT/q) \qquad \text{----- (4)}$$

Where *N* is space charge density, *Vb* the built-in potential, *V* the applied potential, *S* the surface area, *q* the electronic charge, *k* Boltzmann's constant, ε the permittivity. The C-2 versus *V* plot will provide *Vb* and *N* from the intercept and the slope, respectively. The barrier height of the Schottky diode, φ_b , is related to *Vb* by the following eqn. [23]:

$$\varphi_b = V_b + V_n \qquad \text{----- (5)}$$

Where $V_n = (kT/q)ln(N_c/N)$ and

$N_c = 2(2\Pi m^* kT/h^2)^{3/2}$.

Fig. 3 depicts the variation of 1/C2 with applied potential for ZnTe/CdSe heterojunction. The built-in potential is the voltage that is required to completely deplete the heterojunction. The built-in potential can be determined from the x-intercept of the 1/C2 vs voltage graph. The built in potential of the ZnTe/CdSe junction diode showing ideal behavior is obtained from the voltage intercept of a plot of 1/C2 Vs V. The intersection with the voltage axis resulted the built in potential value of 1 eV for this junction, which can be compare well with the earlier report [22]. The calculated values of total number of interface states (*N*), built-in potential (*Vb*) and barrier height (*φb*) are listed in the Table1.

CONCLUSION

The p-ZnTe/n-CdSe heterojuction was fabricated by thermal evaporation on glass substrate using aluminium electrodes. The ideality diode factor is calculated to be about 3.12 and it confirms the presence of high density recombination centers in space charge region. The barrier height is determined for both I-V and C-V characteristics curve as 0.516 and 1.07 eV respectively. From the C-V curve the built in potential is found to be 1 V and the calculated number of interface states is 1.3x1013 cm-3.

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Table 1: Electrical parameters of ZnTe/CdSe heterojunction

Parameters	ZnTe/CdSe Heterojunction	
	I-V	C-V
φ_b (eV)	0.516	1.07
n	3.12	---
V_b(volt)	---	1.00
N (cm^{-3})	---	$1.3x10^{13}$

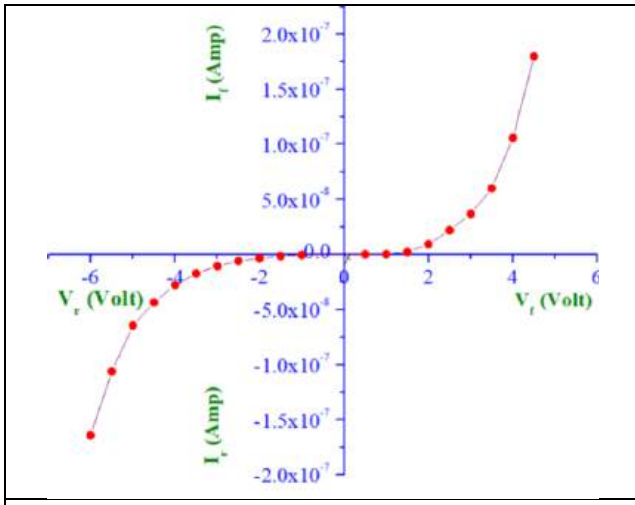


Fig. 1 I-V Characteristics of ZnTe/CdSe heterojunction

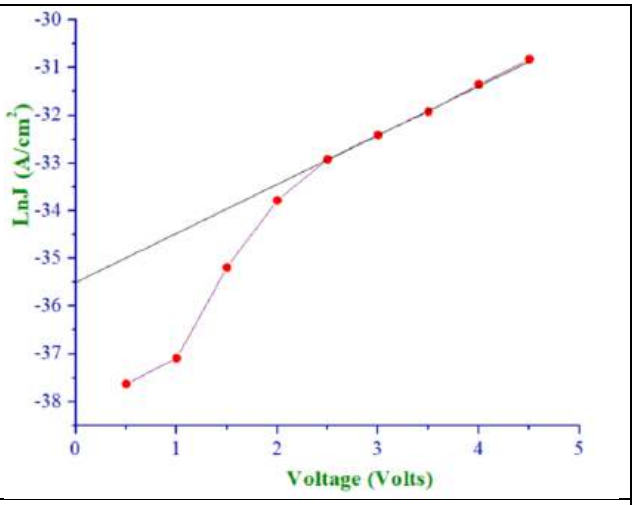


Fig. 2 Ln J Vs Voltage for ZnTe/CdSe heterojunction

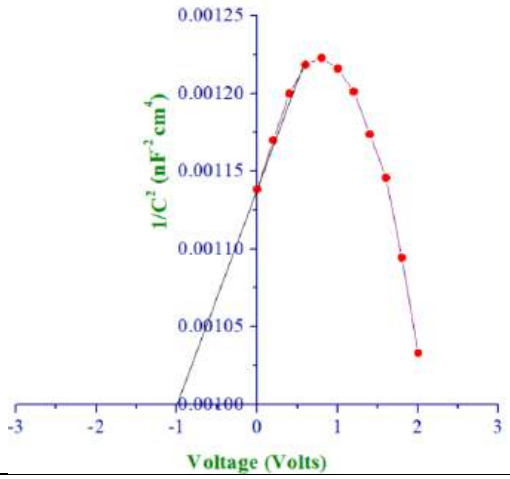


Fig. 3 1/C² vs Voltage for ZnTe/CdSe heterojunction

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RESEARCH ARTICLE

Role of Ayurvedic Intervention in Subclinical Hypothyroidism (*Dhatvagni Mandya*) – Case Study

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ABSTRACT

The prevalence of hypothyroidism in the developed world is about 4-5%. The prevalence of subclinical hypothyroidism in the developed world is about 4-15%. Hypothyroidism is a hypometabolic clinical state caused by insufficient thyroid hormone output for long period of time. Subclinical (mild) hypothyroidism - is characterized by mildly elevated TSH (< 10), but normal fT4 levels. According to Ayurvedic principles, the pathology of Subclinical Hypothyroidism is characterised by "*Dhatvagnimandya*". A 41 years old male patient came to Panchkarma OPD with the complain of Itching on whole body, Fatigue, Loss of appetite, Hoarsness of voice, Constipation and Cold Intolerance since 2 months. He had no earlier history of treatment. For above following comlpaint Ptient was advised *Kanchnar Gugglu, Amrita Gugglu, Kaklarakshak yog* and *Erandbhrist haritaki churn at night.* Patient came to *Panchkarma* OPD for follow up with TSH profile in normal range.

Keywords: *Agnimandya*, TSH, Hypometabolism, *Kanchnar Gugglu*

INTRODUCTION

Hypothyroidism is caused by inadequate function of the thyroid gland itself called primary hypothyroidism or by not getting enough stimulation by thyroid stimulating hormones called secondary hypothyroidism. Primary hypothyroidism is caused by iodine deficiency, autoimmune disease, radiation therapy, drugs or thyroide surgery.[1]

Prevelance

The prevalence of hypothyroidism in the developed world is about 4-5%. The prevalence of subclinical hypothyroidism in the developed world is about 4-15%.[2]

Hypothyroidism is a hypometabolic clinical state caused by insufficient thyroid hormone output for long period of time. A rise in serum thyroid stimulating hormone (TSH) cocentration with normal serum fT4 and fT3 concentration (subclinical hypothyroid) is the first biochemical abnormality. It is later accompanied by a decrease in serum fT4 concentration, at this stage patients have symptoms and need medication.[3]

Subclinical (mild) hypothyroidism is characterized by mildly elevated TSH (< 10), but normal fT4 levels. TSH levels of 10 or more are typically considered true hypothyroidism and treated as such, even if the fT4 falls within the normal range.[4] According to Ayurvedic principles, the pathology of Subclinical Hypothyroidism is characterised by "*Agnimandya*" (low metabolic activity) at the cellular and systemic levels, which is equivalent to hypometabolism, or reduced caloric expenditure, in modern terms. Any level of *Agnimandya* brought on by *Kaphakara Nidana* (Kapha increasing causative factors) leads to increased *Dhatugata Mala Sanchaya* (cellular accumulation of excretory products), which in turn causes *Srotorodha* (microchannel blockage) and causes "*Dhatvagnimandya*" and causes physical and mental symptoms associated with Subclinical Hypothyroid, such as swelling, anaemia, constipation, cold intolerance, etc. Due to this *Agnimandya*, aberrant *Rasa Dhatu*, or semi-digested food, is formed, which is *Ama*. The symptoms of *Ama Lakshana* and Subclinical Hypothyroidism are comparable.[5] The theraprutic approach for *Dhatvagnimandhya* was there for foccused on *Kaphanashak Chikitsa*, *Srotoshodhan*, *Agnideepan*, and *Vatanuloman*.

CASE REPORT

A 41 years old male patient came to Panchkarma OPD with the complain of Itching on whole body, Fatigue, Loss of appetite, Hoarsness of voice, Constipation and Cold Intolerance since 2 months. He had no earlier history of treatment.

History of Past Illness

There is no history of diabetes, hypertension, cardiac issues, or any other complex diseases, nor is there any family history of thyroid disorders. The patient has a reduced appetite, sound sleep, with constipation.

General Examination

The patient was afebrile and pulse was 78/min, Respiratory Rate – 18/ min, BP –130/90 mmHg, Weight –70 kg.

Thyroid local Examination

On Inspection
Localized swelling - Absent
On palpation
Size – Normal, Shape – Normal, Localized temperature - Not Raised, Tenderness – Absent, Localized temperature - Absent

Investigation- dated on 12/12/2023 were following-
Thyroid Profile : T3 –1.34 ng/ml , T4 –7.9ug/dl , TSH –6.80 uIU/ml.

Diagnostic Assesement

Disgnosis was made on the basis of chief complaint of patient and Laboratory investigation sach as T3, T4 and TSH. If the serum FT4 concentration is normal and the TSH is elevated but <10Mu/L then Thyroxine therapy is note recommended as routine tehrapy.[6]

MANAGEMENT

Patient has taken following medicine for duration of 2 months.

1. *Kanchnar Gugglu* – 2 BD
2. *Amrita Gugglu* – 2 BD
3. *Kaklarakshak yog* – 1 BD
4. *Erandbhrist haritaki churn* – 5 gm OD at night

RESULT

Changes in serum Thyroid profile are shown in Table 1.

DISCUSSION

According to Ayurveda *Agnimandya* is the underlying cause of hypothyroidism. Therefore, medications with the characteristics of *Deepana, Pachana, Lekhana, Srotoshodhan, Anulomana*, and *Kaphashamaka* are probably going to check the basic Pathophysiology of hypothyroidism or hypometabolism. This quality listed above are present in the *Kanchanar Guggul*'s ingredients. [7] The ingredients of ***Kanchanara Guggulu*** include *Guggulu, Pippali, Maricha, Sunthi, Amalaki, Bibhataki, Haritaki, Varuna, Tvak, Ela, and Tejpatra.* These ingredient help *relieeving Shotha* enhance *Agnideepan, Pachan, Tridoshahar, Anulomana, Chedana* and *Ruchya. Granthi Vikar* benefits from *Kanchanara* due to its *Anulomana* and *Kaphapitta Shamaka* properties. *Guggulu* with its *Tridoshahara* properties is connected to *Lekhana, Pachan*, and *Deepana karma*. It balances the *Agni,* help with *Srotosodhana,* and reduces both *Vata* and *kapha.*[8] ***Amrita Guggulu*** contains the ingredients *Amrita, Gugglu, Triphala, Varshabhu, Danti, Chitraka, Pippali, Shunthi, Guduchi, Twak, Vidang*, and *Trivrat.* The *Rookshana* properties of *Danti* (Baliospermum montanum), *Triphala* (Terminalia chebula Retz., Terminalia bellerica, Emblica officinalis), *Vidanga* (Embelia ribes), and *Guggulu* (Commiphora mukul) are thought to target the excess *Kapha Dosha* and *Medas*. Additionally, the *Tikshna* and *Ushna* qualities of ingredients like *Pippali, Shunthi, Vidanga*, and *Danti* enhance the formulation. *Guggulu* is specifically known for its beneficial effects on *Srotovishodhana.* [9] ***Kaklarakshak yoga*** helps the lymphatic system operate normally, balances the *Vata* and *Kapha Dosha*, and encourages the removal of inflammatory poisons. *Kaklarakshak Yoga* benefits with ingredients like *Shodita Gugglu, Kanchnar, Ashvagandha, Chitraka, Katuka* and *Guduchi*. As the patients was suffering from constitation also that's why ***Erandbhrist Hritaki Churn*** was also adviced. *Haritaki is Deepana, Pachana, Strotoshodhaka*, due to *Ushna Veerya* and *Laghu Guna*, performs the *Anulomana Karma* due to *Amla Rasa*, *Madhura Vipaka*. *Eranda Taila* is antagonistic to *Vata Dosha* due to its innate qualities and is also regarded as the best *Vata* pacifier and *Dhatuposhaka* (*Vayasthapaka*, *Rasayana*, *Vrushya*) has *Pakvashaya-Shodhaka* action. Thus, it accentuates the properties of *Haritaki* and formulation becomes more powerful in performing the function of *Anulomana* of *Apana Vata* and treating the hypothyroidism.[10]

CONCLUSION

Ayurveda attributes hypothyroidism to Agnimandya (low metabolic activity), leading to symptoms like swelling, anemia, constipation, and cold intolerance. The case study of a 41-year-old male with subclinical hypothyroidism demonstrated the efficacy of Ayurvedic treatments. Medications like Kanchnar Guggul, Amrita Guggul, Kaklarakshak Yog, and Erandbhrist Haritaki Churn, which possess Deepana, Pachana, and Srotoshodhan properties, were effective in managing symptoms and significantly reducing TSH levels from 6.80 uIU/ml to 1.25 uIU/ml.

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Table 1. Thyroid profile

Before Treatment	After Treatment
(Dated on -12/12/2023) T_3 - 1.34 ng/ml T_4 – 7.9 ug/dl TSH – 6.80 uIU/ml	(Dated on - 15/2/2024) TSH – 1.25 uIU/ml

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RESEARCH ARTICLE

Manas Mitra Vatakam Attenuates Maternal Separation Induced Behavioral Alteration in Female Rats

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ABSTRACT

The purpose of this study is to assess how MMV affects the anxiety and depressive-like behaviors that experimental animals exhibit when their mothers are separated. In this study, we use proven models such as brain oxidative indicators, EPM, LDB, antioxidants, and histological observation in conjunction with animal models to evaluate the efficacy of test drugs, i.e., in treating anxiety generated by mother separation stress in rats. The test -1 group received a low dose of MMV 50 mg/kg, while the test -2 group received an oral low dose of MMV 100 mg/kg. When MMV was taken orally, there was a noticeable and dose-dependent increase in both the amount of time spent in the light chamber and the number of entries. Furthermore, MMV exhibits a dose-dependent action that significantly shortens the immobility duration measured by FST. However, test drugs show a decrease in LPO levels at both doses. MMV, on the other hand, was discovered to boost the repair of GSH, SOD, and CAT levels. Based on the behavioral study, oxidative parameters, and histological observation data, MMV significantly improves anxiety and depression-like behavior in experimental rats that is brought on by mother separation.

Keywords: Anxiety, Depression, manas mitra vatakam, Diazepam, EPM, OFT, Light &Dark box, SPT, FST

INTRODUCTION

Anxiety and stress are prevalent psychological symptoms of contemporary society and lifestyles. In tiny amounts, tension and Anxiety is a positive thing; it may inspire and increase productivity. In contrast, it is unhealthy to experience too much stress or to respond strongly to it. Together with general poor health, it can cause certain psychological or physical illnesses including depression, cardiac issues, or infection. Anxiety and harmful behaviors are frequently the result of continuous and unremitting stress. A disorder of the central nervous system is anxiety (Kjernised KD *et al.,* 2004) (Weinberger DR *et al*.,2001).In n humans, anxiety is a typical emotional occurrence. (Cle´ment Y *et al.,* 2002) Anxiety is an uncomfortable emotional state that is linked to unease, discomfort, and worry or fear about certain definite or ambiguous future scenarios. (Gupta V, *et al*., 2010) Usually a reaction to stress, anxiety is characterized by exhaustion, nausea, rapid heartbeat, and breathing difficulties. As the most prevalent mental disorder, One-eighth of people suffer from anxiety. And has grown in importance as a topic of study in the field of psychopharmacology in the last ten years. (Jung JW *et al*., 2006)Anxiety and stress are prevalent psychological effects of contemporary society and way of life. Stress and anxiety can be beneficial in moderation because they can inspire and increase productivity. Still, Excessive stress or a strong reaction to stress is detrimental. In addition to overall ill health, it might result in some medical or psychological conditions including depression, cardiac issues, or infections. Stress that is ongoing and relentless often leads to anxiety and undesirable behaviors. Anxiety is a central nervous system illness. Anxiety characterized by an unpleasant emotional state, uneasiness, discomfort, and fear or concern about a specific or vague future event. (Gupta V *et al*., 2014) Psychiatric disorders related to anxiety affect approximately 25 % for adult's individuals at some point in their lives. The frequency of the rates of anxiety disorders in men and women are 19.2% and 30.5%, respectively.

Among young people, anxiety disorders are remarkably common. Anxiety disorders were reported to be 15.4% prevalent in children between the ages of 7 and 11. Less than 14% of those with such psychiatric disorders, according to a survey, receive treatment. (Leon A, et., al 1997) Clinical conditions that fall under the category of anxiety disorders include phobias, post- traumatic stress disorder, panic disorder, generalized anxiety disorder, obsessive-compulsive disorder, and panic disorder. Anxiety condition related to separation (Gautam M *et al*., 2007). The precise mechanism is not fully understood. In children, anxiety can be a common occurrence. When a baby is seven to nine months old, stranger anxiety starts (Munir, S.,*et al.,* 2019) Disrupted central nervous system modulation is thought to be the cause of anxiety symptoms and the disorders that follow. This disregulation manifests physically and emotionally as different degrees of heightened sympathetic arousal. (Kaplan, H. I., *et al*., 1995) It has been suggested that a variety of neurotransmitter systems contribute to one or more of the involved modulatory processes. The majority typical noradrenergic and serotonergic systems of neurotransmitters are taken into account. Broadly speaking, it is believed that there is a correlation between an overactive noradrenergic system and an underactive serotonergic system Disregulation is the result of these systems' regulation and regulation By additional routes and neuronal circuits in different parts of the brain of both the emotional response to physiological arousal and its experience.(Ressler, K.J.,*et al.,* 2000) Many think that it developed as a result of high noradrenergic system activity and low serotonin system activity. The function of corticosteroid regulation and its connection to anxiety and fear symptoms have drawn some attention. Corticosteroids can alter the action of specific neural pathways, which can impact not just actions during stressful situations but likewise the mind's power. To process fear-inducing stimuli. That was widely believed. That cholecystokinin is a neurotransmitter that controls emotional states. Because these neurotransmitters are so carefully synchronized, modifications to one neurotransmitter system will always cause modifications to another, such as comprehensive feedback systems. Two inhibitory neurotransmitters that reduce the stress response are serotonin and GABA. These neurotransmitters have all emerged as key targets for medicinal substances. (Korte, S.M.*et al*., 2001)

MATERIAL AND METHODS ANIMALS

Healthy female wistar Rat (200-250gm) body weight (6 animals per group) was used in this investigation. The animals were kept in well-ventilated polypropylene cages and maintained under the standard laboratory animal house condition (temp- 25± 2˚c) and humidity (40- 60%) under a 12:12-h light-dark cycle (lights on at 6:00 a.m.), were used. Standard food pellet diet (Nutrivet Life science, Pune) and water ad libitum. The Ministry of Environment and Forests, the government of India, and the Committee for Control and Prevention of Cruelty to Animals Act, 1960 established regulations that the animals were kept in accordance with. . The experimental protocol was approved and sanctioned by the IAEC which having proposal number1865/23-24/P-12. All experimental procedure is carried out by the guidelines provided by CPCSEA New Delhi.

Experimental design

Drugs

Manasmitra Vatakam (p.o.), diazepam (i.p) the MMV was used in the dose of 50 and 100 mg/kg, p.o. as a low dose, and high dose, respectively. Diazepam was dissolved in 0.9% NaCl whereas MMV was dissolved in water.

Groups

Anxiety and depression like behavior caused by maternal separation for 14 days. All the rats except group- I, (NC and DC) were separated for 3 hours per day for 14 days in cage (Aguggia JP et al., 2013).At the day 3 light and dark box, open field test and the day 14 EPM, SPT, FST this behavior Parameter was taken From day 14 to 21 the animals was kept for undistribution period. PND 21 to PND 31 was weaning period. PND 31 to PND 52 the treatment was given. (Aguggia JP, et al., 2013) (Lorigooini Z et al., 2020) The standard group was given diazepam 1 mg/kg dissolved in 0.9 % NaCl and administered intraperitoneally (i. p.) (Orso R et al., 2020)The test -1 group was given the low dose of MMV 50 mg/kg it dissolved in distilled water and then injected orally the test -2 group were given the high dose of MMV 100 mg/kg, it dissolved in distilled water and then administered orally. (Wilson MA et al., 2004) On the day 53, 54, 55 the behavioral parameter likes EPM, OFT, light and dark box, FST, SPT. After the completion of study animals were sacrificed for biochemical parameters like GSH, LPO, Catalase and histopathological assay. (Thirunavukkaras SV *et al*., 2012)

Experimental Design:

Behavioral Parameter Light and dark box

The Crawley and Goodwin two compartment exploratory models have been validated in terms of pharmacology, behavior, and physiology. The two compartment method balances the rat's innate curiosity about a new habitat against the unpleasant characteristics of an open field with intense light. The most accurate metric for determining anxiolytic activity appeared to be time spent in light areas or engaging in exploratory behavior. The light and dark box has two sections: the white-painted light region (27L x 27W x 27H cm) was lit by a 100 W desk lamp, while the black-painted dark area (18L x 27W x 27H cm) was used for lighting. To facilitate movement from one compartment to the other, a 7.5 x 7.5 cm tunnel was used to divide the two sections. The overall number of crosses between the bright and dark compartments. Time spent in bright part of compartment. Time spent in the dark part of cage. (Manisha, R. L. *et al*., 2013)

Open field test

It is often used to observe experimental animals' independent behavior, inquisitive behavior, and stress in unfamiliar settings. This test was designed to assess rats' anxiety-like behaviors. To track locomotors activity, OFT employed square locomotors boxes (× W27.3 × H 20.3 cm). The animals were brought into the testing room a full day before the tests began in order to prevent the assessment of loco motor activity linked to anxiety or novelty. The time spent at the area's center during the test was recorded for five minutes. Every experiment was run during the active/dark phase. To capture and assess the movement of the rodents for this investigation, a video tracking system with MAZEMASTER software was used. Gently remove the subject rodents from the maze at the conclusion of the test

session and place them back in their home cage. Among the parameters noted are the overall distance traveled. (Akter S *et al* 2019)

Elevated plus maze

Every test was conducted outside of the colony chamber in a dimly lit space. Rats were kept in the test chamber for an hour before to the experimental test. The 40 x 7 open arms, two identically sized closed arms, and 10 cm-high side and end walls comprised the EPM device. The arms were joined by a 7 cm by 7 cm gap in the middle. Animal placed in the center of the apparatus with its head facing an open arm, and it was then left for three minutes. After that, the animal was removed and placed back in its original cage. The equipment was cleaned with a 10% chlorine bleach solution in between each test session. An animal was considered to be in an arm if it had all four paws on the central platform and on the central platform if it had at least two paws. The duration of open arms (OAT: (time in open arm/time in open + closed arm) and the quantity of open arm entries (OAE: (number of open arm entries/number of open + closed arm entries) were used to quantify anxiety. In addition, the total number of arm entries was counted to obtain a measure of spontaneous locomotors activity. (Khakpai, *et al* 2023).

Sucrose preference test

Another well-liked technique to look into alterations in rodents' positive emotional cues is the two-bottle choice test, which measures sucrose preference. We used the test to measure the anxiety and depression like behaviors in the investigational animals. To track each mouse's unique fluid consumption, each mouse was kept in a Plexiglas cage with a double- grommet ventilation system. The mice were given a 12-hour water and food fast before testing, and then they were given a 12-hour 1% sucrose solution to help them get used to it. After that, mice were placed in separate housing and allowed to select from two bottles (150 ml each of tap water or 1% sucrose solution). To prevent any adverse effects on preference, the positions of each bottle were switched after six hours. To calculate SP, use the formula SP (%) = sucrose intake (g) / (sucrose intake (g) + water intake (g)) × 100% (E. Vollmer L et al., 2013)

Force swimming test

To keep the rats' hind limbs from touching the tank floor, they were placed in a 44 cm high by 32 cm diameter plastic cylindrical tank that was 28 cm deep and filled with 22°C tap water each session of the pretest and test lasted a total of fifteen minutes in the same tank. To maintain the water as clean as possible, it was changed after two 15-minute or six 5- minute sessions, and waste was taken out of the device at the end of every session. Following the test or pretest stages, the investigational animals were towel-dried and warmed in their home cage using a heating pad for thirty minutes (Hédou G et al., 2001) **Biochemical Evaluation**

Preparation brain tissue homogenate

On the fifty-fifth day, the animals were rendered unconscious via intraperitoneal ketamine (100 mg/kg) anesthesia in order to collect their brains. After being removed, the brain was washed in an ice-cold isotonic tris-KCl solution. The weight of the brain was measured, and it was homogenized at 20°C in 7.4 pH phosphate buffer saline (PBS) before being centrifuged for 10 minutes at 2000 rpm. For the purpose of estimating the various tests, the supernatant was collected (Khurana K *et al.,* 2019).

Estimation of lipid peroxidase

0.1 milliliter homogenate, 1.5 milliliters of 20% (v/v) acetic acid (pH 3.5), 1.5 milliliters of 0.8% (w/v) thiobarbituric acid, and 0.2 milliliters of SDS (8.1% w/v) were added to a 4 milliliter assay mixture. Fill the tube with the mixture above, which was combined, heated to 95 °C for an hour on a water bath, cooled under tap water, and then 1 ml of distilled water was added. Pour in 5ml of the n-butanol and pyridine (15:1) mixture. For ten minutes, the mixture was centrifuged at 2200 rpm. The findings are given as nmol MDA/mg of protein. At 532 nm, the absorbance of the pink-colored, transparent supernatant was measured. (Abd El HA *et al.*,2012)

Estimation of glutathione level

Pick up 0.1 mL of the supernatant as a test sample. The supernatant was made less strong by adding 0.9 ml of phosphate (PO4) water. Put in 1 ml of TCA (20%).I let the mix sit for 20 minutes. After that, it was spun at 10,000 rpm for 10 minutes. 0.25 ml of the liquid was taken away. Use 0.75 ml of phosphate water to add. Also, add 2 ml of DTNB, which is 0.0006M in strength. Ten minutes were spent sitting. A spectrophotometer was used to measure absorbance at 412 nm. (Masella R, *et al* 2005)

Estimation of Catalase level

We measured the catalase (CAT) activity using the method outlined by Claiborne (1985). 0.05 ml of 10% supernatant make up the assay mixture. Add one milliliter of H2O2. To a final amount of 3 ml, add 1.95 ml of phosphate buffer (0.05 M, pH 7). Using a UV spectrophotometer, absorbance was measured at 240 nm (Bouayed J *et al.,* 2009).

Estimation of Superoxide dismutase's level

Take 0.1ml supernatant Add carbonate bicarbonate buffer (pH 9.7), Add epinephrine (1 ml) The absorbance was measured at 480 nm for 2 min (Reena N, *et al* 2012)

Histopathological examination

Once intracardiac perfusion with phosphate buffer formalin was completed, the brain tissue for histopathology was extracted. An area of a mouse brain was embedded in paraffin wax, sectioned into pieces with a thickness of 2–5 μm, and fixed with 10% (v/v) formalin. Eosin and hemotoxylin dye were used to stain the sections for histopathological analysis. (Brat D Jet al 2018)

Statistical analysis

All the values were expressed as mean ± SEM. Statistical comparisons were performed by two ways ANOVA followed by Tukey's multiple comparison tests and one way ANOVA Dunnetts multiple comparison using Graph Pad Prism version 5.0. ***P<0.01, ***P<0.01, ***P<0.001 was considered as significant compared to disease control.

RESULTS

Effect of different doses of MMV on maternal separation induced anxiety-like behaviors in the light and dark box.

As show in fig 2 (A) the disease control group decreased the time spent in light chamber (###P=0.0005) as compared to normal group. The different doses of MMV 50 & 100 mg was increased the time spent in light chamber (*** P= 0.0005, ***P=0.0002) as compared to disease control group. The standard group more significantly increased the time spent in light chamber (****P<0.0001). As show in fig 2 (B) The dose of MMV 100 mg/kg was more notably increased the no of entry in light chamber(****P <0.0001) as compared to disease control group. The standard group significantly increase the no of entry in light chamber (**P 0.0025) as compared to disease control group. Conversely MMV 50 mg/kg was failed to increase the no of entry in light chamber was found to be non significant. MMV administered orally was exhibited significant and dose dependent effect enhancement of time spent in light chamber as well as no. of entries in light chamber dose dependently.

Effect of different doses of MMV on maternal separation induced anxiety-like behaviors in the open field test.

As shown in fig 3 the disease control group decrease the total distance travelled (###P=0.0004) as compared to normal group. The MMV 100 mg/kg more significantly increase the total distance travelled, (****P<0.0001) as compared to disease control groups. Whereas the MMV 50 mg/kg significantly increase the total distance travelled, (***P= 0.0477). The Standard group also increase the total distance travelled. When MMV is taken orally, an open field test can show a significant and dose-dependent effect on the overall distance traveled.

Effect of different doses of MMV on maternal separation induced anxiety-like behaviors in Sucrose Preference Test

As shown in fig 4 the disease control group take the less sucrose intake (####P<0.0001) as compared to normal group. The MMV 100 mg /kg more significantly increase the sucrose intake,(****<0.0001) as compared to disease control group. Whereas, the MMV 50 mg/kg significantly increase the sucrose intake (**P= 0.0023) as compared to disease control group. The standard group show less effect as compared to test group. An exciting and remarkable dose-dependent effect on sucrose preference intake can be observed when MMV is administered, according to a sucrose preference test.

Effect of different doses of MMV on maternal separation induced anxiety-like behaviors in Force swimming test

As shown in fig 5 the results of the FST revealed that the disease control group increase immobility time (###P<0.0001) as compared to normal group. The MMV 100 mg/kg more significantly decrease the immobility time, (****P<0.0001) as compared to disease control group. Whereas, The MMV 50 mg/kg significantly decrease the immobility time,(***P=0.0007) as compared to disease control group. Similarly the standard group more significantly decreases the immobility time, (****P<0.0001) as compared to disease control group. In the force swimming test, MMV given orally can show a significant and dose- dependent impact that reduces immobility time.

Effect of different doses of MMV on maternal separation induced anxiety-like behaviors in the elevated plus maze.

As shown in fig 6 (A) the disease control group decrease the time spent in open arm (##P=0.0005) as compared to normal group. The MMV 100 mg/kg was more significantly increase time spent in open arm, (****P < 0.0001) as compared to disease control group. whereas the MMV 50 mg/kg significantly increase the time spent in open arm (*P= 0.0327) as compared to disease control group. Similarly the standard group significantly increase the time spent in open arm, (*P= 0.0284) as compared to disease control group. When MMV is taken orally, it can show a notable, dose-dependent effect that lengthens the amount of time spent in an open arm position in an elevated plus maze.

As shown in fig 6 (B) The MMV 100 mg/kg was more significantly increase no. of entry in open arm, (****P < 0.0001) as compared to disease control group .whereas the MMV 50 mg/kg significantly increase the time spent in open arm (***P= 0.0009) as compared to disease control group. The standard group significantly increase the no. of entry in open arm, (**P=0.0073) as compared to disease control group. Whenever MMV is administered, it can provide some noteworthy and remarkable effects. More precisely, it can selectively enhance the number of entries in the open arm of the elevated plus maze apparatus.

Effect of different doses of MMV on LPO level

According to figure 7 the disease control group increase the level of LPO (####P< 0.0001) as compared to normal group. The MMV 100 mg/kg was more significantly decrease the level of LPO, (****P < 0.0001) as compared to disease control group. Similarly The MMV 50 mg/kg was more significantly decrease the level of LPO,(****P < 0.0001) as compared to disease control group. The diazepam also more significantly decrease the level of LPO, (****P< 0.0001) as compared to disease control group. The LPO level was significantly reduced by the MMV when given at doses of 50 mg and 100 mg; in a similar vein, the LPO level was most significantly reduced by the 50 mg dose.

Effect of different doses of MMV on GSH level.

As shown in figure 8 the disease control group decrease the level of GSH (#### P<0.0001) as compared to normal group. MMV 100 mg/kg was more significantly increase the level of GSH, (****P < 0.0001) as compared to disease control group. Whereas MMV 50 mg/kg was significantly increase the level of GSH as compared (***P=0.0008) to disease control group. The diazepam increase the level of GSH (P =0.0067), as compared to disease control group.

Effect of different doses of MMV on Catalase level.

As shown in figure 9 the disease control decrease the Catalase level #### P=0.0001as compared to normal group. The MMV 50 &100 mg/kg was more significantly increase the level of catalase, (****P< 0.0001) as compared to disease

control group. Similarly the diazepam was more significantly increase the level of catalase, (****P< 0.0001) as compared to disease control group.

Effect of different doses of MMV on SOD level.

As shown in figure 10 the disease control decrease the SOD level (#### P=0.0001) as compared to normal group. The MMV 50 &100 mg/kg was more significantly increase the level of SOD, (****P< 0.0001) as compared to disease control group. Similarly the diazepam was more significantly increase the level of catalase, (****P< 0.0001) as compared to disease control group.

Histopathological Examination

Figure 11 (a) Normal group: Microscopy shows brain tissue neuronal architecture. An oval or spherical neuron. No cortical abnormalities were observed. Figure 11(b): Disease Control: group-Hippocampus neuron degeneration is visible in brain tissue. Figure 11(c): Standard: Microscopically, brain tissue exhibits normal neuron architecture. Round-to-oval neuron. There were no abnormalities. Figure 11 (d) Test 1: Microscopic brain tissue reveals normal neuron architecture. Round-to-oval neuron. No cortical abnormalities. Figure 11 (e) Test 2: Microscopic brain tissue indicates normal neuron architecture. Round-to-oval neuron. No cortical abnormalities. Based on the findings of the histological analysis, no statistically significant differences were observed across all groups when the amygdala and hippocampus regions were examined.

DISCUSSION

Anxiety disorders are the most frequent psychiatric disorders among diseases called mood disorders.(Villas Boas GR et al., 2020) Stress primarily affects the brain, which can subsequently result in the development of mental diseases associated to stress and cognitive difficulties. (Gregus A et al., 2005)(Wright RL, et al., 2006)Stress exposure has been linked to alterations in the brain's morphology, function, and neurology that are closely linked to stress disorders. (North CS, *et al.,* 2016) Consistent with earlier research, our findings also showed anatomical and functional alterations in a number of brain regions associated with the regulation of behavior and cognition, including as the amygdala.(Laugharne, C et al., 2016)cerebral cortex and hippocampal regions. Alongside these abnormalities in behavior and cognition, there were physiological changes as well, such as increased levels of the stress hormone corticosterone.(Meng L, *et al.*,2016) (Zhu X et al.,2017) Author also reported that induction of stress causes significant changes in the central nervous system (CNS) include brain and the spinal cord, and it also plays a crucial role in the body's response against stress, stress also caused on impact to the levels of various neurotransmitters in the CNS.

It include norepinephrine and dopamine, which mostly involved in attention, motivation, and regulation of mood and behavior in human and animals but it was usually found to be increase in response to stress. (Ulya T *et al.,* 2021) Whereas, serotonin level in brain, was found to be decreased during stress and which is primarily involved in the mood and behavior regulation. In addition to this, stress activates specific brain regions, including the amygdala and the prefrontal cortex. Moreover amygdala also plays an important role to regulate the anxiety and phobias in the animals and human. (Nefs G *et al.,* 2019)According to the previous studies, the prevalence of anxiety disorders was found to be a total of 34.2% of women reported having anxiety symptoms after giving birth. The prevalence was, in detail, 34.5% between one and twenty- four weeks after delivery and 30.8% after that point. (Campos AC, *et al.,* 2013) Based upon the prevalence rate as well as published data in concerned to maternal separation associated anxiety. Our protocol was frame object there was requirement of induction of anxiety using maternal separation model in the animal. As concerned with this framed approach we have reviewed the article and there were many studies which were conducted on laboratory animals subjected to separation stressors which significantly exhibit behavioral changes in relation to anxiety disorders. Moreover in earlier literatures authors were employed various stimuli to induce anxiety-like behavior in laboratory animals as like that of clinical anxiety and these are psychological and physical stress, neonatal isolation stress, stress induced by circadian rhythm, stress induced by noisy stimulus, low-temperature induced stress, restraint and immobilization stress, social defeat stress, chronic unpredictable stress,

electric foot-shock induced stress.(Sarkar D.*et al*.,2020) On other hand we have the second approach in our study that the selection of test drug for the treatment maternal separation induced anxiety. The No. of treatment are available in the market they did not give the satisfied result with maximum side effect. Author reported that synthetic drug have a lots of side effect by considering this current approach we had selected the MMV. A Polyherbal formulation containing Protein, tannins, phenols, flavonoids, saponins, amino acids, glycosides, and steroids are phytoconstituents found in MMV. The author reported that MMV changed a number of antioxidant parameters, showed potent anti-free radical activity, and might have an effect on the production and release of the neurotransmitter enzyme acetyl-cholinesterase. MMV a Polyherbal formulation containing about the 20 plant is a powerful memory enhancer and has therapeutic effects on the central nervous system. A previous literature indicates that MMV possesses antioxidant potential has wide application to neurological disorder. (Kusnecov AW *et al*., 1994)
Based on this current evidence, we designed an experimental design to investigate the effect of MMV on anxiety and depression like behavior in experimental animals. The study uses animal models to assess the effects of the formulation of MMVs on maternal separation stress-induced anxiety and depression like conditions. The aim of the study is to plan several steps, including the selection and purchase of animals and drugs, as well as the assessment of behavioral parameters with various tests such as light and dark box, OFT, SPT, FST, and EPM. Here we observed and evaluated behavioral changes such as time spent in the light chamber, no entry into the light chamber, total distance travelled, intake of sugar, immobility time, and time spent in the open arm, no entry into the open arm. In our study, we observed that the treatment group significantly increased the time spent and number of steps into the light chamber using the light and dark box. In addition, the OFT model is used, showing that the treatment group has increased the total distance traveled. In the SPT treatment group, the intake of sucrose in the animal increased. In FST, the treatment group decreased the time of immobilization compared to the disease control group. EPM also shows that the treatment group significantly increases the time spent and the absence of entry into the open arm. Although the behavioral study did not satisfy the mechanism and also fulfilled the objective of the protocol during the maternal separation animal goes through the oxidative stress so we use the oxidative parameter. We explored the effect of the MMV on antioxidant markers. To verify this, we examined the effects of MMV glutathione levels (GSH), lipid peroxidation (LPO), and catalase (CAT), superoxidation (SOD) demutase. The results obtained showed that chronic treatment with MMV significantly reduced LPO and increased the level of GSH, Catalase, and SOD.

CONCLUSION

The present study concluded that the anxiolytic and anti-depressant effect of MMV. MMV ameliorated behavioral deficits in maternal separation induced anxiety and depression like behavior. The Result of present study and main objective of this study was to critically evaluate the effect of test drug i.e. in the treatment anxiety and depression like behavior induced by maternal separation stress model in experimental animals. After induction of anxiety and depression by using maternal separation stress method in rat's different parameters in animals by using model such as EPM, LDB, brain oxidative markers, antioxidants along with histopathological observation. From the results obtained in behavioral study, oxidative parameters and histopathological analysis, it was concluded that MMV (100 mg/kg p.o.) possesses more significant activity in the experimental models of maternal separation induced anxiety and depression. More study need to be done to find out the mechanism along with factor and neurotransmitter evolve for the anxiolytic effect of MMV in experimental animals.

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Table.1: Experimental design of behavioral models of anxiety and depression

Sr. no.	groups	No of animal	Treatment
1	Normal	6	Received normal saline injection
2	Disease control	6	Maternal separation stress for 3 hours /day for 14 consecutive days
3	standard	6	Diazepam 1 mg/kg
4	Test -1	6	MMV 50 mg/kg
5	Test-2	6	MMV100 mg/kg

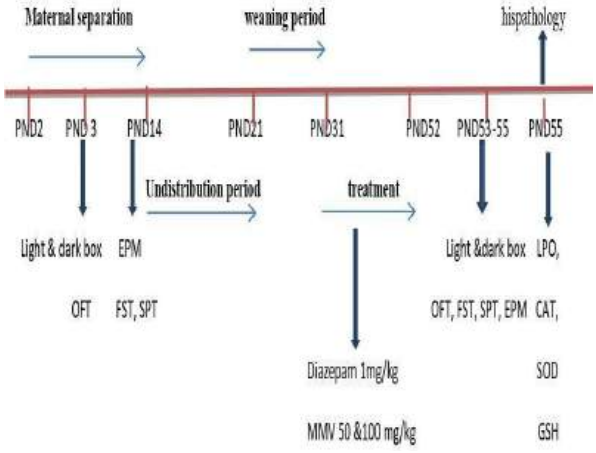


Fig.1: Schematic representation of the experimental procedure.

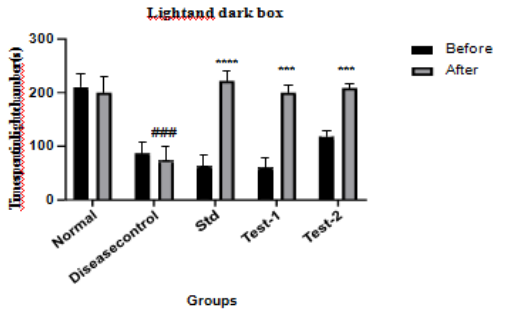


Figure 2. (A) The effects of different doses (50 &100 mg/kg) of MMV on time spent inlight chamber in light and dark box. Data are represented as means± SEM (n=6). Two-way ANOVA followed by Turkey's multiple comparison, ###P=0.0005, ****P<0.0001, *** P= 0.0005, ***P=0.0002 vs disease control.

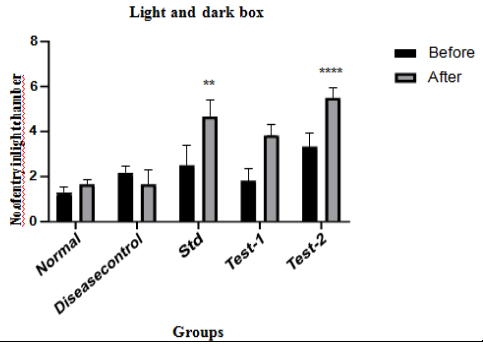


Figure 2. (B) The effects of different doses (50 &100 mg/kg) of MMV on no of entry in light chamber in light and dark box. Data are represented as means± SEM (n=6). Two-way ANOVA followed by Turkey's multiple comparison, P>0.9999, **P 0.0025, P= 0.0505, ****P <0.0001 vs disease control group.

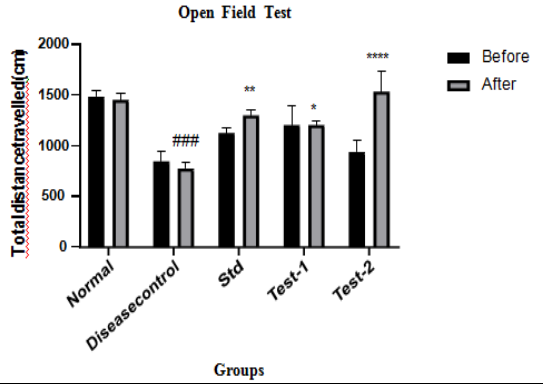


Figure 3. The effects of different doses (50, &100 mg/kg) of MMV on total distance travelled in open field test.Data are represented as means± SEM (n=6). Two-way ANOVA followed by Turkey's multiple comparison, ###P=0.0004, ****P=0.0093, ***P= 0.0477, ****P<0.0001 vs disease control group.

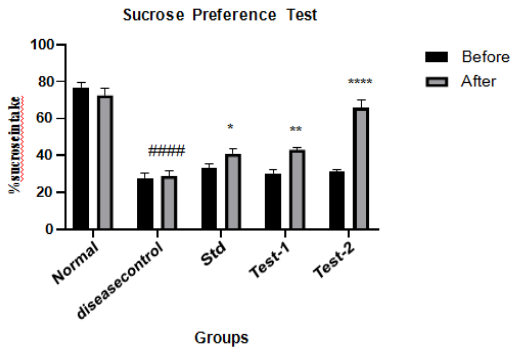


Figure 4 the effects of different doses (50 &100 mg/kg) of MMV on sucrose intake in sucrose preference test. Data are represented as means± SEM (n=6). Two-way ANOVA followed by Turkey's multiple comparison, ####P<0.0001,*P= 0.0115, **P= 0.0023, ** <0.0001**

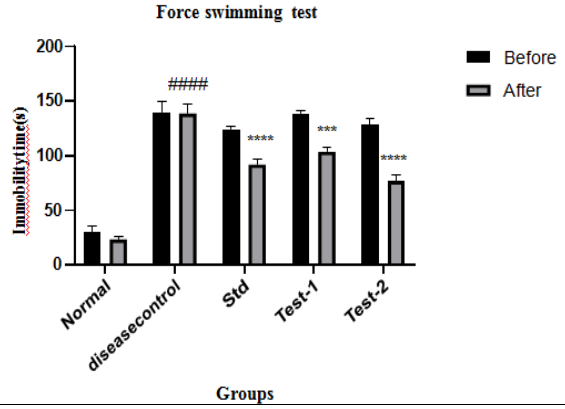


Figure 5 the effects of different doses (50, &100 mg/kg) of MMV on immobility time in sucrose preference test.Data are represented as means± SEM (n=6). Two-way ANOVA followed by Turkey's multiple comparison, ####P<0.0001, ****P<0.0001, ***P=0.0007, ****P<0.0001vs disease control group.

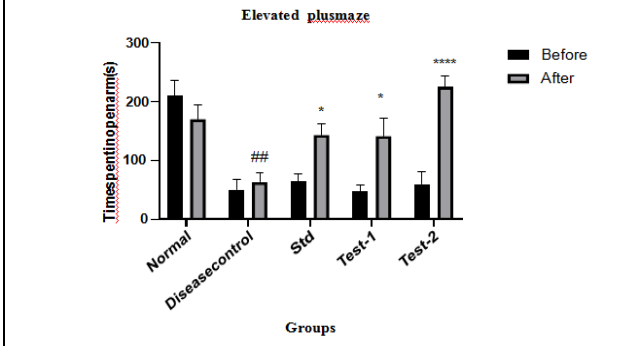


Figure 6 (A). The effects of different doses (50 &100 mg/kg) of MMV on time spent open arm in Elevated plus maze. Data are represented as means± SEM (n=6). Two-way ANOVA followed by Turkey's multiple comparison, ##P=0.0005,*P=0.0284,*P= 0.0327, ****P < 0.0001

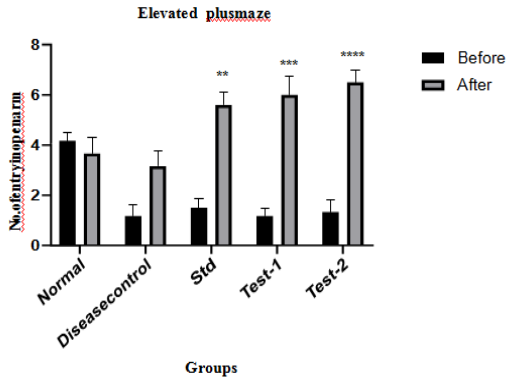


Figure 6 (B).The effects of different doses (50 &100 mg/kg) of MMV on no. of entry in open arm in Elevated plus maze. Data are represented as means± SEM (n=6). Two-way ANOVA followed by Turkey's multiple comparison, P=0.8920, **P=0.0073, ***P= 0.0009, ****P<0.0001 vs disease control group.

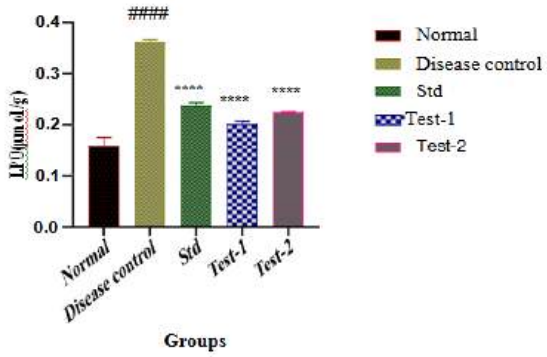


Figure 7 the effects of different doses (50 &100 mg/kg) of MMV on level of LPO. Data are represented as means± SEM (n=6). One-way ANOVA followed by Dunnett's multiple comparisons test, ####P< 0.0001, ****P< 0.0001, ****P < 0.0001, ****P < 0.0001vs disease control group

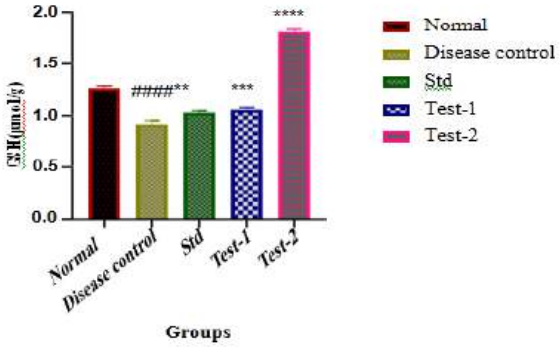


Figure 8 the effects of different doses (50 &100 mg/kg) of MMV on level of GSH. Data are represented as means± SEM (n=6). One-way ANOVA followed by Dunnett's multiple comparisons test #### P<0.0001, **P =0.0067, ***P=0.0008, ****P < 0.0001 vs disease control group

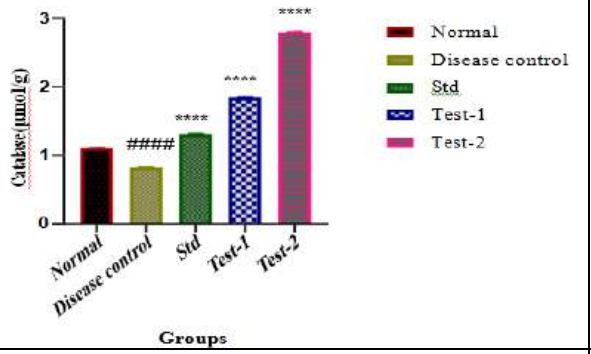


Figure 9 the effects of different doses (50 &100 mg/kg) of MMV on level of catalase. Data are represented as means± SEM (n=6). One-way ANOVA followed by Dunnett's multiple comparisons test ####0.0001, ****P< 0.0001, ****P < 0.0001, ****P < 0.0001 vs disease control group.

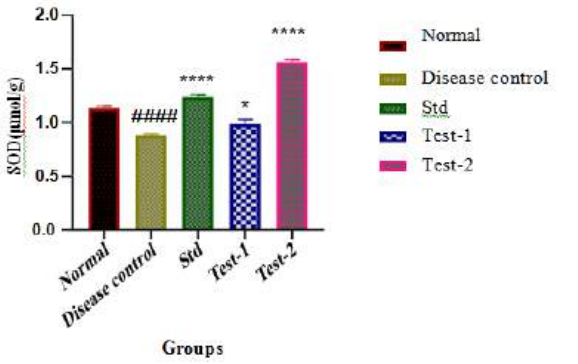


Figure 10 the effects of different doses (50 &100 mg/kg) of MMV on level of catalase. Data are represented as means± SEM (n=6). One-way ANOVA followed by Dunnett's multiple comparisons test ####P< 0.0001, ****P< 0.0001,* P=0.0194, ****P < 0.0001 vs disease control group.

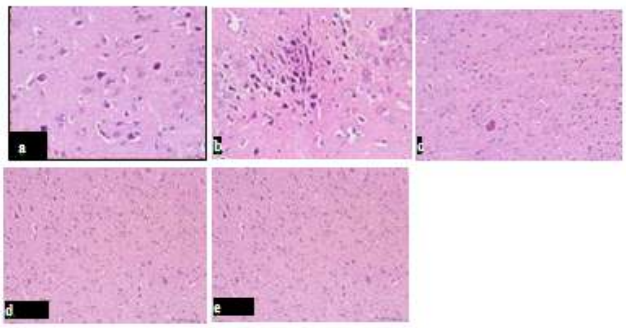


Figure 11 Histopathological Examination

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RESEARCH ARTICLE

A Supply Chain Model with Service Level Constraints Considering Items Using Type-2 Fuzzy Inventory System

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ABSTRACT

Due to unavoidable reasons, the demand for essential goods in the business sector is always changing. It has become quite difficult to choose the right method for profitable business. Business strategies are based on constant and fuzzy demands. Two types of constrains are considered to avoid the backorder cost. Combining the service level constrains with constant and type 2-fuzzy demand, the study compares the total cost and establishes the best stratergy. The model improves the quality of products and reduces the vendor`s setup cost. This model followed by the transportation discount policy for the hassle free delivery rate, depending on the number of transported products. The defuzzification method of type-2 fuzzy variable was developed by this study. Numerical examples and sensitivity analysis are also presented here.

Keywords: Supply chain management, Controllable lead time, type-2 Fuzzy set, interval approximation, Transportation discounts, Service level constraints.

INTRODUCTION

The number of defects may not be high, but any production process can yield perfect and faulty products. The supply-chain business process can be distributed by bad production. A combination of three different strategies-constant demand, fuzzy demand, and service level constraints makes a revolution for a supply chain management model. For a distribution free model, further investment for improved quality and a deduction in setup cost can improve the business process with a minimum total cost. The fuzzy method is used to compare the results of the different issues. The quality improvement policy involves asymmetric approaches for reducing and eliminating waste. The cost to setup the equipment for processing different goods among the supply chain members is incurred by the seller and buyer. The study shows a strategy, the quality of the products needs to be improved. The buyer distinguishes the delivery product from the rest by screening them. The vendor pays a holding and transportation cost for the returns of the faulty products. This model shows an increase in the number of transported products and a decrease in the transportation cost. The customers cannot afford to wait. They choose the other way around. The buyer invests in decreasing the time between the order delivery and delivery supplied to reduce the lead time crashing cost. The fuzzy concept considers the uncertain matter. The fuzzy concept can play a vital role in the smooth running of the business. Fuzzy demand over came many obstacles through research through research from profitable business directions [1]. Supply chain management is pushed by imperfect production. Controllable lead time and service level constraints can be overcome [2]. The unavoidable situation can be overcome by transportation cost and inspection policy [3]. Inspection errors and the return of faulty items are common for profitable cases from the buyer side [4]. Quality improvement and setup cost reduction are challenges for the vendor side [5-7]. A supply chain model developed here with service level constraints and different strategies to determine the best method of a smooth running business process. Decision making fuzzy relation equations, and pre-processing of data are some of the application of type-2 fuzzy sets [8]. No inventory model has been proposed in type-2 fuzzy environment, as an evidence of a literature review and to the best of my knowledge. The main goal of this research is to come up with a fuzzy inventory model. The present paper considers demand rate and ordering cost of time as interval type-2 fuzzy sets (IT2FSS) [9]. A new method of defuzzification of IT2FS is proposed and applied to the model. The mathematical model is analysed to find closed form formulae of order quantity and minimum delivery rate. The model is deduced from a comparative study with other model. The rest of the paper is in order. The proposed defuzzification method presented in section 2. The entire paper uses notations and assumptions in section 3. Section 4 describes mathematical modelling and section 5 gives the methodology to determine the solution. Section 6 has a numerical example and section 7 has a sensitivity analysis by changing the fuzzy parameters. After the discussion is concluded in section [8].

METHODOLOGY

This section provides a brief introduction to type-2 fuzzy set, and then proposes a new method of de-fuzzification.

Preliminaries

IT2FS : Let X R (real numbers) be a finite non-empty set, called universal set, and let Int ([0,1]) be the collection of all closed subintervals of [0, 1]. An IT2FS $\tilde{A}$ in X is defined as

$\tilde{A} = \{(x, \mu_{\tilde{A}}(x) : x \in X, where \mu_{\tilde{A}} : X \to Int([0,1)]$ is defined as

$\mu_{\tilde{A}}(x) = [\mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+}], 0 \le \mu_{\tilde{A}}^{-} \le \mu_{\tilde{A}}^{+} \le 1,$ i.e., grade of membership of $x \in \tilde{A}$ is an interval $[\mu_{\tilde{A}}^{-}, \mu_{\tilde{A}}^{+}]$.

Interval type-2 trapezoidal fuzzy set (IT2TrFS)

An interval type-2 trapezoidal fuzzy set (IT2TrFS) is a IT2FS

$\tilde{A} = [\tilde{A}^L, \tilde{A}^U] = [(\tilde{a}_1^L, \tilde{a}_2^L, \tilde{a}_3^L, \tilde{a}_4^L; h_A^L), (\tilde{a}_1^U, \tilde{a}_2^U, \tilde{a}_3^U, \tilde{a}_4^U; h_A^U)]$,where $\tilde{A}^L and \tilde{A}^U$ are generalized trapezoidal fuzzy members and $\tilde{A}^L \subseteq \tilde{A}^U$. $\tilde{A}^L and \tilde{A}^U$ are defined by lower membership function(LMF) $\mu_{\tilde{A}}^{\ L}$ and upper membership function(UMF) $\mu_{\tilde{A}}^{\ U}$ as follows:

$$\mu_{\tilde{A}}^{\ L} = \begin{cases} h_A^L\left(\dfrac{x - a_1^L}{a_2^L - a_1^L}\right), a_1^L \le x \le a_2^L; \\ h_A^L, a_2^L \le x \le a_3^L; \\ h_A^L\left(\dfrac{a_4^L - x}{a_4^L - a_3^L}\right), a_3^L \le x \le a_4^L; \\ 0, otherwise; \end{cases}$$

$$\mu_{\tilde{A}}^{\ U} = \begin{cases} h_A^U\left(\dfrac{x - a_1^U}{a_2^U - a_1^U}\right), a_1^U \le x \le a_2^U; \\ h_A^U, a_2^U \le x \le a_3^U; \\ h_A^U\left(\dfrac{a_4^U - x}{a_4^U - a_3^U}\right), a_3^U \le x \le a_4^U; \\ 0, otherwise; \end{cases}$$

Interval approximation of IT2TrFS

Definition

The Interval approximation of IT2TrFS $\tilde{A}$ is defined as follows:

$$[A_\alpha^-, A_\alpha^+] = \left[\frac{1}{4}[(a_1^L + a_2^L)h_A^L + (a_1^U + a_2^U)h_A^U], \frac{1}{4}[(a_3^L + a_4^L)h_A^L + (a_3^U + a_4^U)h_A^U]\right].$$

Definition

Mean (defuzzified to a scalar) value of the interval opproximation of IT2TrFS $\tilde{A}$ is defined as

$$M(\tilde{A}) = \frac{A_\alpha^- + A_\alpha^+}{2}$$

$$= \frac{1}{8}\left[(a_1^L + a_2^L + a_3^L + a_4^L)h_A^L + (a_1^U + a_2^U + a_3^U + a_4^U)h_A^U\right].$$

Arithmetic operations on IT2TrFS

Let $\tilde{X} = [\tilde{X}^L, \tilde{X}^U] = [(\tilde{X}_1^L, \tilde{X}_2^L, \tilde{X}_3^L, \tilde{X}_4^L; h_X^L), (\tilde{X}_1^U, \tilde{X}_2^U, \tilde{X}_3^U, \tilde{X}_4^U; h_X^U)]$ and

$\tilde{Y} = [\tilde{Y}^L, \tilde{Y}^U] = [(\tilde{Y}_1^L, \tilde{Y}_2^L, \tilde{Y}_3^L, \tilde{Y}_4^L; h_Y^L), (\tilde{Y}_1^U, \tilde{Y}_2^U, \tilde{Y}_3^U, \tilde{Y}_4^U; h_Y^U)]$ be two non-negative IT2TrFSs; then arithmetic operations on these are defined as follows:

1.Addtion :

$$X \oplus Y = \left[(\tilde{X}_1^L + \tilde{Y}_1^L, \tilde{X}_2^L + \tilde{Y}_2^L, \tilde{X}_3^L + \tilde{Y}_3^L, \tilde{X}_4^L + \tilde{Y}_4^L; \min(h_X^L, h_Y^L)), (\tilde{X}_1^U + \tilde{Y}_1^U, \tilde{X}_2^U + \tilde{Y}_2^U, \tilde{X}_3^U + \tilde{Y}_3^U, \tilde{X}_4^U + \tilde{Y}_4^U; \min(h_X^U, h_Y^U)) \right].$$

2. Subtraction:

$$X \Theta Y = \left[(\tilde{X}_1^L - \tilde{Y}_4^L, \tilde{X}_2^L - \tilde{Y}_3^L, \tilde{X}_3^L - \tilde{Y}_2^L, \tilde{X}_4^L - \tilde{Y}_1^L; \min(h_X^L, h_Y^L)), (\tilde{X}_1^U - \tilde{Y}_4^U, \tilde{X}_2^U - \tilde{Y}_3^U, \tilde{X}_3^U - \tilde{Y}_2^U, \tilde{X}_4^U - \tilde{Y}_1^U; \min(h_X^U, h_Y^U)) \right].$$

3. Multiplication:

$$X \otimes Y = \left[(\tilde{X}_1^L \times \tilde{Y}_1^L, \tilde{X}_2^L \times \tilde{Y}_2^L, \tilde{X}_3^L \times \tilde{Y}_3^L, \tilde{X}_4^L \times \tilde{Y}_4^L; \min(h_X^L, h_Y^L)), (\tilde{X}_1^U \times \tilde{Y}_1^U, \tilde{X}_2^U \times \tilde{Y}_2^U, \tilde{X}_3^U \times \tilde{Y}_3^U, \tilde{X}_4^U \times \tilde{Y}_4^U; \min(h_X^U, h_Y^U)) \right].$$

4.Division:

$$X \oslash Y = \left[(\tilde{X}_1^L / \tilde{Y}_4^L, \tilde{X}_2^L / \tilde{Y}_3^L, \tilde{X}_3^L / \tilde{Y}_2^L, \tilde{X}_4^L / \tilde{Y}_1^L; \min(h_X^L, h_Y^L)), (\tilde{X}_1^U / \tilde{Y}_4^U, \tilde{X}_2^U / \tilde{Y}_3^U, \tilde{X}_3^U / \tilde{Y}_2^U, \tilde{X}_4^U / \tilde{Y}_1^U; \min(h_X^U, h_Y^U)) \right].$$

Where $\tilde{Y}_1^L, \tilde{Y}_2^L, \tilde{Y}_3^L, \tilde{Y}_4^L, \tilde{Y}_1^U, \tilde{Y}_2^U, \tilde{Y}_3^U \; and \tilde{Y}_4^U$ are positive real numbers.

5. Multiplication by a real number a:

$$a\tilde{X} = \begin{cases} [(a\tilde{X}_1^L, a\tilde{X}_2^L, a\tilde{X}_3^L, a\tilde{X}_4^L; h_X^L), (a\tilde{X}_1^U, a\tilde{X}_2^U, a\tilde{X}_3^U, a\tilde{X}_4^U; h_X^U)], if a \geq 0; \\ [(a\tilde{Y}_1^L, a\tilde{Y}_2^L, a\tilde{Y}_3^L, a\tilde{Y}_4^L; h_Y^L), (a\tilde{Y}_1^U, a\tilde{Y}_2^U, a\tilde{Y}_3^U, a\tilde{Y}_4^U; h_Y^U)], if a \leq 0. \end{cases}$$

6.Division by a real number a:

$$\tilde{X} / a = \begin{cases} [(\tilde{X}_1^L / a, \tilde{X}_2^L / a, \tilde{X}_3^L / a, \tilde{X}_4^L / a; h_X^L), (\tilde{X}_1^U / a, \tilde{X}_2^U / a, \tilde{X}_3^U / a, \tilde{X}_4^U / a; h_X^U)], if a > 0; \\ [(\tilde{Y}_1^L / a, \tilde{Y}_2^L / a, \tilde{Y}_3^L / a, \tilde{Y}_4^L / a; h_Y^L), (\tilde{Y}_1^U / a, \tilde{Y}_2^U / a, \tilde{Y}_3^U / a, \tilde{Y}_4^U / a; h_Y^U)], if a < 0. \end{cases}$$

NOTATIONS AND ASSUMPTIONS

The purpose of the problem along with symbols and hypothesis are described. At the first problem, purpose describes elaborately, then symbols of the mathematical model, and at the last part, assumping briefly describe.

Notations

The model structure is dependent on variables and parameters.

Input parameters

q order quantity

g probability of imperfect production

h setup cost for vendor

L length of the lead time

n number of shipments

t transportation cost

σ standard deviation of the demand

x retaining cost of good quality incurred by the vendor

y retaining cost of defective product incurred by the buyer

z retaining cost incurred by the vendor

r screening rate

f fraction of annual capital investment

b scaling parameter of the investment for improvement function

B scaling parameter of the investment for the setup cost reduction function

$g_\circ$ primary probability of defective production

$h_\circ$ initial cost of setup incurred by the vendor

d demand

a ordering cost

c compensation cost of the lead time

Φ fraction of defective products

k replacing cost of defective products
v screening cost
β the reciprocal of p
w fraction of customers demand
u_i minimum duration for lead time component
v_i normal duration for lead time component
m_i crasing cost
L_i length of the lead time with i^{th} components
p production rate
JTC(q) joint total cost

Assumptions

The model is formulated using assumption,

1. A supply chain management model is proposed with supply chain members vendor and buyer. The product demand and ordering cost is considered a type-2 fuzzy number. The vendor`s defective production is considered.
2. The p production and screening rate r was incurred by the vendor and buyer. The market demand for supply chain members must be greater than the production and screening rate r. The buyer inspects the produced lot with screening rate r, which shows the defects that are generally produced. It is assumed that the screening of the products is free of error.
3. This model takes service level constraints into account improved quality and stock out situation. The investment function of the improved quality products and setup cost reductiontechnique are used in logarithmic expressions.
4. A distribution-free approach is considered. The transportation discount policy is based on the quantity of the product. The crashing cost for lead time per cycle is considered.

$$c(L) = m_i(L_{i-a} - L) + \sum_{j=1}^{i-1} m_j(v_j - u_j), where L \in (L_i - L_{i-1})$$

5. The least market demand is equal to the number of perfect products $q(1+g)(1-g) \geq dq(1+g)/r$ which implies that $g \leq 1 - d/r$. The holding cost incurred by the buyer is considered for the perfect and defective products.

MODEL FORMULATION

The proposed model has supply chain management two members with capital investment for improved quality products and setup cost reduction under the service level constraints. The vendor has a production ratio of p. When the system is out of control, defective products are produced. A holding cost is incurred for the replacement of the faulty product. The buyer shows a stochastic demand even though the model shows the changes in the type-2 fuzzy demand.

Vendor´s model

The vendor`s production is based on stochastic and type-2 fuzzy demand. The capital investment for improving the quality of production high. The defective products can be replaced quickly. The time taken for the delivery and the time taken for the order are considered here to reduce the lead time, service level constraints. The vendor`s costs are considered as follows.

Vendor′s setup cost (VSC)

The vendor can use this cost to setup equipment to make different goods. It is the most expensive for a production inventory model and supply chain management. The production improves faster, when the setup is developed. The total setup investment cost is, VSC= $\frac{dh}{nq}$

Vendor′s quality improvement cost (VQIC)

Defective production is an essential factor for a production system, which gives uncertainty to a supply chain, when the top products are perfect, a production is reliable. The vendor invests capital in order to improve the quality of their products.ie) To make the system in-control. The cost is given as, VQIC= $fb\log\frac{g_o}{g}$

Vendor′s setup reduction cost (VSRC)

The production setup is the most important factor that affects the total cost of a supply chain. The model is developed by introducing a small cost that addresses the quality and quantity of the products, and the setup investment cost is reduced. A logarithmic function is used to express the cost. The cost is given as,

VSRC= $fB\log\frac{h_o}{h}$

Vendor′s holding cost (VHC)

The supply chain is strong because of the holding cost. This type of investment is used to store unsold products. The total supply chain costs are parallel to the ordering costs and shortage costs. The cost for holding the products, remodifying with an advertisement, and long-time replenishment are included in VHC. Vendors consider the holding cost to be the cost of holding the products until they are delivered to the buyer. The total cost of holding the product is, VHC = $\frac{zq}{2}[n(1-d\beta)-1+2d\beta]$

Vendor′s defective cost (VDC)

In a production supply chain model defective production is a common factor. The quality quantity of the product are reduced. The total cost is increased by defective products. When the machine is out of control, the invests in new products. The total cost for replacement is given as, VDC = kdg

Vendor total cost (VTC)

The total cost is incurred by a vendor

VCT = VSC+VQIC+VSRC+VHC+VDC

$$= \frac{dh}{nq} + fb\log\frac{g_o}{g} + fB\log\frac{h_o}{h} + \frac{zq}{2}[n(1-d\beta)-1+2d\beta] + kdg$$

BUYER′S MODEL

The buyer invests in the ordering cost and market transfer to receive the products from the vendor. The buyer invests in the holding cost for two different products. The buyer invests in the transportation and screening of the received products even after the defective products returned to the vendor for replacement.

The buyer costs are considered as follows:

Buyer´s ordering cost (BOC)

The moments are connected through the ordering cost. The buyer invests in the ordering cost to purchase the product from the vendor. There are different ways to place or order. To purchase the products from the vendor, the buyer invests in the ordering cost. The total ordering cost that the buyer invests is given as ,BOC= $\frac{da}{nq}$

Buyer´s lead time crashing cost (BLC)

The lead time is the gap between receiving an order and delivering it. The lead time is a vital factor in the customer demand and many researches considered it to be a negligible amount. The model considered the cost to reduce the time between ordering and delivery. The cost of lead time is given by, BLC = $\frac{dc}{q}$

Buyer´s perfect product holding cost (BPHC)

The vendor gives the products to the buyer and distinguishes them as perfect and defective products. They can sell the products immediately or stock them for a specific time. The products may become defective. The buyer invests in two types of costs to hold the products. The buyer invests in the quality of the product is given by, BPHC = $a\left[gq+\frac{g(1+g)dq}{2r}\right]$

Buyer´s imperfect product holding cost (BIPHC)

The buyer losses are high due to the defect in the products. Most buyers return their products to the vendors, and the vendors accept them for the smooth running of the business. The buyer invests in different costs and returns the products to the vendor for a new one. Different stock holding cost can identify the perfect products, maintain the lead time, and fulfil the customer demand. The BIPHC is given by, BIPHC = $b\left[\frac{q}{2}+\frac{\sigma^2 L}{4(1-w)q}+\frac{g(1+g)dq}{2r}\right]$

Buyer´s screening cost (BSC)

The buyer separates the good and bad products through the screening cost. The market demand for the perfect product must be met. The capital is invested by the buyer for screening products. The buyer can investigate the quality of the products by investing a specific cost. The buyer can transfer the product to different places. The BSC is given as follows,

BSC = $vd(1+g)$

Buyer´s transportation cost (BTPC)

The buyer invests in transportation costs to get the product from the vendor to them. The vendor can return the product that are defective. The vendor and buyer supply-chain system depends on transportation to maintain customer demand. The buyer can use the BTPC to transport the products to the customer. Hence the BTPC is given as follows:

BTPC = dt

There are techniques that can be used to reduce the total cost of transportation. The transportation cost is related to demand when it is not constant.

Buyer total cost (BTC)

BTC = BOC+BLC+BPHC+BIPHC+BSC+BTPC

$$=\frac{da}{nq}+\frac{dc}{q}+x\left[gq-\frac{g(1+g)dq}{2r}\right]+y\left[\frac{q}{2}+\frac{\sigma^2 L}{4(1-w)q}+\frac{g(1+g)dq}{2r}\right]+vd(1+g)+dt$$

TOTAL COST OF THE SUPPLY CHAIN MANAGEMENT

The supply chain management has joint cost without a constraint and constant annual demand is given by,

JTC(q)= VTC +BTC

$$= \frac{dh}{nq} + fb\log\frac{g_o}{g} + fB\log\frac{h_o}{h} + \frac{zq}{2}[n(1-d\beta)-1+2d\beta] + kdg +$$

$$\frac{da}{nq} + \frac{dc}{q} + x\left[gq - \frac{g(1+g)dq}{2r}\right] + y\left[\frac{q}{2} + \frac{\sigma^2 L}{4(1-w)q} + \frac{g(1+g)dq}{2r}\right] + vd(1+g) + dt$$

The above eqn can be written as,

$$JTC(q) = \frac{dh}{nq} + \frac{zq}{2}[n(1-d\beta)-1+2d\beta] + \frac{da}{nq} + \frac{dc}{q} + x\left[gq - \frac{g(1+g)dq}{2r}\right] + y\left[\frac{q}{2} + \frac{\sigma^2 L}{4(1-w)q} + \frac{g(1+g)dq}{2r}\right] + L$$

Where, $L = fb\log\frac{g_o}{g} + fB\log\frac{h_o}{h} + kdg + vd(1+g) + dt$

SOLUTION METHODOLOGY

Crisp model

The classical method is used to solve the mathematical model.

At first, the joint total cost is partially differentiated and equated to zero.

i.e., $\frac{\partial JTC(q)}{\partial q} = 0$.

$$\frac{-1}{q^2}\left[\frac{dh}{n} + \frac{da}{n} + dc + \frac{y\sigma^2 L}{4(1-w)}\right] + \left[\frac{z}{2}\left[n(1-d\beta)-1+2d\beta\right] + xg - \frac{g(1+g)d}{2r} + \frac{y}{2} + \frac{yg(1+g)d}{2r}\right] = 0$$

Thus , the decision variable obtain the optimum results as follows,

$$q = \sqrt{\frac{d\left[\frac{h}{n} + \frac{a}{n} + c\right] + \frac{y\sigma^2 L}{4(1-w)}}{x\left[g - \frac{g(1+g)d}{2r}\right] + y\left[\frac{1}{2} + \frac{g(1+g)d}{2r}\right] + \frac{z}{2}\left[n(1-d\beta)-1+2d\beta\right]}}$$

and the second order partial derivatives are

$$\frac{\partial^2 JTC(q)}{\partial q^2} = \frac{2}{q^3}\left[\frac{dh}{n} + \frac{da}{n} + dc + \frac{y\sigma^2 L}{4(1-w)}\right] > 0.$$

Therefore, $\frac{\partial^2 JTC(q)}{\partial q^2}$ convex in q.

Fuzzy model

We now demand and ordering cost are IT2TrFSs, whose grade of membership are defined as follows:

$\tilde{d} = [\tilde{d}^L, \tilde{d}^U] = [(\tilde{d}_1^L, \tilde{d}_2^L, \tilde{d}_3^L, \tilde{d}_4^L; h_d^L), (\tilde{d}_1^U, \tilde{d}_2^U, \tilde{d}_3^U, \tilde{d}_4^U; h_d^U)]$ and $\tilde{a} = [\tilde{a}^L, \tilde{a}^U] = [(\tilde{a}_1^L, \tilde{a}_2^L, \tilde{a}_3^L, \tilde{a}_4^L; h_a^L), (\tilde{a}_1^U, \tilde{a}_2^U, \tilde{a}_3^U, \tilde{a}_4^U; h_a^U)]$ where $d_i^L \le d_{i+1}^L, d_i^U \le d_{i+1}^U, a_i^L \le a_{i+1}^L, a_i^U \le a_{i+1}^U, i = 1,2,3.$

$a_1^U \le a_1^L, a_4^L \le a_4^U, d_1^U \le d_1^L, d_4^L \le d_4^U, 0 \le a_1^L, a_4^U \le 1 and 0 < h_a^L \le h_a^U \le 1, 0 < h_d^L \le h_d^U \le 1$. Arithmetic operations defined in sec 2.1.4are used hereto calculate the fuzzy joint total cost as follows:

$$JT\tilde{C}(q)=\frac{dh}{nq}\Theta\frac{nd\beta zq}{2}\oplus\frac{2d\beta zq}{2}\oplus kdg\oplus\frac{da}{nq}\oplus\frac{dc}{q}\Theta\frac{xg(1+g)dq}{2r}\oplus\frac{yg(1+g)dq}{2r}\oplus vd(1+g)\oplus dt+R$$

Where, $R=fb\log\frac{g_o}{g}+fB\,\mathrm{og}\frac{h_o}{h}+\frac{zq}{2}(n-1)+xgq+\frac{yq}{2}+\frac{y\sigma^2L}{4(1-w)q}$

Depending upon the values of $h_a^L,h_a^U,h_d^L and h_d^U$, four cases arise: (1) $h_a^L\le h_d^L\le h_a^U\le h_d^U$,(2) $h_a^L\le h_d^L\le h_d^U\le h_a^U$,(3) $h_d^L\le h_a^L\le h_d^U\le h_a^U$, (4) $h_d^L\le h_a^L\le h_a^U\le h_d^U$. Hence the IT2TrFS profit function $JT\tilde{C}$ can be expressed as,

$$JT\tilde{C}=\begin{cases}[(JTC_1^L,JTC_2^L,JTC_3^L,JTC_4^L;h_a^L),(JTC_1^U,JTC_2^U,\\ JTC_3^U,JTC_4^U;h_a^U)],h_a^L\le h_d^L\le h_a^U\le h_d^U;\\ [(JTC_1^L,JTC_2^L,JTC_3^L,JTC_4^L;h_a^L),(JTC_1^U,JTC_2^U,\\ JTC_3^U,JTC_4^U;h_d^U)],h_a^L\le h_d^L\le h_d^U\le h_a^U;\\ [(JTC_1^L,JTC_2^L,JTC_3^L,JTC_4^L;h_d^L),(JTC_1^U,JTC_2^U,\\ JTC_3^U,JTC_4^U;h_d^U)],h_d^L\le h_a^L\le h_d^U\le h_a^U;\\ [(JTC_1^L,JTC_2^L,JTC_3^L,JTC_4^L;h_d^L),(JTC_1^U,JTC_2^U,\\ JTC_3^U,JTC_4^U;h_a^U)],h_d^L\le h_a^L\le h_a^U\le h_d^U\end{cases}$$

The defuzzified value of IT2TrFS profit function $JT\tilde{C}$ given as follows:

$$M(JT\tilde{C})=\begin{cases}M(JT\tilde{C}_{h_a^L,h_a^U}),h_a^L\le h_d^L\le h_a^U\le h_d^U;\\ M(JT\tilde{C}_{h_a^L,h_d^U}),h_a^L\le h_d^L\le h_d^U\le h_a^U;\\ M(JT\tilde{C}_{h_d^L,h_d^U}),h_d^L\le h_a^L\le h_d^U\le h_a^U;\\ M(JT\tilde{C}_{h_d^L,h_a^U}),h_d^L\le h_a^L\le h_a^U\le h_d^U\end{cases}$$

Where for $m=h_a^L,h_d^L;n=h_a^U,h_d^U$

$$JT\tilde{C}(q)=R+\frac{1}{8}\left\{\begin{array}{l}\left(\frac{h}{nq}+\frac{(2-n)\beta zq}{2}+kg+\frac{c}{q}+\frac{g(1+g)q}{2r}(y-x)+(1+g)+t\right)\left((d_1^L+d_2^L+d_3^L+d_4^L)m+(d_1^U+d_2^U+d_3^U+d_4^U)n\right)+\\ \frac{1}{nq}\left((d_1^La_1^L+d_2^La_2^L+d_3^La_3^L+d_4^La_4^L)m+(d_1^Ua_1^U+d_2^Ua_2^U+d_3^Ua^U+d_4^Ua_4^U)n\right)\end{array}\right\}$$

The profit of the above given equation can be written as follows:

$$JT\tilde{C}(q)=R+\left(\frac{h}{nq}+\frac{(2-n)\beta zq}{2}+kg+\frac{c}{q}+\frac{g(1+g)q}{2r}(y-x)+(1+g)+t\right)\left(d^Lm+d^Un\right)+\frac{1}{nq}\left(z^Lm+z^Un\right)$$

Where,

$$d^L = \frac{d_1^L + d_2^L + d_3^L + d_4^L}{8},$$

$$d^U = \frac{d_1^U + d_2^U + d_3^U + d_4^U}{8},$$

$$z^L = \frac{d_1^L a_1^L + d_2^L a_2^L + d_3^L a_3^L + d_4^L a_4^L}{8},$$

$$z^U = \frac{d_1^U a_1^U + d_2^U a_2^U + d_3^U a^U + d_4^U a_4^U}{8}.$$

At first, the joint total cost is partially differentiated and equated to zero. i.e.,

$$\frac{-1}{q^2}\left[\left(\frac{h}{n}+c\right)\left(d^L m + d^U n\right) + \frac{1}{n}\left(z^L m + z^U n\right) + \frac{y\sigma^2 L}{4(1-w)}\right] + \left[\left(\frac{(2-n)\beta z}{2} + \frac{g(1+g)(y-x)}{2r}\right)\left(d^L m + d^U n\right) + \frac{z(n-1)}{2} + xg + \frac{y}{2}\right] = 0$$

We get, $\tilde{q} = \sqrt{\dfrac{\left[\left(\frac{h}{n}+c\right)\left(d^L m + d^U n\right) + \frac{1}{n}\left(z^L m + z^U n\right) + \frac{y\sigma^2 L}{4(1-w)}\right]}{\left[\left(\frac{(2-n)\beta z}{2} + \frac{g(1+g)(y-x)}{2r}\right)\left(d^L m + d^U n\right) + \frac{z(n-1)}{2} + xg + \frac{y}{2}\right]}}$

NUMERICAL EXPERIMENT

The numerical example validates the proposed model.

Example

The mathematical model is numerically tested to validate the theoretical solution. All data used are based on the industry visit and certain data are verified by Sarkar and Mahapatra [1]; the following input parameter values are considered here to illustrate the numerical example. d = 500 (units/year); σ = 7 ($/batch); β = 1/300 ($/unit); a = 50 ($/setup); $h_\circ$ = 40 ($/setup); x = 6 ($/unit per year); y = 10 ($/unit per year); z = 4 ($/unit per year); v = 0.25 ($/unit); γ= 2152 (units/year); k = 20 ($/defective unit); b = 4000; B = 400; f = 0.1 ($/year); $g_\circ$ = 0.08; w = 0.98; c = 28 ($/ order); and t = 0.20 ($/unit);g=0.037;h=20.75;L=3;n=3.

Crisp model

The results of the order quantity and joint total cost for crisp model is given as follows, q =86.47 , JTC(q) = $1766.5

Fuzzy model

The sensitivity table clearly shows that the transportation cost parameter is directly related to order quantity and the joint total cost. Graphical representation of the table 2 is given by,

CONCLUSION

This model demonstrated the most effective method for minimizing the overall supply chain expenses while considering type-2 fuzzy demand and service level limitations. This study additionally examined interval type-2 fuzzy ordering costs and suggested a technique to convert it into a precise value. The primary objective of this model was to achieve the lowest total cost by concurrently optimizing the decision variables. A numerical example is also provided to reinforce the mathematical formulation and approach. Ultimately, the sensitivity analysis reveals that type-2 fuzzy variable parameters have a considerable impact on the decision-making policy.

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Table 1.Sensitivity of heights of IT2TrFS $\tilde{d}$ and $\tilde{a}$.

$(h_d^L, h_d^U, h_a^L, h_a^U)$	(m,n)	Fuzzy parameters	q
(0.8,0.8,1,1)	(0.8,0.8)	d^L (0.8)+ d^U (0.8) z^L (0.8)+ z^U (0.8)	87.39

(0.8,0.85,0.95,1)	(0.8,0.85)	d^L (0.8)+ d^U (0.85) z^L (0.8)+ z^U (0.85)	89.07
(0.85,0.85,0.95,1)	(0.85,0.85)	d^L (0.85)+ d^U (0.85) z^L (0.85)+ z^U (0.85)	90.55
(0.8,0.95,0.85,0.9)	(0.8,0.9)	d^L (0.8)+ d^U (0.9) z^L (0.8)+ z^U (0.9)	90.79
(0.95,0.95,0.9,0.95)	(0.9,0.95)	d^L (0.9)+ d^U (0.95) z^L (0.9)+ z^U (0.95)	95.63
(1,1,1,1)	(1,1)	d^L (1)+ d^U (1) z^L (1)+ z^U (1)	100.74

Table 2.Sensitivity of heights of IT2TrFS $\tilde{d}$ and Effects of fluctuation of parameter t.

t	(m,n)	q	JTC(q)
0.20	(0.8,0.8)	87.39	1779.61
	(0.8,0.85)	89.07	1800.18
	(0.85,0.85)	90.55	1817.36
	(0.8,0.9)	90.79	1820.36
	(0.9,0.95)	95.63	1873.37
	(1,1)	100.74	1923.56
0.15	(0.8,0.8)	87.39	1755.11
	(0.8,0.85)	89.07	1744.87
	(0.85,0.85)	90.55	1791.56
	(0.8,0.9)	90.79	1794.23
	(0.9,0.95)	95.63	1845
	(1,1)	100.74	1892.93
0.10	(0.8,0.8)	87.39	1730.61
	(0.8,0.85)	89.07	1749.56
	(0.85,0.85)	90.55	1765.52
	(0.8,0.9)	90.79	1768.12
	(0.9,0.95)	95.63	1816.62
	(1,1)	100.74	1862.31
0.05	(0.8,0.8)	87.39	1706.11
	(0.8,0.85)	89.07	1724.24
	(0.85,0.85)	90.55	1739.49
	(0.8,0.9)	90.79	1741.98
	(0.9,0.95)	95.63	1788.25
	(1,1)	100.74	1831.68

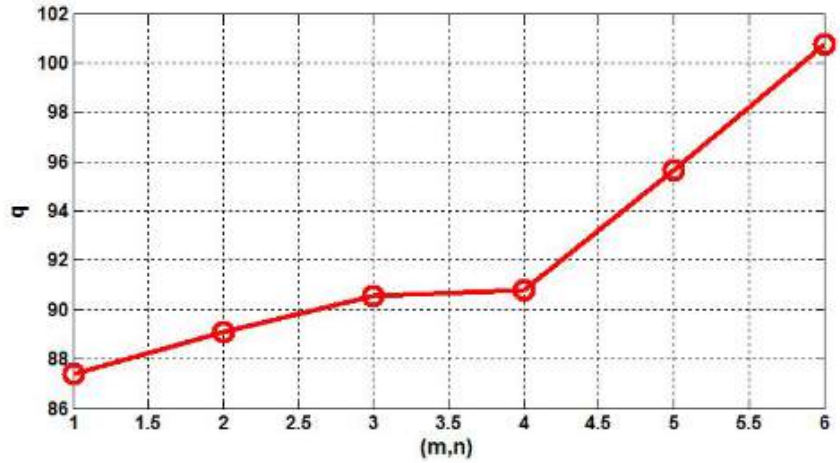

q
(m,n)
102
100
98
96
94
92
90
88
86
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6

Fig:1

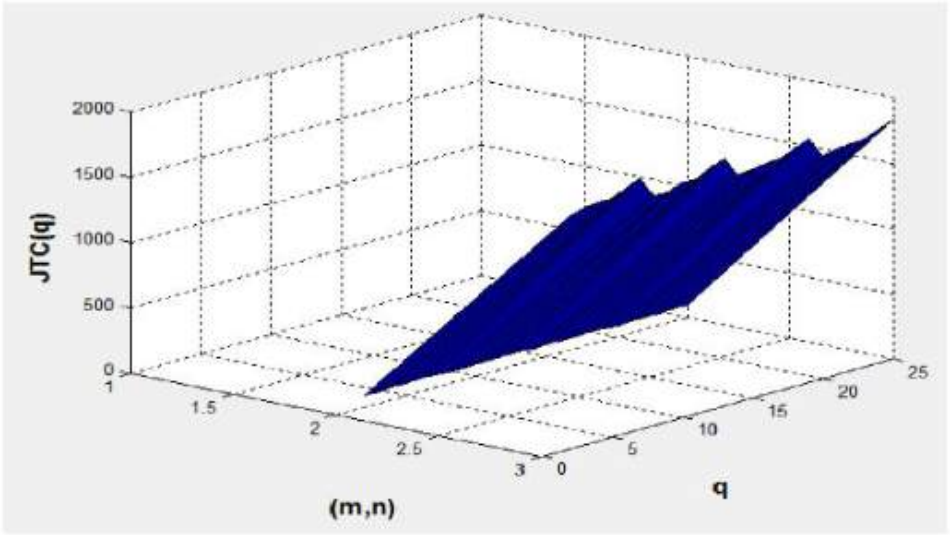

JTC(q)
(m,n)
q
2000
1500
1000
500
0
1
1.5
2
2.5
3
0
5
10
15
20
25

Fig:2

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RESEARCH ARTICLE

Stochastic Model for New Extended Distribution with Properties and Application to Survival Time of Cancer Patients

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ABSTRACT

Statistical analysis plays a part in medical research, particularly in cancer studies, where finding the best model for survival data is vital. Recent research shows that adding parameters to classical distributions rarely improves their fit to such data. This work presents and explores the Weighted Kpenadidum Distribution (WKD), a unique two-parameter distribution meant to overcome this constraint. The proposed distribution's statistical and mathematical features, including the derivation of entropy, are extensively studied. This distribution also has its probability density function for order statistics determined. Parameters are estimated using the maximum likelihood estimation (MLE) approach. Furthermore, the model's efficacy is proven by applying it to real-world data sets and comparing its fit to that of a widely known distribution. The results highlight the potential of WKD to provide improved modeling of survival data in medical research.

Keywords: Weighted distribution, Reliability Analysis, Entropy, Order Statistics, Maximum likelihood Estimation.

INTRODUCTION

Over the last few years, statisticians have become familiar with various innovative statistical distributions. Developing new distributions often aims to address mathematical issues, real-world applications, or both. Weather

modeling, insurance, risk management, finance, and survival data analysis all require the extension of classical distributions to a greater extent. Adding parameters to existing distributions increases their flexibility and usefulness for data analysis. Weighted distributions emerge naturally from stochastic processes and are documented using a weighting function. The length-biased distribution occurs when the weight is determined by the length of the unit of interest. Fisher (1934) proposed weighted distributions to represent ascertainment bias, and Rao (1965) generalized the concept to discrete distributions. Rao described scenarios in which observations follow stochastic models but do not correspond to their original distribution unless every observation has an equal chance of being recorded. If x is a random variable with a probability density function $f(x)$, and $w(x)$ is a weight function such that $0 \leq w(x) \leq 1$ the weighted probability density function $f_w(x)$is given by

$$f_w(x) = \frac{w(x)f(x)}{E(w(x))}; x > 0$$

Where $w(x)$ is a normalizing constant ensuring the total probability equals unity. A notable special case is when $w(x) = x$ or $w(x) = x^c(\alpha > 0)$, leading to length-biased or size-biased distributions. These distributions are particularly useful for examining tail properties and improving goodness-of-fit studies. Numerous researchers have proposed innovative techniques for creating enhanced probability distributions, emphasizing their application in various domains. The significant contributions to the development and application of weighted distributions by various authors are, Hashempour and Alizadeh (2023) introduced the weighted half-logistic distribution and explored its properties and estimation methods. Helal *et al.* (2022): studied the statistical properties of the weighted shanker distribution. Chesneau *et al.* (2022): proposed a modified weighted exponential distribution with applications. Eyob *et al.* (2019): developed the weighted Quasi-Akash distribution. Elangovan and Anthony (2019): investigated the weighted om distribution for survival times. Atikankul *et al*. (2020): examined the length-biased weighted Lindley distribution. Hassan *et al*. (2019): proposed a new generalization of the Pranav distribution using weighted techniques. Shanker and Shukla (2017): presented the quasi-shanker distribution. The weighted Kpenadidum distribution, current research introduces a novel generalization of the Kpenadidum distribution, referred to as the weighted Kpenadidum distribution (WKD. This distribution adapts existing methodologies to analyse survival times, particularly in breast cancer datasets. Statistical properties for the examination of density and survival functions, hazard rate functions, and moments were identified. The model's parameters are estimated using maximum likelihood approaches. The WKD is proved to be more effective at fitting data than conventional distributions. The statistical programming language r was employed to conduct all analyses, demonstrating the practical applicability of the WKD model in survival data analysis.

WEIGHTED KPENADIDUM DISTRIBUTION

In this Section, we define the probability density function (pdf) and cumulative distribution function (cdf) of the weighted Kpenadidum distribution

$$f(x;\theta) = \frac{\theta^4}{2(\theta^4 + \theta + 6)}(2x^3 + x^2 + 2\theta)e^{-\theta x}; x > 0, \theta > 0 \quad (1)$$

We have considered a random variable x with a probability density function f(x). Let w(x) be a non-negative weigh function, then the probability density function of the weighted random variable x_w is given by

$$f_w(x) = \frac{w(x)f(x)}{E\big(w(x)\big)}; x > 0 \quad (2)$$

Where w(x) is a non-negative weighted function and

$E\big(w(x)\big) = \int w(x)f(x) < \infty, 0 < E\big(w(x)\big) < \infty$

In this paper, we study the weighted Version of Kpenadidum distribution, taking w(x)= $x^c$to get the weighted Kpenadidum distribution , the probability density function (pdf) of the weighted version is given by

$$f_w(x) = \frac{x^c f(x)}{E(X^c)}$$

Where,$E(X^c) = \int_0^\infty x^c f(x)\, dx$

$E(X^c) = \frac{2(c+3)^{'}+\theta(c+2)!+2\theta^4 c!}{\theta^{c}.2(\theta^4+\theta+6)}$ (3)

Substituting the value of equation (1) and (3) in equation (2), we get the probability density function (pdf) of weighted Kpenadidum distribution,

$$f_w(x,c,\theta) = \frac{\theta^{c+4}}{2(c+3)!+\theta(c+2)!+2\theta^4 c!}x^c(2x^3+x^2+2\theta)e^{-\theta x}; x>0, \theta>0, c>0 \quad (4)$$

The cumulative distribution function (cdf) of the weighted Kpenadidum distribution is obtained as

$$F_w(x,c,0) = \int_0^x f_w(x,c,\theta)\,dx$$

$$= \int_0^\infty \frac{\theta^{C+4}}{2(c+3)!+\theta(c+2)!+2\theta^4 c!}x^c(2x^3+x^2+2\theta)e^{-\theta x}\,dx$$

On simplifying the integration by substation method and using incomplete gamma function, we get

$$F_w(x,c,\theta) = \frac{2\gamma(c+4,\theta x)+\theta\gamma(c+3,\theta x)+2\theta^3\gamma(c+1)}{2(c+3)!+\theta(c+2)!+2\theta^4 c!} \quad (5)$$

RELIABILITY ANALYSIS

Survival function

The survival function of weighted K penadidum distribution (WKD) is given as by $S(x) = 1 - F_w(x;c,\theta)$

$$S(x) = 1 - \frac{\left(2\gamma(c+4,\theta x)+\theta\gamma(c+3,\theta x)+2\theta^3\gamma(c+1)\right)}{(2(c+3)!+\theta(c+2)!+2\theta^4 c!)}$$

Hazard Rate Function

The hazard rate function is given by $h(x) = \frac{f_w(x;c,\theta)}{1-F_w(x;c,\theta)}$ is an important measure for characterizing life phenomenon

$$h(x) = \frac{\theta^{c+4}x^c(2x^3+x^2+2\theta)e^{-\theta x}}{(2(c+3)!+\theta(c+2)!+2\theta^4 c!) - 2\gamma(c+4,\theta x)+\theta\gamma(c+3,\theta x)+2\theta^3\gamma(c+1)}$$

Mills Ratio

$$\text{Mills Ratio} = \frac{1}{h_r(x)}$$

$$MR = \frac{2\gamma(c+4,\theta x)+\theta\gamma(c+3,\theta x)+2\theta^3\gamma(c+1)}{\theta^{c+4}x^c(2x^3+x^2+2\theta)e^{-\theta x}}$$

Mean Residual function

The mean Residual function of (WKD) is given by

$$M(x) = \frac{1}{s(x)}\int_x^\infty t\cdot f(t)\,dt$$

$$M(x) = \frac{1}{1-\frac{2\gamma(c+4,\theta x)+\theta\gamma(c+3,\theta x)+2\theta^3\gamma(c+1)}{(2(c+3)!+\theta(c+2)!+2\theta^4 c!)}} \times \int_0^\infty t.\frac{\theta^{c+4}}{2(c+3)!+\theta(c+2)!+2\theta^4 c!}t^c(2t^3+t^2+2\theta)e^{-\theta t}\,dt$$

On simplifying the integration by substation method and using the upper incomplete gamma function, we get

$$M(x) = \frac{\left(2\Gamma(c+5,\theta x)+\theta\Gamma(c+4,\theta^x)+2\theta^4\Gamma(c+2,\theta x)\right)}{(2(c+3)!+\theta(c+2)!+2\theta^4 c!) - 2\gamma(c+4,\theta x)+\theta\gamma(c+3,\theta x)+2\theta^3\gamma(c+1)} - x$$

STOCHASTIC ORDERING

Stochastic ordering is an important tool in finance and reliability theory to assess the comparative performance of the models. Let X and Y be two random variables with pdf, cdf, and reliability function $f(x;\theta,c), f(y;\theta,c), F(x;\theta,c), F(y;\theta,c), S(x) = 1 - F(x;\theta,c) and\ S(y) = 1 - F(x;\theta,c)$ Then,

1. Mean residual life order denoted by $X \leq_{MRLO} Y, If\ m_x(x) \leq m_y(y), \forall x$
2. Hazard rate order denoted as $X \leq_{HRO} Y, If\ \frac{S_X(x)}{S_Y(y)}\ is\ decreasing\ if\ x \geq 0$
3. Stochastic order denoted as $X \leq_{SO} Y, If\ S_X(x) \leq_{SO} S_Y(x),\ \forall x$
4. Likelihood ration order denoted as $X \leq_{LRO} Y, If\ \frac{f_X(x;\theta,c)}{f_Y(x;\theta,c)}$

Assume that X and Y are two independent random variables with pdf $f_X(x;\theta,c)$and $f_Y(x;\lambda,\alpha)$ If $\theta < \lambda$ and $\alpha < c$

$$\Lambda = \frac{f_x(x;\theta,c)}{f_y(x;\lambda,\alpha)}$$

$$\Lambda = \frac{\left(\frac{\theta^{c+4}x^c(2x^3+x^2+2\theta)e^{-\theta x}}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)}{\left(\frac{\lambda^{\alpha+4}x^\alpha(2x^3+x^2+2\lambda)e^{-\lambda x}}{2(\alpha+3)!+\lambda^2(\alpha+2)!+2\lambda^4\alpha!}\right)}$$

$$\Lambda = \frac{\theta^{c+4}2(\alpha+3)! + \lambda^2(\alpha+2)! + 2\lambda^4\alpha!}{\lambda^{\alpha+4}2(c+3)! + \theta^2(c+2)! + 2\theta^4c!} \times \frac{x^c(2x^3+x^2+2\theta)}{x^\alpha(2x^3+x^2+2\lambda)} e^{(\lambda-\theta)x}$$

Thus,

$$\log(\Lambda) = log\left[\frac{\theta^{c+4}2(\alpha+3)! + \lambda^2(\alpha+2)! + 2\lambda^4\alpha!}{\lambda^{\alpha+4}2(c+3)! + \theta^2(c+2)! + 2\theta^4c!}\right] log[x^c(2x^3+x^2+2\theta)] - log[x^\alpha(2x^3+x^2+2\lambda)] + (\lambda-\theta)x$$

Differentiating to x we get,

$$\frac{\partial \log(\Lambda)}{\partial x} = \left[\frac{cx^{c-1}(6x^2+2x)}{x^c(2x^3+x^2+2\theta)}\right] - \left[\frac{\alpha x^{\alpha-1}(6x^2+2x)}{x^\alpha(2x^3+x^2+2\lambda)}\right] + (\lambda-\theta)$$

$$\frac{\partial \log(\Lambda)}{\partial x} < 0\ if\ \lambda < \theta, \alpha < c$$

Thus, $X \leq_{LRO} Y, X \leq_{HRO} Y, X \leq_{MRLO} Y, and\ X \leq_{SO} Y$

STATISTICAL PROPERTIES

Moments

If a random variable x has the pdf of (WKD) is given by (4), then the corresponding r[th] moment is given by

$$\mu_r^{'} = E(X^r) = \int_0^\infty x^r f(x;c,\theta)\, dx$$

$$E(X^r) = \frac{\theta^{c+4}}{2(c+3)! + \theta(c+2)! + 2\theta^4c!} \int_0^\infty x^{c+r}(2x^3+x^2+2\theta)e^{-\theta x}\, dx$$

$$E(X^r) = \frac{\theta^{C+4}}{2(c+3)! + \theta(c+2)! + 2\theta^4c!}\left(\frac{2\Gamma(c+r+4)}{\theta^{c+r+4}} + \frac{\Gamma(c+r+3)}{\theta^{c+r+3}} + \frac{2\theta\Gamma(c+r+1)}{\theta^{c+r+1}}\right)$$

$$E(X^r) = \frac{2\Gamma(c+r+4) + \theta\Gamma(c+r+3) + 2\theta^4\Gamma(c+r+1)}{\theta^r(2(c+3)! + \theta(c+2)! + 2\theta^4c!)} (6)$$

Where $\Gamma(\cdot)$is the gamma function, the mean and variance can be obtained by substitutingr = 1 and r = 2 in eqn. (6)

$$E(X) = \frac{2\Gamma(c+5) + \theta\Gamma(c+4) + 2\theta^4\Gamma(c+2)}{\theta(2(c+3)! + \theta(c+2)! + 2\theta^4c!)}$$

$$E(X^2) = \frac{2\Gamma(c+6) + \theta\Gamma(c+5) + 2\theta^4\Gamma(c+3)}{\theta^2(2(c+3)! + \theta(c+2)! + 2\theta^4c!)}$$

$$\text{Variance} = \frac{2\Gamma(c+6) + \theta\Gamma(c+5) + 2\theta^4\Gamma(c+3)}{\theta^2(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)} - \left(\frac{2\Gamma(c+5) + \theta\Gamma(c+4) + 2\theta^4\Gamma(c+2)}{\theta(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)}\right)^2 \quad (7)$$

Harmonic Mean

The harmonic mean of the (WKD) is given by

$$H.M = E\left(\frac{1}{x}\right) = \int_0^\infty \frac{1}{x} f_w(x; c, \theta)\, dx$$

$$H.M = \frac{\theta^{c+4}}{2(c+3)! + \theta(c+2)! + 2\theta^4 c!} \int_0^\infty x^{c-1}(2x^3 + x^2 + 2\theta) e^{-\theta x}\, dx$$

After simplification we get,

$$H.M = \frac{\theta\left(2\Gamma(c+3) + \theta\Gamma(c+2) + 2\theta^4\Gamma(c)\right)}{2(c+3)! + \theta(c+2)! + 2\theta^4 c!}$$

Moment Generating function and characteristic Function

If a random variable X has the pdf of (WKD) given by (4), the corresponding r[th] Moment is given by

$$M_{X_w}(t) = E(e^{tx})$$

$$M_{X_w}(t) = \int_0^\infty e^{tx} f(x)\, dx$$

Using Taylor's Series

$$M_{X_w}(t) = \int_0^\infty \left[1 + tx + \frac{(tx)^2}{2!} + \cdots\right] f(x)\, dx$$

$$M_{X_w}(t) = \int_0^\infty \sum_{j=0}^\infty \frac{t^j}{j!} f(x)\, dx$$

$$M_{X_w}(t) = \sum_{J=0}^\infty \frac{t^j}{j!} \cdot \frac{2\Gamma(c+j+4) + \theta\Gamma(c+j+3) + 2\theta^4\Gamma(c+j+1)}{\theta^j(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)}$$

$$M_{X_w}(t) = \frac{1}{(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)} \sum_{J=0}^\infty \frac{t^j}{j!\,\theta^j} . 2\Gamma(c+j+4) + \theta\Gamma(c+j+3) + 2\theta^4\Gamma(c+j+1)$$

Similarly, we can get the characteristic function of (WKD) can be obtained as

$$\phi_{X_W}(t) = M_{X_w}(it)$$

$$\phi_{X_W}(t) = \sum_{J=0}^\infty \frac{(it)^j}{j!} \mu_j'$$

$$\phi_{X_W}(t) = \frac{1}{(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)} \sum_{J=0}^\infty \frac{(it)^j}{j!\,\theta^j} . 2\Gamma(c+j+4) + \theta\Gamma(c+j+3) + 2\theta^4\Gamma(c+j+1)$$

Ordered Statistics

In this section, we derived a closed form for the pdf of the i[th] order statistic of the (WKD). Let $x_1, \dots, x_n$be ta simple random sample from weighted Kpenadidum distribution with c.d.f and pdf given by (4) and (5). Let $x_{(1:n)} \leq x_{(2:n)} \leq \cdots \leq x_{(n:n)}$ denote the order statistics obtained from this sample. We now give the probability density function of $x_{r:n}$, say $f_{r:n}(x)$ of $x_{r:n}, i = 1,2, \dots, n$. The probability density function of the r[th] order statistics $x_{r:n}, r = 1,2, \dots, n$ given by

$$f_{r:n}(x) = \frac{n!}{(r-1)!\,(n-r)!}[F(x;C,\theta)]^{r-1}[1-F(x,c,\theta)^{n-r}f(x;C,\theta), \quad x>0$$

$$f_{r:n}(x) = \frac{n!}{(r-1)!\,(n-r)!}\left(\frac{(2\gamma(c+4,\theta\mu)+\theta\gamma(c+3,\theta\mu)+2\theta^4\gamma(c+1,\theta\mu)}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)^{r-1} \times\left(1-\frac{(2\gamma(c+4,\theta\mu)+\theta\gamma(c+3,\theta\mu)+2\theta^4\gamma(c+1,\theta\mu)}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)^{n-r} \times\left(\frac{\theta^{c+4}}{2(c+3)!+\theta(c+2)!+2\theta^4c!}x^c(2x^3+x^2+2\theta)e^{-\theta x}\right) (8)$$

The distribution of the minimum first-order Statistic $X_{(1)} = \min(x_1, x_2, \dots, x_n)$ and the largest order of Statistics $X_{(n)} = \max(x_1, x_2, \dots, x_n)$ can be computed by replacing r in the previous equation with 1 and n. so we get

$$f_{1:n}(x) = \frac{n\,\theta^{c+4}}{2(c+3)!+\theta(c+2)!+2\theta^4c!}x^c(2x^3+x^2 +2\theta)e^{-\theta x}\left(1-\frac{(2\gamma(c+4,\theta\mu)+\theta\gamma(c+3,\theta\mu)+2\theta^4\gamma(c+1,\theta\mu)}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)^{n-1}$$

$$f_{n:n}(x) = \frac{n\,\theta^{c+4}}{2(c+3)!+\theta(c+2)!+2\theta^4c!}x^c(2x^3+x^2+2\theta)e^{-\theta x}\left(\frac{(2\gamma(c+4,\theta\mu)+\theta\gamma(c+3,\theta\mu)+2\theta^4\gamma(c+1,\theta\mu)}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)^{n-1}$$

Likelihood Ratio Test

In this section, we derive the likelihood ratio test from the (WKD). Let $x_1, x_2, \dots, x_n$be a random Sample from the weighted Kpenadidum distribution.

Testing the hypothesis, we have the null and alternative hypothesis

$H_0: f(x) = f(x,\theta)\ against\ H_1: f(x) = f_w(x;c,\theta)$

The following test statistic is used to test whether the random Sample of size n comes from the Kpenadidum distribution or the weighted Kpenadidum distribution.

$$\triangle = \frac{L_1}{L_2} = \prod_{i=1}^{n}\frac{f_w(x_i;c,\theta)}{f(x_i,\theta)}$$

$$\triangle = \prod_{i=1}^{n}\frac{\theta^c 2(\theta^4+\theta+6){x_i}^c}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}$$

$$\triangle = \left(\frac{\theta^c 2(\theta^4+\theta+6)}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)^n \prod_{i=1}^{n}{x_i}^c$$

We have rejected the null hypothesis

$$\triangle = \left(\frac{\theta^c 2(\theta^4+\theta+6)}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)^n \prod_{i=1}^{n}{x_i}^c > k$$

Equivalently, we also reject the null hypothesis.

Where,

$$\triangle^* = \prod_{i=1}^{n}{x_i}^c > k\left(\frac{\theta^c 2(\theta^4+\theta+6)}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)^n$$

$$\triangle^* = \prod_{i=1}^{n}{x_i}^c > k^*$$

Where, $k^* = k\left(\frac{\theta^c 2(\theta^4+\theta+6)}{2(c+3)!+\theta^2(c+2)!+2\theta^4 c!}\right)$

For large sample N, 2 log A is distributed as Chi-square Variate with one-degree freedom. Thus, we reject the null hypothesis When the probability value is given by $P(\Delta^* > \alpha^*)$where,

$\alpha^* = \prod_{i=1}^{n} x_i{}^c$less than the level of significance and $\prod_{i=1}^{n} x_i{}^c$ is the observed value of the statistic Δ^*

Entropy

The entropy was first introduced by Renyi (1961). It describes how much information is used in many fields Such as statistics and engineering. Entropy is defined as a measure of uncertainty of the probability distribution of a random variable X as

Renyi Entropy

The entropy of a random variable x measures the variation of the uncertainty. The Renyi entropy is defined by

$$R_\gamma = \frac{1}{(1-\gamma)}\log\int_0^\infty \left(f(x;c,\theta)\right)^\gamma dx\,, \qquad \gamma > 0, \gamma \neq 1$$

$$R_\gamma = \frac{1}{(1-\gamma)}\log\left(\frac{\theta^{c+4}}{2(c+3)!+\theta^2(c+2)!+2\theta^4 c!}\right)^\gamma \int_0^\infty x^{c\gamma}(2x^3+x^2+2\theta)^\gamma e^{-\theta\gamma x}\,dx$$

Using binomial series expansion,

$$(a+b+c)^z = \sum_{i=0}^{\infty}\binom{z}{i}(a)^{z-i}(b+c)^i$$

$$(1+z)^a = \sum_{j=0}^{\infty}\binom{a}{j}x^j$$

Then, the following power series expansion

$$a^z = \sum_{k=0}^{\infty}\frac{(\log(a))^k z^k}{k!}$$

$$R_\gamma = \frac{1}{(1-\gamma)}\log\left(\frac{\theta^{c+4}}{2(c+3)!+\theta^2(c+2)!+2\theta^4 c!}\right)^\gamma \sum_{i=0}^{\gamma}\sum_{j=0}^{i}\binom{\gamma}{i}\binom{i}{j}\theta^j 2^{j+\gamma-1}\frac{\Gamma(c\gamma-i-2j+3\gamma+1)}{\theta\gamma^{(c\gamma-i-2j+3\gamma+1)}}$$

after simplification we get, $R_\gamma = \frac{1}{(1-\gamma)}\log\left(\frac{\theta^{c+4}}{2(c+3)!+\theta^2(c+2)!+2\theta^4 c!}\right)^\gamma \sum_{i=0}^{\gamma}\sum_{j=0}^{i}\sum_{k=0}^{j}\sum_{i=0}^{j+\gamma-1}\frac{(\log(\theta))^k j^k}{k!}\binom{\gamma}{i}\binom{i}{j}\binom{j+\gamma-1}{i} \times \frac{\Gamma(c\gamma-i-2j+3\gamma+1)}{\theta\gamma^{(c\gamma-i-2j+3\gamma+1)}}$

Tsallis Entropy

The Boltzmann-Gibbs(B-G) statistical mechanics initiated by Tsallis have attracted a great deal of attention. This generalization of (B-G) statistics was proposed firstly by introducing the mathematical expression of Tsallis entropy (Tsallis, 1988) for a continuous random variable which is defined as

$$T_\gamma = \frac{1}{\gamma-1}1-\int_0^\infty \left(f(x)\right)^\gamma dx\,;\gamma > 0, \gamma \neq 1$$

$$T_\gamma = \frac{1}{\gamma-1}\left(1-\int_0^\infty\left(\frac{\theta^{c+4}}{2(c+3)!+\theta^2(c+2)!+2\theta^4 c!}\right)^\gamma dx\right)$$

$$T_\gamma = \frac{1}{\gamma-1}\left(1-\left(\frac{\theta^{c+4}}{2(c+3)!+\theta^2(c+2)!+2\theta^4 c!}\right)^\gamma\right)\int_0^\infty x^{c\gamma}(2x^3+x^2+2\theta)^\gamma e^{-\theta\gamma x}\,dx$$

Solving the integral we obtain

$$T_\gamma = \frac{1}{\gamma-1}\left(1-\left(\frac{\theta^{c+4}}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)^\gamma \sum_{i=0}^{\gamma}\sum_{j=0}^{i}\sum_{k=0}^{j}\sum_{i=0}^{j+\gamma-1}\frac{(\log(\theta))^k j^k}{k!}\binom{\gamma}{i}\binom{i}{j}\binom{j+\gamma-1}{i} \times \frac{\Gamma(c\gamma-i-2j+3\gamma+1)}{\theta\gamma^{(c\gamma-i-2j+3\gamma+1)}}\right)$$

Bonferroni And Lorenz Curves

The Bonferroni and Lorenz curves (Bonferroni, 1930) have applications not only in economics to study income and poverty, but also in other fields like reliability demography, insurance, and medicine. The Bonferroni curve B(P) and Lorenz curve L(P) are defined as,

$$B(P) = \frac{1}{P\mu}\int_0^q xf(x;c,\theta)\,dx$$

and

$$L(P) = \frac{1}{\mu}\int_0^q xf(x;c,\theta)\,dx$$

Where, $q = F^{-1}(P);\ q\ \epsilon\ [0,1], and\ \mu = E(x)$

Using the proposed pdf, we get

$$B(P) = \frac{1}{P\left(\frac{2\Gamma(c+5)+\theta\Gamma(c+4)+2\theta^4\Gamma(c+4)}{\theta\ 2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\right)} \times \int_0^q x\ \frac{\theta^{c+4}}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}x^c(2x^3+x^2+2\theta)e^{-\theta x}\,dx$$

$$B(P) = \frac{\theta^{c+5}}{P\ 2\Gamma(c+5)+\theta\Gamma(c+4)+2\theta^4\Gamma(c+4)}\int_0^q x^{c+1}(2x^3+x^2+2\theta)e^{-\theta x}\,e^{\theta x}\,dx$$

On simplifying the integration by substitution method and using incomplete gamma function we get

$$B(P) = \frac{\left(2\gamma(c+5,\theta q)+\theta(c+4,\theta q)+2\theta^4(c+2,\theta q)\right)}{P\ 2\Gamma(c+5)+\theta\Gamma(c+4)+2\theta^4\Gamma(c+4)}$$

Where $L(P) = P\ B(P)$

$$L(P) = \frac{\left(2\gamma(c+5,\theta q)+\theta(c+4,\theta q)+2\theta^4(c+2,\theta q)\right)}{2\Gamma(c+5)+\theta\Gamma(c+4)+2\theta^4\Gamma(c+4)}$$

ESTIMATION OF PARAMETER

The Maximum Likelihood Estimation (MLE) and Fisher Information Matrix.

The maximum likelihood method is applied to obtain the estimation for the parameter of (WKD) with parameter θ and c the likelihood function is defined as

$$L(x;\theta,c) = \prod_{i=1}^{n} f(x_i;\theta,c)$$

$$= \prod_{i=1}^{n}\left(\frac{\theta^{c+4}}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}x_i^c\left(2x_i^3+x_i^2+2\theta\right)e^{-\theta x_i}\right)$$

$$= \frac{\theta^{c+4}}{2(c+3)!+\theta^2(c+2)!+2\theta^4c!}\prod_{i=1}^{n}x_i^c\left(2x_i^3+x_i^2+2\theta\right)e^{-\theta x_i}$$

Now, log-likelihood can be given as

$$\log L = n(c+4)\log(\theta) - n\log(2(c+3)!+\theta(c+2)!+2\theta^4c!+c\sum_{i=1}^{n}\log(x_i)+\sum_{i=1}^{n}\log\left(2x_i^3+x_i^2+2\theta-\theta\sum_{i=1}^{n}x_i\right)(10)$$

Differentiating the above equation (6) toθ and C partially, we get

$$\frac{\partial \log L}{\partial \theta} = n(c+4) - \frac{n\left((c+2)! + 8\theta^3 c!\right)}{(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)} + \sum_{i=1}^{n} \frac{2}{\left(2x_i^3 + x_i^2 + 2\theta\right)} - \sum_{i=1}^{n} x_i = 0 \quad (11)$$

$$\frac{\partial \log L}{\partial \theta} = n\, log(\theta) - n\frac{(2\,\psi(c+3) + \theta\,\psi(c+2) + 2\theta^4 \psi c)}{(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)} + \sum_{i=1}^{n} x_i = 0 \quad (12)$$

Where $\psi(.)$ is the digamma function.

Then, the maximum likelihood estimation of the unknown parameters can be obtained by equating the equations from (11) and (12). However, the equations cannot be solved analytically, thus we solved them numerically using R programming with some data sets.

To obtain a confidence interval we use the asymptotic normality results. We have that if $\hat{\lambda} - \left(\hat{\theta}, \hat{c}\right)$ denotes the MLE of $\lambda = (\theta, c)_1 \sqrt{n}\left(\hat{\lambda} - \lambda\right) \to N\left(0, I^{-1}(\lambda)\right)$

Where I (λ) is Fisher's information Matrix i.e.,

$$I(\lambda) = -\frac{1}{n}\begin{pmatrix} E\left(\frac{\partial^2 \log L}{\partial \theta^2}\right) & E\left(\frac{\partial^2 \log L}{\partial c \partial \theta}\right) \\ E\left(\frac{\partial^2 \log L}{\partial \theta \partial c}\right) & E\left(\frac{\partial^2 \log L}{\partial c^2}\right) \end{pmatrix}$$

Where

$$E\left(\frac{\partial^2 \log L}{\partial \theta^2}\right) = -n\frac{(c+4)}{\theta^2} - \frac{n(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)24\,\theta^4 c! - \left((c+2)! + 8\theta^3 c!\right)}{(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)^2} + \sum_{i=1}^{n} \frac{4}{\left(2x_i^3 + x_i^2 + 2\theta\right)}$$

$$E\left(\frac{\partial^2 \log L}{\partial c \partial \theta}\right) = \frac{n}{\theta} + n\Bigg((2(c+3)! + \theta(c+2) + 2\theta^4 c!)\,\psi(c+2) + 8\theta^3 \psi(c) - \left((c+2)! + 8\theta^3 c!\right)\frac{(2\,\psi(c+3) + \theta\,\psi(c+2) + 2\theta^4 \psi c)}{(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)^2}\Bigg)$$

$$E\left(\frac{\partial^2 \log L}{\partial c^2}\right) = n(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)\begin{pmatrix} 2\psi'(c+3) + \theta\psi'(c+2) \\ +2\theta^4 \psi'(c) \end{pmatrix} 4(c+3)^2! + \frac{4\theta(c+2)!\,(c+3)! + 8\theta^4(c+3)!\,c! + \theta^2(c+2)!^2 + 4\theta^5(c+2)!\,c! + 4\theta^8 c!^2}{(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)^2}$$

$$E\left(\frac{\partial^2 \log L}{\partial \theta \partial c}\right) = \frac{n}{\theta} + (2(c+3)! + \theta(c+2) + 2\theta^4 c!)\,\psi(c+2) + 8\theta^3 \psi(c)) - \frac{4(c+3)!^2 + 4\theta(c+2)!\,(c+3)! + 8\theta^4(c+3)!\,c! + \theta^2(c+2)!^2 + 4\theta^5(c+2)!\,c! + 4\theta^8 c!^2}{(2(c+3)! + \theta(c+2)! + 2\theta^4 c!)^2}$$

Where $\psi'(.)$ Is the first-order derivative of the digamma function. Since λ being unknown, we estimate $I^{-1}(\lambda)$ by $I^{-1}\left(\hat{\lambda}\right)$and this can be used to obtain an asymptotic confidence interval for θ, c.

APPLICATION TO REAL-LIFE DATA

In this section, the proposed weighted Kpenadidum distribution is applied to the real data sets. The secondary data has been taken from a private tertiary care hospital in Puducherry.

Dataset 1: Age distribution of the patients in years:

55, 58, 55, 58, 51, 65, 49, 50, 37, 47, 49, 56, 67, 68, 50, 55, 67, 44, 63, 55, 62, 51, 65, 47, 38, 69, 62, 36, 42, 66, 64, 46.

Dataset 2: Survival time (in months) of patients

63, 61, 58, 57, 55, 26, 5, 20, 54, 58, 30, 24, 35, 27, 47, 67, 70, 78, 39, 26, 65, 77, 49, 50, 27, 41, 65, 52, 48, 62, 38, 26.

We observe its flexibility over some well-known existing distributions. The results for the analysis in this present study were obtained using R software. We have also calculated the Akaike Information Criteria (AIC), Bayesian

Information Criteria (BIC), Akaike Information Criteria Corrected (AICC) and $-2\log L$ for the considered distributions to observe their fit. The distribution with the lowest values AIC, BIC, and AICC is regarded as the best. To compare the goodness of fit of the fitted distribution, the following criteria: Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), Akaike Information Criteria Corrected (AICC) and $-2\log L$.
AIC, BIC, AICC and $-2\log L$ can be evaluated by using the formula as follows.

$$AIC = 2k - 2\log L\,, BIC = k\log n - 2\log L \text{ and } AICC = AIC + \frac{2k(k+1)}{(n-k-1)}$$

Where, $k =$ number of parameters, n sample size and $-2\log L$ is the maximized value of the log-likelihood function. From Table 1 and Table 2, the (WKD) has the two-parameter distributions of the lowest AIC, BIC, and AICC value, thus making it fit better than the (Exponential, Lindley, and Shanker) distributions.

CONCLUSION

In this paper, the weighted Kpenadidum is a new distribution, extended in this study to model lifetime data. The suggested distribution's moments, entropy, order statistics, survival and hazard functions, and other statistical characteristics have all been investigated. Parameters for a weighted Kpenadidum distribution were inferred using the greatest likelihood technique. High accuracy is shown when the maximum likelihood technique has been used to estimate the parameters. Statistical distributions are essential in medical research, and their use can have a high impact on public health, especially in cancer research. The usefulness of this distribution is thus illustrated by applying it to certain real datasets that explain the survival of a small number of patients with breast cancer. The weighted Kpenadidum distribution outperforms other competing distributions according to several goodness-of-fit criteria. Compared to other well-known distributions, the weighted Kpenadidum distribution offers a better fit.

Competing of Interests
There are no competing interests.

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Table 1: The MLEs of the weighted Kpenadidum distribution parameters and AIC, BIC, AICC, and -2log L value for the given data set 1

Distribution	ML Estimates	-2log L	AIC	BIC	AICC
Weighted Kpenadidum distribution	$\hat{c} = \mathbf{30.4574503}$ $(\mathbf{10.1052120})$ $\hat{\theta} = \mathbf{0.6363895}$ $(\mathbf{0.1880471})$	**167.0268**	**171.0268**	**173.2978**	**171.2268**
Kpenadidum	$\hat{\theta} = 0.073675679$ (0.007679891)	197.087	199.087	200.2225	199.287
Exponential	$\hat{\theta} = 0.018486788$ (0.003843444)	229.6043	231.6043	232.397	231.8043
Lindley	$\hat{\theta} = 0.036309855$	213.2929	215.2929	216.4284	215.4929

	(0.005351172)				
Shanker	$\hat{\theta} = 0.036913112$ (0.005434862)	212.5362	214.5362	215.6717	214.7362

Table 2: The MLEs of the weighted Kpenadidum distribution parameters and AIC, BIC, AICC, and -2log L value for the given data set 2

Distribution	ML Estimates	-2log L	AIC	BIC	AICC
Weighted Kpenadidum distribution	$\hat{c} = \mathbf{0.37015970}$ $(\mathbf{1.23068974})$ $\hat{\theta} = \mathbf{0.08588601}$ $(\mathbf{0.02573853})$	**208.3212**	**210.4165**	**211.552**	**210.6165**
Kpenadidum	$\hat{\theta} = 0.078583453$ (0.008269432)	208.4165	212.3212	214.5922	212.5212
Exponential	$\hat{\theta} = 0.018486788$ (0.003843444)	229.6043	231.6043	7397.	231.8043
Lindley	$\hat{\theta} = 0.038691930$ (0.005702976)	214.8162	216.8162	217.9516	217.0162
Shanker	$\hat{\theta} = 0.039387544$ (0.004834864)	214.3808	216.3808	217.5163	216.5808

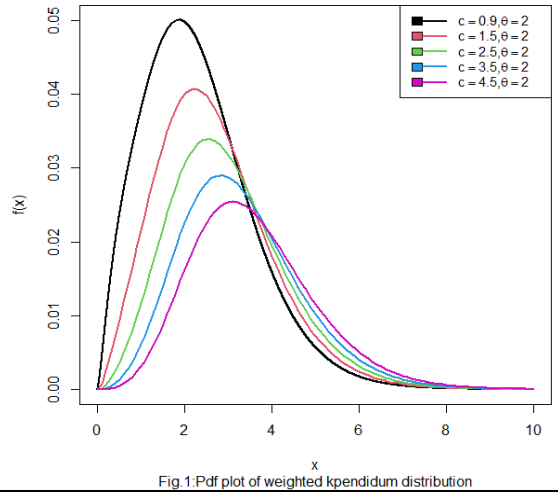


Fig.1:Pdf plot of weighted kpendidum distribution

Fig:1

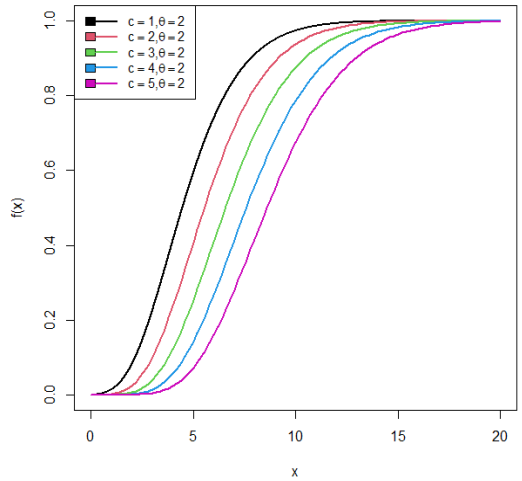


Fig.2:cdf plot of weighted Kpendidum distribution

Fig:2

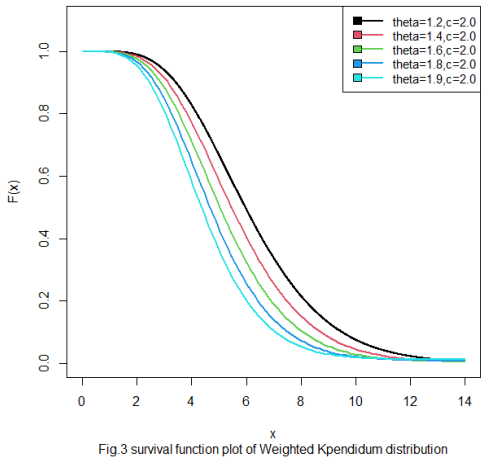


Fig.3 survival function plot of Weighted Kpendidum distribution

Fig:3

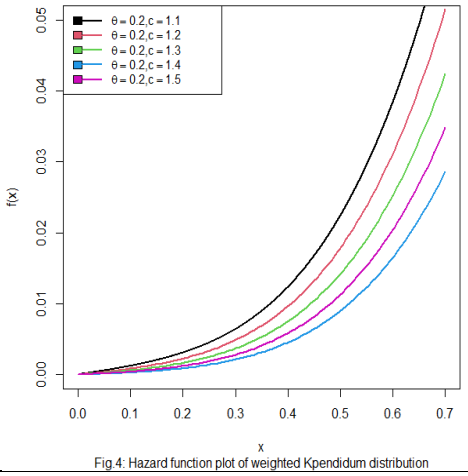


Fig.4: Hazard function plot of weighted Kpendidum distribution

Fig:4

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RESEARCH ARTICLE

Prediction of Carbon Dioxide Emission in India through Robust Regression Method

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ABSTRACT

Because of the dire circumstances facing the planet's occupants and the continuation of life on it during the past 50 years, experts worldwide are gravely concerned about global warming. There are too many reasons why the problem exists. The unchecked release of greenhouse gases mainly carbon-dioxide (CO_2) is one of the primary drivers of global warming. This emission rate in India varies by region based on a number of factors, including population, economic growth, and industrialization. This research uses a 30-years data set from 1990 to 2020 in India in an attempt to develop a robust regression model of CO_2 emissions. When it comes to the accuracy and reliability of CO_2 emissions, Robust regression algorithms can perform better than any traditional modelling. By mitigating extreme values, these methods can provide a clearer understanding of the relationships between emissions and their predictors. A variety of Robust regression techniques can be used for our present model. However, we adopt a comprehensive approach that makes advantage of Python with stats models for M-Estimation and scikit-learn for Quantile Regression. Future emissions, the impact of various policies, and the dynamics of CO_2 sources and sinks may all be predicted by using our present model. After that, prediction of CO_2 has been done by applying the model from 2025-2035. During the analysis of the model, the model shows its own innovativeness.

Keywords: CO_2 emission, Quantile, Robust Regression method, Regression Coefficients, Standard error ratio

INTRODUCTION

India is one of the world's most populous and rapidly developing countries, and its carbon dioxide emissions have been rising steadily over the past few decades [1,2,3]. As a major contributor to global greenhouse gas emissions, the need to understand and model CO_2 emissions in India has become critical for policy formulation, environmental planning, and sustainable development. Mathematical modeling can be a powerful tool to predict, analyze, and mitigate the environmental impacts of CO_2 emissions [4-9]. India is the third-largest emitter of CO_2 globally at present, with emissions primarily driven by fossil fuel combustion for energy, transportation, and industrial activities. According to recent data from the Global Carbon Project, India's CO_2 emissions surpassed 2.8 gigatonnes (Gt) in 2022, accounting for approximately 7% of global emissions. This rapid increase in emissions is linked to India's expanding energy demand, population growth, urbanization, and industrialization. While India has committed to reducing its carbon intensity (CO_2 emissions per unit of GDP) and increasing renewable energy deployment under its Nationally Determined Contributions (NDCs) for the Paris Agreement, achieving these targets presents considerable challenges. The energy sector in India, particularly coal-based power generation, remains the largest source of CO_2 emissions. In addition, the transportation sector, characterized by rapid urbanization and a reliance on fossil fuels, has seen an increasing contribution to national emissions. Industrial processes, particularly in cement, steel, and chemical industries, also significantly contribute to CO_2 output [10-12]. The combination of a growing economy, rising energy demand, and limited alternative energy infrastructure further complicates the reduction of emissions in the country. Mathematical models help to quantify and predict the relationship between various factors that contribute to CO_2 emissions along with the possible future emissions based on the models. The models can range from simple linear regression models to complex system dynamics models. Some of the prominent types of models used for CO_2 emissions in India are Linear Regression Models, Logarithmic Models, Environmental Kuznets Curve (EKC) Model, System Dynamics Models, Integrated Assessment Models (IAMs) etc. [13-20]. The process of calibrating and validating these models is crucial to ensure their accuracy and reliability. Calibration involves adjusting the model parameters so that the predicted emissions match historical data. This can be done using statistical methods such as least squares fitting or more advanced techniques like Bayesian inference. Validation, on the other hand, involves testing the model against out-of-sample data to ensure its predictive power. So, Mathematical modeling of CO_2 emissions in India offers a comprehensive approach to understanding and addressing the challenges posed by climate change. By using regression models, environmental Kuznets curves, system dynamics, and integrated assessment models, policymakers and researchers can gain insights into the complex relationship between economic growth, energy consumption, and emissions. The results from these models can guide India's transition towards a low-carbon economy, enabling sustainable development while mitigating the adverse impacts of climate change. Mathematical models, when used effectively, provide a foundation for evidence-based decision-making, helping India to balance development needs with environmental stewardship. In the present research work, robust regression method is used for the prediction of CO2 emission from 2025-2035 based on last thirty years data and encouraging results have been identified.

Mathematical modelling and Statistical analysis based on Robust Regression method

In order to simulate or create the set of suitable equations that depict the emission of carbon dioxide into the atmosphere, mathematical modelling for CO_2 emissions is essential. These models can be used to forecast future emissions, evaluate the effects of different policies, and comprehend the dynamics of sources and sinks of CO_2. With the use of the *Robust regression method*, we have created a mathematical model of India's carbon dioxide emissions in this current study. Robust regression techniques can outperform any traditional modelling in terms of CO_2 emission accuracy and dependability. Through the mitigation of extreme values, these techniques can offer a more lucid comprehension of the correlations between emissions and their predictors.

METHODOLOGY

Numerous robust regression methods are available for application, including

(i) **M-Estimation**: Use a loss function to lessen the significance of outliers. eg. Huber's M-estimator and Tukey's bi weight function.

(ii) **Quantile Regression***:* The response variable's conditional quantiles, like the median, are modelled because they are less susceptible to outliers.

(iii) **Least Absolute Deviations (LAD) Regression**: Reduces the total absolute deviations rather than the squared deviations, increasing its robust to outliers.

(iv) In the present research investigation, a broad methodology is employed that uses Python with stats models for M-Estimation and scikit-learn for Quantile Regression.

Our present model

Modeling has been done based on the link between the year (independent variable) and both total CO_2 emissions and per capita emissions (dependent variables) utilizing Quantile Regression via M-Estimation on the available data (CO_2 emissions across the years). The conditional quantiles of the emissions (i.e., the higher or median quantiles) has been estimated using quantile regression.

Model Setup

In our model, y_i indicate the year CO_2 emissions (either the total or per person emissions), for year i, and X_i represents the year. Our goal is to model y_i for various quantiles as a function of X_i. The quantile regression equation for quantile τ may be expressed as: $Q_\tau\left(y_i / X_i\right)=\beta_0+\beta_1 X_i$, where, $Q_\tau\left(y_i / X_i\right)$ be the conditional τ-th quantile of y_i given X_i; β_0, and β_1 represent the intercept and the slop respectively.

Quantile Regression Objective Function

The check loss function is used in quantile regression to estimate and is defined as follows: $\rho_\tau(u)=\tau.u.1(u\geq 0)+(1-\tau).(-u).1(u<0)$, where $u=y_i-\left(\beta_0+\beta_1 X_i\right)$ indicates the residual. Our object is to minimize the sum of these losses over all observations i.

Quantile Regression via M-Estimation

We minimize a robust loss function in M-estimation. One way to think about the check loss function in quantile regression is as a particular kind of M-estimator. The following goal is minimized: $\min \sum_{i=1}^{n} \rho_\tau\left(y_i-\left(\beta_0+\beta_1 X_i\right)\right)$ Regarding every quantile τ, Through the solution of this minimization issue, β_0, β_1 we estimate β_0, and β_1.

Applying this to present Data: This model can be used to analyze CO_2 emissions per capita as well as overall in the dataset. Procedures for Quantile Regression Implementation be as follows:

(i) Construct the data: Division of the data into x (years) and y (CO_2 emissions).

(ii) **Quantile Regression Model:** Regarding every quantile of interest τ, set a quantile regression model with the help of an optimization ocedure that minimizes the check loss function.

(iii) **Model different quantiles:** Use quantiles like 0.25 (lower quartile), 0.50 (median), 0.75 (upper quartile), etc.

(iv) Review **the model:** Visualization is possible for the fitted quantiles to assess how well the model captures the trend.

Table 1 represents the real data, and predicated data for the CO_2 emissions in India during 1990 – 2020 along with the residual in each year indicating the deviation from real emission data.

Figure 1 describes a comparative study of the real data vs predicated data for the CO_2 emissions in India during 1990 – 2020 showing the trends of emission in both the cases. It has been observed from the Fig. that till the year 2018, though the emission is continuously increasing but after 2018, the trend is decreasing.

Analyzing the Outcome: From the Table 1, we can note down the following observations:

(i) Quantile 0.50: The median trend in total CO_2 emissions over time is shown by the line for quantile 0.50.

(ii) Quantile 0.25 and 0.75: The evolution of the lower and higher ranges of the CO_2 emissions distribution throughout time is captured by these quantiles. Quantile regression offers a thorough grasp of many distributional components and is resistant to outliers. By swapping out the dependant variable in the preceding steps, this method can also be used to calculate per capita CO_2 emissions.

Robust regression is characterized by the robust regression coefficients shown in Table 2. Robust regression is widely recognized for its increased resilience against outliers and assumptions broken, such as homoscedasticity and normality, when evaluating the significance of regression coefficients. To sum up, robust regression estimates coefficients in a manner akin to ordinary least squares (OLS), but with modifications that improve the dependability of significance tests when outliers or heteroscedasticity are present. Still, standard errors, t-values *(the coefficient estimate to standard error ratio)*, p-values (*The p-value, which is derived from the t-value, determines whether the coefficient differs from zero significantly)*, are used to interpret significance. The above two tables make it clear that the residuals, standard error, t-value, and p-value are all reasonably minimal when compared to the empirical and real data, demonstrating the high calibre of the suggested model for CO_2 emissions. Based on the present modelling, we can estimate the total kilotons of CO_2 emissions in India during 2025 - 2035 in Table 3 and also makes a graphical presentation in Figure. 2 for clear visualization.

CONCLUSION

The Robust Regression method proves to be a valuable tool for predicting CO_2 emissions in India, offering resilience against data irregularities and providing actionable insights. It emphasizes the need for urgent, multi-faceted approaches to mitigate emissions while balancing economic growth. As India strives to meet its climate commitments under global agreements such as the Paris Accord, such predictive models will be instrumental in monitoring progress and guiding sustainable development strategies. By integrating advanced methodologies and interdisciplinary data, India can chart a path toward a low-carbon future, contributing significantly to global climate goals.

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Table 1. Computed model data based on Robust Regression method*

Year	Total Kilotons CO_2	Per Capita Metric Tons Per Capita	Predicted Total kilotons CO_2 values through Robust Regression method	Residuals
1990	563575.4	0.6475	584111.1	-20535.7
1991	607224	0.6831	623059.3	-15835.3
1992	626293.3	0.6901	642007.5	-15714.2
1993	651351.1	0.7031	661955.7	-10604.6
1994	685903	0.7256	701904.9	-16001.9
1995	737856.4	0.7652	753854.1	-15997.7
1996	774070.2	0.7872	791819.3	-1749.1
1997	819268.8	0.8174	837784.5	-18515.7
1998	836269.9	0.8187	854785.7	-18415.8
1999	901325.2	0.8662	923841.9	-22516.7
2000	937858.4	0.8851	959375.7	-21517.3
2001	953537.3	0.8837	975055.6	-21518.3
2002	985453.3	0.8972	1006967	-15113.7
2003	1011771	0.9055	1030099	-18328.0
2004	1085667	0.9555	1103999	-18332.0

2005	1136466	0.9843	1154805	-18339.0
2006	1215205	1.0365	1233545	-18340.0
2007	1336737	1.1236	1355077	-18340.0
2008	1424383	1.1804	1443733	-18350.0
2009	1564881	1.2789	1584231	-18350.0
2010	1659983	1.338	1679333	-18350.0
2011	1756744	1.3969	1776094	-18350.0
2012	1909442	1.4982	1928792	-18350.0
2013	1972429	1.5277	1991779	-18350.0
2014	2147107	1.6425	2166467	-18360.0
2015	2158023	1.6313	2177383	-18360.0
2016	2195249	1.6399	2214609	-18360.0
2017	2308804	1.7049	2328164	-18360.0
2018	2458176	1.7956	2477536	-18360.0
2019	2423951	1.7525	2443291	-18360.0
2020	2200836	1.5761	2220196	-18360.0

*[Ref. www.macrotrends.net]

Table 2. Robust Regression Coefficients

Coefficient	Value	Std. Error	t-value	p-value
Intercept	584111.1	12345.6	47.3	< 0.001
Year	12345.6	234.5	52.6	< 0.001

Table 3. Estimated values of CO_2 emissions in India (2025 – 2035)

Year	Predicted CO_2 Emissions (Kilotons)
2025	1,147,803
2026	**1,148,369**
2027	**1,148,936**
2028	**1,149,503**
2029	**1,150,070**
2030	**1,150,637**
2031	**1,151,204**
2032	**1,151,770**
2033	**1,152,337**
2034	**1,152,904**
2035	**1,153,471**

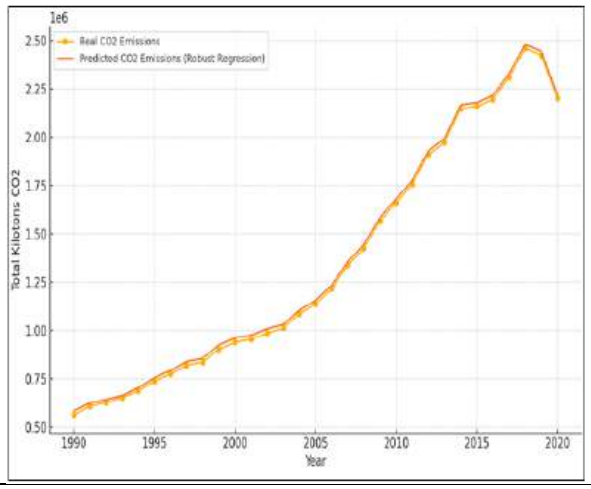


Figure 1: Emission of CO_2: Real vs Predicted in India (1990 – 2020)

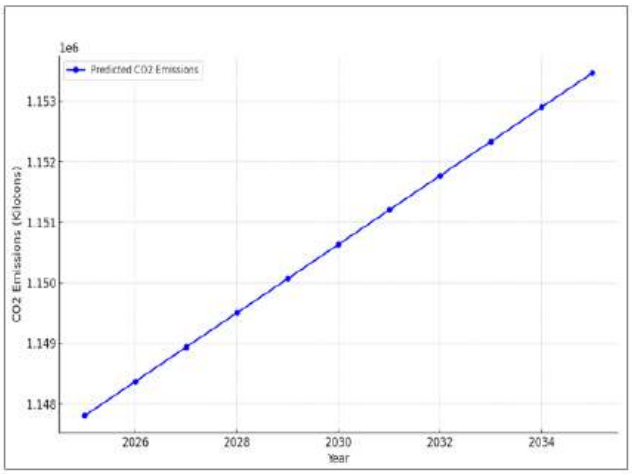


Figure 2: Graphical presentation of predicted values CO_2 emissions in India (2025 – 2035)

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RESEARCH ARTICLE

Physiotherapy Intervention Following Excision of Brainstem Cavernoma –A Case Report

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ABSTRACT

Brainstem cavernomas are rare vascular malformations that can lead to severe neurological deficits following haemorrhage. Surgical removal of brain stem cavernomas result in severe neurological deficits due to their anatomical position. Specific physiotherapy intervention combined with Proprioceptive neuromuscular facilitation (PNF) stabilization exercises, Frenkel exercises, strength and endurance exercises have improved postural control, balance and coordination. This case report analyses the eight week targeted physiotherapy intervention following post excision of brainstem cavernoma.

Keywords: brainstem cavernoma, physiotherapy, PNF stabilization

INTRODUCTION

Cavernous malformation are intracranial vascular malformations which ranges from less than one-quarter inch to 4 inches. Brainstem cavernoma are vascular hamartomatous lesions made up of sinusoidal vascular spaces without cerebral parenchyma which accounts for between 18 and 22% of all intracranial vascular malformations [1]The clinical presentation of brainstem cavernomas can be varied depending on the location of the lesion which may be relatively asymptomatic or neurologically devasted. Cavernous malformations can be superficial or deep lesions where deep lesions have worse prognostic features. Deep lesions are seen in brainstem, cerebellar nuclei, thalamus, or basal ganglia. Brainstem cavernomas exhibit symptoms such as cranial nerve deficits, sensory abnormalities,

motor abnormalities, headache, ataxia, vertigo, nausea, and disorientation [2] Early diagnosis of cavernous malformation is crucial for management which is usually diagnosed with imaging studies where Magnetic Resonance Imaging (MRI) is found to have higher specificity to diagnose both symptomatic and asymptomatic malformations as well as cavernomas location[3]. Surgical removal is the gold standard treatment for cavernous malformations which can be microsurgical resection or stereotactic radio surgery whereas asymptomatic cavernous malformations are conservatively managed by observing overtime and allowing them to progress naturally [4]. Brain stem cavernomas have 30 times greater risk of haemorrhage than non brainstem lesions due to their anatomical position and is more likely to cause severe neurological deficits making difficult in surgical removal and rehabilitation [5,6].Post operative outcome of brainstem cavernomas depends on the patient's preoperative condition whereas patients with good preoperative status have good post operative outcomes in 95% of patients [7].Motor recovery following excision of brainstem cavernoma is unique based on the individual deficits which is enhanced by various therapeutic interventions. This case report highlights the impairments of a patient with brainstem cavernoma excision in the acute period and effect of specific physiotherapy intervention strategies swithuch as PNF technique and Coordination exercises to bring about better motor recovery and functional independence.

CASE REPORT

A 28 year old male reported to Sri Ramachandra hospital with complaints of sudden onset of severe headache persistent for 4 days with same intensity for which he was admitted and found to have Pontine Cavernoma with hemorrhage. Patient had similar history in September 2023 with acute onset of slurred speech, double vision and minimal weakness of right upper and lower limb where CT scan showed acute intraparenchymal haemorrhage in pons and diagnosed with brainstem cavernoma and managed conservatively. He was on close monitoring of his neurological status and was under regular Physiotherapy which reverted him back to a near normal state. Now presently, sudden onset of headache in May 2024with increased intensity showed severe acute and chronic haemorrhages which was indicated for surgery. Patient underwent craniotomy with excision of cavernoma. Following surgery patient developed neurological deficits in right UL and LL for which he was referred for Physiotherapy

CLINICAL INVESTIGATIONS

Patient was diagnosed with Brain stem Cavernoma and Pre operative MRI Brain revealed hetero intense space occupying lesion involving pons and upper medulla extending into the left cerebellar peduncle. Mass effect in the form of effacement of fourth ventricle and cerebello pontine angle was seen.

CLINICAL FINDINGS

On observation in lying position, patient had adducted and internally rotated Rt shoulder, extended elbow and neutral wrist and hand position. He had adducted and externally rotated right hip with extended knee and plantar flexed ankle in lying position. Muscle consistency was firm on palpation and higher mental function examination showed that the patient was alert, comprehending, oriented to time place and person with good attention and memory. Motor examination showed diminished tendon jerks with near normal muscle tone and muscle strength of 4/5 in manual muscle testing. Patient was able to do isolated movements patterns with gross in coordination in upper and lower limb. Sitting balance was fair in feedforward and feed backward mode and Standing balance was poor. Outcome measures like Scale for the Assessment and Rating of Ataxia (SARA), Berg Balance scale (BBS) and Barthel Index were evaluated pre and post -intervention as shown in Table 2&3

PHYSIOTHERAPY INTERVENTION

Rehabilitation program consisted of General strength and Endurance exercises, PNF stabilization exercises, Frenkel Exercises, Balance and Gait training (Table 1). Frenkel's exercises was carried out with the principles of concentration, repetition and precision and PNF techniques of rhythmic stabilization in different positions to improve trunk stability were insisted. Postural control was improved in sitting, kneeling and standing with technique of PNF approximation. Exercises were progressively made more complex as the patient's abilities improved, with continuous verbal cues to maximize performance.

RESULTS

Scale for the assessment and rating of ataxia (SARA) showed significant improvement in coordination after eight weeks of intervention in all the components of SARA as shown in Table 2.Pre and post intervention scores of BBS showed a change of 29 point difference from 13 to 42. Functional independence measured with Barthel index showed a significant change as shown in Table3.

DISCUSSION

Brainstem cavernomas are vascular malformations characterized by abnormal, dilated blood vessels that form a cavernous structure within the brainstem. These lesions can disrupt normal brainstem function, leading to a range of neurological symptoms including motor deficits, sensory abnormalities and difficulties with coordination and speech [8].Our patient presented with post-surgical impairments in coordination, balance and gait. The intervention strategy incorporated a tailored rehabilitation program that combined with PNF rhythmic stabilization techniques to target the in coordination and imbalance. The Rhythmic stabilization, a technique of PNF with alternating isometric contraction without movement enhances the stability of both the trunk and the limbs addressing ataxic symptoms by improving neuromuscular control which was appreciated in our patient and findings was in concordance with the study done by Dionisio et al (2018) who showed improvement in trunk stability [9].PNF is found to facilitate the ability of performing the tasks than just improving the movements in specific directions which is supported by the study done by Kofotolis et al (2005) who showed that PNF training can alter fiber type and cross sectional area enhancing the performance [10].Improvements in coordinated movements could be attributed to Frenkel's exercises and reaching in functional positions which had improved the spatial and temporal aspects of movement which is in concordance with the study done by Adnan *et al* (2016) who showed that Frenkel Exercises decreased ataxia and improved the quality of movement [11]. Prognosis of our patient following cavernoma excision with eight weeks of intervention showed considerable change in SARA and Berg balance scale which transformed the individual from severe dependency to moderate dependency as measured with Barthel index.

CONCLUSION

We conclude that providing specific physiotherapy interventions of PNF stabilization exercise and Frenkel exercises with general strength and endurance exercises improves postural control, balance and coordination resulting in increased functional performance. The positive outcome of this patient encourages to plan and incorporate interventions based on specific techniques to attain better functional recovery.

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CONFLICTS OF INTEREST

None declared

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Table: 1 physiotherapy Intervention

	TASKS TO BE PERFORMED
Muscle strength and endurance	Isotonic strengthening exercises with manual resistance for upper extremity and lower extremity muscles
Coordination	Frenkel's Exercises for UL and LL, Reaching in functional positions
Postural control and Balance	PNF techniques of Rhythmic stabilization and Approximation Feed forward and Feed backward balance training in sitting and standing
Gait Training	Weight bearing exercises, Step onto 8-inch step Side stepping Obstacle walking Walking on uneven surface Tandem walking

Table: 2 Scale for the Assessment and Rating of Ataxia

Outcome measures	**Pre intervention**	**Post intervention**
SARA Total score	20/40	7.5/40
Gait	6/8	2/8
Stance	4/6	2/4
Sitting	2/4	1/6

Speech disturbance	3/6	1/6
Finger chase	1.5/4	0.5
Nose -finger test	1.5/4	0.5
Fast alternating hand movements	1 /4	0/4
Heel -shin	1 /4	0.5

Table:3 Berg Balance Scale and Barthel Index

Outcome measures	Pre intervention		Post intervention	
	Score Obtained	Maximum score	Score Obtained	Maximum score
Berg balance scale	13	56	42	56
Barthel index	35	100	80	100

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RESEARCH ARTICLE

Santal Tribe and its Collective Action : A Reflection

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ABSTRACT

In order to preserve and convey the ancient values, beliefs, practices, and conventions, the Santals developed collective leadership prior to their migration and settlement in Santal Parganas. When members strayed from standard procedures, this collective leadership also offered social control mechanisms. A historical analysis of Santal leadership and its practice at pivotal points in the social structure, together with demographic and socioeconomic characteristics. The collective action of a Santal community is performed by A full-fledged village council traditionally consists of seven administrative elders: The Village Headman: Manjhi, The Deputy Headman: Paranik, The Guardian of Morals: Jog-Manjhi, Assistant to Jog-Manjhi: Jog Paranik, A messenger (Godet), The village priest (Naeke) and his assistant (Kudamnaeke). These officials were chosen by the villagers at the time of a village's founding.

Keywords: Action, Collective, Community, Culture, Santal, Tribe

INTRODUCTION

The Santals are an ethnic tribal group who mostly inhabit the states of Jharkhand, Bihar, West Bengal, Odisha, Chatisgarh, and Assam. There is also a sizable Santal minority in neighboring Bangladesh and a small population in Nepal. Santals constitute the largest group among tribal communities. They belong to the Proto-Australoid race. The settlement of Medinipur known as Santal was first mentioned in Walter Hamilton's narrative (1820). He said that in the jungles lived an impoverished, oppressed class known as Santals. Some believe the term 'Santal' originated from 'Saont' or 'Samanta'. Once, an area of East Medinipur was known as 'Samantabhum' or 'Saont'. Most likely, they were the original inhabitants of this region. They also mentioned this place 'SantDisham' or 'SantDesh' in their mythology. 'Santal' means inhabitant of 'SantDesh'. The Santal tribe of India have a traditional tribal lifestyle. Forest trees and flora serve the basic needs of Santaltribe.The tribes are also engaged in fishing and cultivation. Theys are also skilled

in the production of musical instruments, mats, baskets, and other crafts. The Santal tribe is divided mainly into twelve sects viz. Soren, Murmu, Mandi, Kisku, Hansda, Besra, Tudu, Baske, Hembrom, Pauria, Bedea and Choral. Each sect has a totem symbol of its own. Leadership is exercised at the village level by the village council and the administrative elders. The parganas and pargana councils serve as the main decision-making body between communities. The yearly hunt council serves as the highest court of appeal and decision-making at the regional level. The cultural norms linked with the village demonstrate that traditionally territorial tribal identities have been virtually exclusively concentrated on the village. The village boundary is frequently painstakingly delineated, used only by the local community, and (more often than not) administered completely by the village chief (Piang, 2015).

The village elders' council, which exercises collective leadership, governs not only village life but also how the inhabitants interact with the outside world. The headman represents justice and propriety. He is required to uphold the moral and legal traditions of his forefathers in both his personal behavior and his interactions with others. He opposes the current era's assimilationist tendencies as a defender of traditions. As a representation of justice, he stays away from arbitrary decisions and employs mediation to reach agreements and address anomalies. It would be impossible to preserve Santal society and identity without this efficient operation. According to long-standing Santal customs, the headman represents authority. Even when a young man takes over the role, his opinions are taken seriously and his opinions are given careful consideration. An examination of various Santal terms that the villagers use to address their headman can summarize their expectations of him. For instance, the term "MaranHor," which translates to "Big Man," is used to describe a Manjhi (village headman), suggesting both seniority and importance. He's also a “Bud AkilHor”, which means a wise and knowledgeable man. He offers “solha”, which means he offers sage advice; he is meant to be a “Ayuric” (leader), which is someone who is actively working toward goals rather than just serving as a passive counsellor. The ideas of significance, seniority, experience, wisdom, and active leadership are all woven throughout these ideas. As territorial assertion is increasingly considered as critical to maintaining cultural autonomy and assuring development, tribal identity frequently draws on myths and legends to justify the concept of an indigenous territorial homeland (Xaxa, 1999).

Medicine-Man, Charm-Doctor and Exorcist: Jan Guru or Ojha

The Ojha, also known as the Jan Guru, typically performs the roles of exorcist, charm-doctor, and medicine-man. Witches, sorcerers, and the malevolent effects of impersonal forces and powers are among the antisocial behaviors that the Ojha aims to uncover and combat. Being a clearly religious individual, he is supposed to possess unique abilities and knowledge that other tribal members do not, such as the ability to control evil spirits. As long as he doesn't use his power to hurt other Santal society members, it is considered beneficial. The Ojha is also a doctor who is extremely knowledgeable about the therapeutic qualities of everyday items and drugs. He also asserts that he is able to identify and address the root causes of illness and bad luck. He uses divination and self-possession by a spirit who discloses the nature, cause, and remedial procedures involved in healing the sick in order to support his claim. There is no public compensation for the Ojha'slabor, and his position is not inherited. Only after the individual is cured or the tragedy is eliminated does the specific household that hires him pay. Some anthropologists claim that this Ojha institution is a Hindu adaption. Not every community uses every one of these officials. The size of the village and the volume of requests for their services determine how many officials are really employed there. The headman ultimately determines the number of elders after consulting the village council. The nature of Santal leadership and power is explained by the relationships between the village officials. Village elders are neither subordinates or instruments of the headman's authority, while being answerable to both the headman and the village council, according to field observations and conversations with the leaders and populace. Each elder's responsibilities are typically carried out on their own, as is seen from the Santal custom. Village elders are appointed for life, unless the council determines that a person is either physically incapable of carrying out their responsibilities or morally reprehensible. Although it rarely happens, such tenure can allow these authorities to amass coercive or excessive influence over the locals. First of all, they don't organize into an administrative clique with the goal of gaining more authority. Second, any propensity toward the concentration of power in the hands of any one or a handful of administrative elders is thwarted by the regularity of council meetings and the ongoing efficacy of egalitarian expectations. Village life used to run smoothly under this traditional authority, and the villagers felt secure since they thought they were under the guidance that their forefathers had recommended. This style of Santal leadership has

changed significantly as a result of interactions with external cultures and the slow development of conventional leadership. The only places where traditional authority still operates as it did in the past are a few remote Santal settlements.

The Village Council: "KulhiDurup"

The Santals' traditional village government is so grassroots that the assembly of all the village's adult males eventually has the last say on decisions. Under the direction of the headman, the villagers themselves resolve conflicts, violations of the peace, divorce disputes, and social infractions in the village. Frequently, the Kulhi Durup serves as a sort of conciliation board. All guys are welcome to attend, talk, and usually have lengthy conversations. It is common to bring in good speakers to act as advocates. One Santal saying that emphasizes the value of hearing all sides of an argument is "you cannot cook a cake on side up." As a result, in every conflict, the people must hear both sides. Every head of the household serves as a judge at the Kulhi Durup. The adage "you cannot clap with one hand," which states that the headman cannot resolve a dispute by himself but that the entire village must help, perfectly captures the role of the villagers in decision-making. But the last word is always with the headman. His role as a facilitator at council sessions stems from his duty to preserve the customs of the forefathers. These "Hapramkoak Dustur" traditions serve as the foundation for decision-making. Decisions should ideally reflect a full grasp of the situation, but in practice, discussions frequently fall short of this level. To address some macro-level issues, the Santals created a subregional leadership system in addition to the village-level leadership practiced by the elders and the village council. Pargana is the name of this subregional organization. This organization is no longer in operation.

The Pargana Council

In order to handle inter-village connections, an authority had to be established early in Santal history. This inter-village group developed into the Pargana and its council during their migration and settlement in Damin-i-Koh. A group of villages that accept the jurisdiction of an inter-village council is known as a Pargana. A Pargana typically comprised of ten to twenty villages in a contiguous area, though the exact number of villages was not always consistent. The headmen and chosen delegates from each village in a Pargana made up the inter-village council. Although its rulings had a legislative effect by setting precedents for similar circumstances that later arose, the Pargana assembly functioned as a high court of last resort. Due to the novelty of the issue or a lack of community agreement, the Pargana assemblies typically addressed issues that the local council was unable to settle. A few disputes between the villages also made it to the assembly.

Parganait

One representative from each village was chosen by the Pargana council to be the Parganait. He inevitably rose to become the most prominent and powerful person in the ten to twenty communities. The ability to lead in the preservation of traditional values and possess a thorough understanding of ancestral customs were the most crucial selection criterion for the parganait. This was important since the Parganait was regularly asked to advise the local village councils and elders on Santal customs when issues arose from the difficulties of living in Damin-i-koh.

Desh-Manjhi

During the Pargana Council's deliberations, the Parganait received assistance from the Desh-Manjhi. He was chosen by the Pargana village headmen.

The Annual Hunt Council

The Lo Bir, also known as the Hunt Council, is the Santals' highest court of appeal, which meets once a year during the annual hunt or DisomSendra. The dirhi, or hunt superintendent, is in charge of the Lo Bir council. "High Court" and "Parliament" are the names Archer gives to this council. The tribe itself is the ultimate authority, even though the parganas and village headmen are in charge of day-to-day administration. The people must come together in order to exercise their sovereignty. The recognized method of bringing them together is the yearly hunt. Although these councils rarely produce significant changes, they do have the significant benefit of making the current legislation widely known and guaranteeing that the oral code is understood. Even in the most impoverished Santal,

they foster a sense of active democracy and give them the impression that the rules are their own, not imposed by others.

The Breakdown of Egalitarian Value

The collapse of the Santal egalitarian values has been aided by increased external connections with the dominant society. The caste system-based dominant society upholds the ideas of inferiority and inequity. The significance of this virtue has steadily been eroded by untouchability and other forms of social discrimination that are prevalent in the prevailing culture. The collapse of this value has also been exacerbated by the unfair treatment received in government offices, village markets, workplaces, and other public settings. The significance of this egalitarian value has likewise been significantly diminished by educated Santal leaders. With their newly gained social skills, knowledge, and abilities, educated Santals are attempting to improve their level of living relative to other Santals. Members of a homogeneous group are becoming more and more diverse as a result of this attempt to create a new status in Santal culture. The significance of egalitarian values in Santal culture has been undermined by their extent of influence and abrupt ascent to power without the approval of the ancestors' traditions. This egalitarian ideal has been undermined in part by the Block administration's establishment of development agencies.

Village Oneness (AtoSagai)

"Village oneness" (AtoSagai) is a second key concept that the Santals share. This unity can be observed in mixed villages where the Santals are a minority as well as in villages where they make up the majority. This sense of community unity gives Santals a sense of identity and security. They distinguish themselves from other ethnic groups by demonstrating their community unity. Their distinct values, traditions, and mores are safeguarded, preserved, and passed down through this unity. Additionally, this unity guarantees them a comfortable life and an ongoing web of social connections. Collective responsibility and communal rights are the foundation of village unity. The Santal tradition prioritizes the interests of the village over what can be regarded as individual rights whenever decisions about land use are made by the village headman and his council. The obligations known as "Santal" serve to restrain personal inclinations and financial incentives. Worship and festivals, personal rituals and ceremonies, group drinking customs, and agricultural and associated economic activities are some of the ways that the Santal community expresses its unity. Opportunities to foster village unity are constantly presented by these social and cultural forces. Santhals have a strong sense of unity. The yearning for their own grand tradition to unite all Santhali people has long existed and has only grown in recent years (Bandopadhyay, 2019).

Worship and Festivals

In addition to ensuring and fulfilling religious sentiments and goals, worship and festivals as community events offer numerous chances to establish and fortify social institutions and bonds. It is customary for all homes to participate in the village-wide worship of the village spirits, known as Jaher Bongas. Because of how crucial this local worship is to its unity, Santals from other villages—even if they are related—are not allowed to take part. No two villages have the same Jaher Spirits, even if the spirits of the sacred grove are the identical for all Santals residing in various villages. Only the residents of a specific hamlet are eligible to participate in this worship. Every big festival is attended by the entire village. The village assembly chooses when and how the festivities will be celebrated. Each household is expected to contribute a percentage of the supplies required for the feasts and worship ceremonies that make up the entire festival. Nothing is bought; the Godet (village messenger) and designated others go from house to house requesting complete cooperation. They gather everything for the entire village, including chosen leaves, straw mats, driedcowdung for fire, salt, rice, pulse, meat, and drink (Handi). The celebration of every worship and festival affirms the unity and oneness of the Santal village.

Individual Rites and Ceremonies

The turning points in the life-course of an individual Santal are the critical occasions of birth, initiation, marriage, and death. All of these life stages are issues that affect the entire community, not just the family. The families involved as well as the village as a whole benefit from the rites and ceremonies performed on these occasions. The birth of a child defiles and taints not only the specific home but the entire village. The Bongas (spirits) of the sacred grove are said to

become defiled. No festival or any Bonga worship is held in the village until the purification ceremony is observed. In the same way, when a Santal dies, his house and the entire village become polluted. The village is bereft of its protective spirits, and the household is deprived of the care of its Orak Bongas (household spirits). No marriages, festivals, nor any public worship can be performed within the village until the funerary rites have been performed. Traditional festivals, such as performing arts and religious ceremonies, are becoming increasingly popular as a means of preserving cultural identity and promoting social solidarity (Barai, 2019).

Communal Drinking

Another social mechanism for strengthening and continuing village oneness is the social drinking, which is an essential part of every Santal worship, festival, ritual, hospitality, decision-making process. Discussing the alcoholic consumption pattern of tribes in general the tribal people drink for social integration and as a token of social solidarity and unity. Political parties and religious reformers have paid close attention to the negative aspects of drinking and its effects on the socioeconomic sectors.

Agriculture and Related Economic Practices

The Naeke (priest), on the behalf of the village community, decides upon a day and the time for invoking the JaherBonga and calling Maran Buru for winds and rain. At home each household offers sacrifices to the household (KhuntBongas) requests a rich harvest. The sowing is first conducted by the Naeke (Priest), followed by each lineage. In this phase, the agricultural activity first starts in the name of the community(JatiaPera) and is followed by every individual household. Agriculture especially paddy cultivation, is the chief source of livelihood of the Santals. Agriculture gives the full rhythm and measure of the seasonal sequence of the year. It is something more than just a means of livelihood: it is a whole way of life. It unites an entire family and a village in a single task. Agricultural practices and other related activities are conducted in unison, and for this, each individual has to make adjustment for this corporate endeavour.

Santal's Traditional Collective Marriages Rituals

The Santal society's traditional marriages rites are a powerful manifestation of its social structure, cultural identity, and values. These deeply meaningful rituals honor ancestors' customs and foster closer community bonds. The focus on community is central to Santal marriage rites. Not only do the bride and groom's family attend weddings, but the entire community does as well. This group participation emphasizes the value of mutual aid and social solidarity, reaffirming the idea that marriage is a connection that unites two families and their communities in addition to two individuals. A social fabric is strengthened and a sense of belonging is fostered by the active engagement of friends, family, and villages (Ghosh, 2018). The marriage ritual includes a variety of sacrifices to deities, which represent thanks and a plea for benefits. These sacrifices might range from food to cattle, demonstrating the Santals' reverence for their spiritual beliefs and ancestral traditions. By performing these rites, the couple requests heavenly favour for a fruitful and harmonious life together. This spiritual aspect of marriage highlights the interdependence between daily living and religious traditions in Santal culture. Santal marriages rely heavily on unique courtship customs. These techniques promote mutual agreement and family approval, which are critical components in developing harmonious partnerships. Traditionally, families discuss the match, emphasizing the value of family ties and compatibility. This emphasis on consent demonstrates a dedication to preserving domestic peace and social stability (Singh, 2020). Exchanging gifts, such as animals, money, or other assets, is an important part of Santal weddings. These presents serve several functions: they show respect between families, develop interpersonal relationships, and reflect the financial aspects of marriage. The exchange of presents can also indicate social rank, with the value of the gifts frequently reflecting families' standing in the community. This practice supports the notion that marriage is not only a personal relationship, but also a significant societal commitment. The bride and groom wear traditional clothes that have cultural significance. Their dress represents their heritage, representing pride in their identity and the move from single to married life. The outfit frequently contains brilliant colours and intricate designs, highlighting the workmanship and artistic expressions of the Santal. Celebratory dances and music are fundamental to Santal weddings, representing joy and cultural history. These performances are not only amusing, but also help to bring the community together in celebration, reinforcing cultural traditions and collective memory. Music and

dancing communicate shared delight, emphasizing the necessity of social cohesiveness throughout key life events. Specific rites, such as tying the nuptial knot, represent the couple's commitment and loyalty. This act represents the binding aspect of marriage and the duties that go along with it. It highlights the idea that marriage is a lifetime commitment founded on love, trust, and mutual support. Following the wedding, practices such as visiting the bride's family strengthen kinship bonds and ensure continued support from both sides. These rituals emphasize the interdependence of families and the need for maintaining strong relationships after the wedding (Tribal Research Institute, 2021). Santal marriage ceremonies encompass a diverse range of cultural, spiritual, and social components. They help to establish communal relationships, honor ancestral customs, and reflect the ideals that define Santal identity. These rites allow the Santal people to commemorate individual partnerships while simultaneously reinforcing their collective heritage and communal integrity.

CONCLUSION

The collective action of Santal tribe necessarily entails the examination of the Santal culture system, its notions, values, beliefs and conventions. The influence of a culture is decisive when the community studied exists as a highly stratified and homogenous group. Historically the Santal people managed to persistently preserve their distinctive ethnic identity and homogenous character. Collective action of Santal tribe to a large extent influence and determine the personal and social characteristics of tribe. A Santal in his cultural setting first learns the values, expectations, and prohibitions of his community. A Santal develops a basis for establishing relationships with others by adopting the existing models of relationships that are available in the community. Therefore the collective actions of the community determine and order priorities and aspirations of the individual members of the community.

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RESEARCH ARTICLE

IoT-Enabled Smart System for Hair Health Analysis and Monitoring

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ABSTRACT

This research presents the design and evaluation of an IoT-based system for continuous monitoring and assessment of hair and scalp health. Traditional methods of hair care and diagnostics often lack real-time capabilities and fail to provide comprehensive data. To overcome these challenges, we developed a comb-shaped device equipped with capacitive and environmental sensors to measure key parameters like scalp moisture, temperature and humidity. The Internet of Things integration enables seamless data transmission to a cloud platform, facilitating real-time monitoring and long-term tracking of hair health. This system offers a non-intrusive, cost-effective solution for both personal and clinical use, delivering timely feedback and recommendations through remote access. The proposed IoT-based approach represents a significant advancement in hair care technology, offering enhanced personalization and efficiency in hair health management.

Keywords: Internet of Things (IoT), Scalp health monitoring, Wearable sensors, Arduino.

INTRODUCTION

Human hair, despite its reduced functional role, retains significant emotional and social importance. Its complex keratin-based structure offers strength and flexibility, with properties varying widely across different ethnic groups and individuals. Understanding these variations is essential for developing effective hair care solutions and technologies. Recent advancements in non-invasive technologies, such as capacitive imaging systems, have provided valuable insights into hair health and cosmetic conditions. These technologies allow for precise measurement and analysis of hair properties, offering critical data for clinical, cosmetic, and forensic applications. Accurate monitoring

of scalp conditions, including temperature and moisture, is vital for maintaining a healthy scalp. This study introduces an IoT-based hair quality detection system—a comb-like device equipped with advanced sensors designed to measure scalp moisture, environmental conditions, dandruff, and hair roughness. By integrating capacitive imaging and various sensor technologies, such as humidity and temperature sensors, the device offers comprehensive data on scalp and hair health [1][2].The IoT integration enables continuous, real-time monitoring and data transmission to a cloud-based platform, allowing for remote access and long-term tracking of hair and scalp conditions. This innovative approach aims to enhance scalp health management by providing timely, personalized insights, ultimately contributing to more effective hair care solutions.

SYSTEM ARCHITECTURE

The IoT-Enabled Hair Health Analyzer measures hair and scalp parameters using multiple sensors connected to a microcontroller and integrated into an IoT platform for real-time analysis. The architecture comprises:

Sensor Layer

- **Capacitive Sensors**: Detect hair thickness and surface properties.
- **Photo-sensor (QRB1114):** Measures optical properties like reflectivity and texture of hair.
- **LM35 Temperature Sensor:** Monitors scalp temperature, detecting potential issues.
- **DHT11/DHT22 Sensor:** Tracks ambient temperature and humidity for environmental context.

Processing Layer

- **Arduino Nano:** Central processor that collects and normalizes sensor data, sending it to the IoT platform for analysis.

Communication Layer

- **Wireless Module (ESP8266/Bluetooth):** Facilitates real-time data transmission to the cloud or mobile devices.

IoT Platform Layer

- **Cloud Platform:** Stores, analyzes, and visualizes data, providing insights into scalp and hair health conditions.

User Interface Layer

- **Mobile/Web Application:** Displays real-time data and recommendations to users in a user-friendly interface.
- **Data Flow:**
    1. Sensors collect hair and scalp data.
    2. Arduino Nano processes and transmits data via a wireless module.
    3. IoT platform analyses and stores data.
    4. User interface displays results and insights in real-time. This streamlined system provides continuous, real-time monitoring of hair and scalp health for better care and early issue detection.

LM35/DHT Temperature Sensor

The LM35 is an analog temperature sensor commonly used in various temperature measurement applications. It provides accurate and linear temperature readings and is widely used in both academic and industrial projects.The DHT series (DHT11/DHT22) are digital temperature and humidity sensors commonly used in various environmental monitoring applications. These temperature sensors play an important role in the IoT-Enabled Hair Health Analyzer by providing accurate temperature readings [3][8].

LM35

This sensor delivers highly precise readings of the scalp's temperature. It is perfect for monitoring the scalp environment, as it can directly record the temperature in °C without any additional calibration. In the Hair Health Analyzing system, the LM35 helps in measuring the temperature of the scalp, which can give indications of hair

conditions like dryness, excess heat, or other scalp health issues. The collected data is then processed by the Arduino Nano to ensure real-time temperature monitoring, which adds valuable context to overall hair health diagnostics.

DHT11/DHT22

The DHT series sensors are used to measure both temperature and humidity, which makes them most appropriate for environmental data collection. The DHT11 is a basic sensor. It has a moderate accuracy, while the DHT22 provides higher precision. These sensors installed in the Hair Health Analyzer system are used to observe the ambient temperature and humidity around the scalp. These factors are directly related to the hair and scalp health. High humidity levels can lead to moisture buildup, while low levels may cause dryness, both conditions are harmful and play a major role in hair damage[4].

Photo-sensor

The QRB1114 is a reflective object sensor, commonly known as a photo-sensorthat is integral to systems requiring precise object detection or measurement, such as the IoT-Enabled Hair Health Analyzer. Optical properties of hair like hair thickness, surface texture and reflectivity are very important as per the point of view of hair health. For the assessment of optical properties of hair or to detect hair strands for quality analysis, the QRB1114 can be utilized in the Hair Health Analyzer system. This photo sensor is integrated with the Arduino Nano. The combination of these is used to detect variations in different optical properties. The values of these properties are recorded on the basis of the amount of IR light reflected back from the hair strands [4]. Then we process the collected data for the overall assessment of hair health. The infrared (IR) emitter and phototransistor are combined in a compact package. By measuring the reflected IR light, the combination detects the changes in different surface properties. The addition of the QRB1114 sensor increases the system's capability to capture **non-contact measurements**, providing accurate, real-time feedback at the same time it is energy-efficient and compact. It increases the precision of the analyser, particularly when applied in such situations where physical contact may affect the hair's natural properties or distort the readings [5].

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Arduino-Nano

The Arduino-nano is an open-source microcontroller platform based on hardware and software. It is applied from simple to complex applications during building any electronics based project. The Arduino Nano is a compact, versatile microcontroller board that plays a Crucial role in IoT-based systems, like the IoT-Enabled Hair Health Analyzer[6]. In the Hair Health Analyzer system, the Arduino Nano serves as the controlling. It records data from various connected sensors like capacitive sensors used to detect hair thickness, DHT11/DHT22 for determination of humidity and temperature, and LM35used for scalp temperature measurements. It is equipped with an ATmega328P microcontroller, which makes it suitable for projects requiring a small footprint, low power consumption, and ease of use. Its features, such as multiple digital and analog pins, allow seamless integration with sensors and other components.

- The microcontroller processes this sensor data and sends it to an IoT platform or user interface for further analysis and visualization, contributing to real-time hair health diagnostics.
- The use of Arduino Nano makes the system easily programmable, reliable sensor communication, and a power-efficient operator, which are essential in portable IoT-enabled solutions.

METHODOLOGY

Sensor Calibration and Validation

Calibration: Each sensor (DHT11, LM35, RGB) is calibrated to ensure ac

- accuracy in data collection.
- **Validation:** Sensor data is validated against known standards to confirm reliability and precision.

Data Analysis Techniques

- **Descriptive Analytics:** Summarizes data to provide a snapshot of current environmental conditions and hair quality.
- **Predictive Analytics:** Utilizes machine learning algorithms (e.g., regression models, neural networks) to predict future hair quality trends based on historical data.
- **Prescriptive Analytics:** Provides actionable recommendations for users based on the analysis of sensor data.

PROPOSED SYSTEM

Hair quality is influenced by a variety of factors including environmental conditions, temperature, humidity, and aesthetic elements such as color and shine. The integration of Internet of Things (IoT) technology into hair care presents an opportunity to continuously monitor and analyze these factors to provide actionable insights for personal hair health management. This research proposes an IoT based system that utilize LM35/DHT sensors, along with RGB lighting, to create a comprehensive hair quality analysis framework.

Components used:

- **LM35/DHT Sensor**
  - **Purpose:** Measures ambient temperature.
  - **Function:** Monitors temperature variations affecting hair texture and strength.
  - **Integration:** Provides data on temperature extremes that can lead to hair damage, complementing the findings of Kumar *et al.* [2].
- **RGB Lighting Sensor**
  - **Purpose:** Analyzes hair color and shine.
  - **Function:** Evaluates aesthetic factors indicative of hair health.
  - **Integration:** Captures data on how light reflects off hair, aiding in the evaluation of color and shine as discussed by Sharma *et al.* [3].

The image is showing the sensor integration and the basic workflow for the IoT-Enabled Hair Health Analyzer. It clearly outlines how various system components interact to measure and analyse different factors for hair and scalp health. The detailed description is as follows:

System Workflow Description

1) **Hair Comb:** The process is initiated by using hair comb. The primary function of comb is to prepare the hair for analysis. It ensures that the hair is free of tangles or obstructions, which enables sensors to collect accurate data.
2) **Sensors:** The sensor array includes various sensors crucial for the evaluation of hair and scalp properties:
   a. **LM35 Temperature Sensor:** Detects any hair related issues by Measuring the scalp's temperature.
   b. **DHT11/DHT22 Sensor:** Used to Monitors the surrounding environment by measuring the ambient temperature and humidity levels, factors that can impact hair and scalp health.
   c. Capacitive Sensors: Detects the different physical characteristics of hair like thickness and surface properties.
d. **QRB1114 Photo sensor:** It is used to Analyze the optical properties of the hair, such as surface texture and reflectivity.
3) **Sensing Mechanism:** With the integrated sensor array, data pertaining to the condition of both the hair and scalp is sampled in real time using the sensing mechanism. The sensors, when used in combination, provide complete physical, thermal and environmental analysis of the health of the hair.
4) **Hair Health Analysis:** The received sensor data is utilized for further examination of the hair and scalp. This data is processed to develop insights on hair's condition, issues with the scalp, and other factors which may correlate to the health of the hair. These insights can be accessed through a mobile or web application for monitoring purposes.

Overall System Flow

The process starts with the user commencing their hair routine of combing their hair, then moves on to the collection of data through sensors regarding the user's scalp and hair. This is all captured in the final sensing step, which integrates all the collected information for further analysis on the user's health. This covers the information IoT systems provide on real time, effortless, and precise monitoring of one's hair and scalp injuries. The objective's integration of various sensors guarantees for the best results on the hair's health condition and gives the users opportunity to make the correct choice at the right moment.

Data Collection and Transmission

- **Real-Time Monitoring**
  - Sensors continuously collect data on temperature, humidity, and hair color.
  - Data is transmitted to a controller unit via networking protocols (e.g., MQTT or HTTP).
- **Data Processing**
  - Collected data is processed using cloud-based analytics.

User Interface

- **Mobile Application**
  - Displays real-time data from sensors.
  - Provides visual representations of environmental conditions and hair quality metrics.
  - Offers personalized recommendations based on sensor data.
- **Alerts and Notifications**
  - Users receive alerts when sensor data indicates potential issues (e.g., high/low humidity or temperature).
  - Recommendations are provided to mitigate adverse conditions and improve hair health.

System Integration

- **IoT Connectivity:**
  - Utilizes IoT platforms for data transmission and management.
  - Ensures remote accessibility and control over the hair quality monitoring system.
- **Cloud Storage and Analysis:**
  - Data is securely stored in the cloud.
  - Cloud-based analytics processes large volumes of sensor data, enabling scalable and efficient analysis.

CONCLUSION

The incorporation of photo-sensors and temperature sensors in an IoT-based hair quality analysis system shows great promise in evolving technology within the personal care domain. These sensors capture real time information from the environment, such as temperature and humidity, which are critical for maintaining good health of the hair [5]. Studies emphasize the need for controlling these variables to avoid hair damage and ensure general well-being. Enhanced real-time data processing allows the system to automatically track and adapt to the changes in the environment, which optimizes the management of hair care practices. The inclusion of RGB lighting in conjunction with DHT11 and LM35 sensors further enriches the system by enabling the evaluation of aesthetic factors, including hair color and shine. This multifaceted approach not only assesses environmental influences but also provides insights into the visual quality of hair. The synergy between these technologies contributes to a comprehensive understanding of hair health, allowing for personalized recommendations and refined hair care routines [3]. Advancements in sensor technology and real-time analytics are pivotal in enhancing the accuracy and effectiveness of hair quality analysis. Future research is anticipated to focus on improving sensor precision and developing more sophisticated IoT-based systems [7]. These developments are expected to offer even more accurate and actionable insights, thereby expanding the capabilities of hair care management solutions. In summary, the proposed IoT-based hair quality analysis system represents a significant leap forward in personal care technology. By integrating DHT11

and LM35 sensors with RGB lighting, the system provides a holistic approach to monitoring and managing hair health. The combination of real-time data processing and personalized feedback empowers users to make informed decisions about their hair care routines, leading to improved hair quality and overall health. Future research will continue to advance sensor technologies and data analysis techniques, further enhancing the system's functionality and effectiveness.

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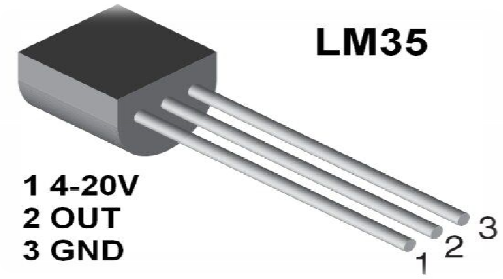


Figure 1: LM35



Figure 2: DHT

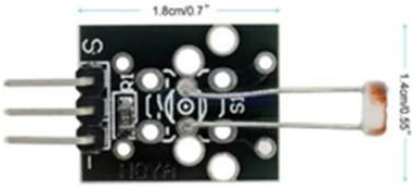


Figure 3:- Photo Sensor

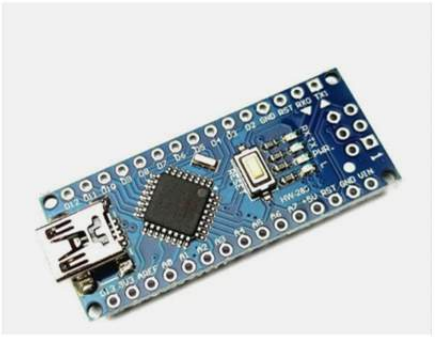


Figure 4: -Arduino

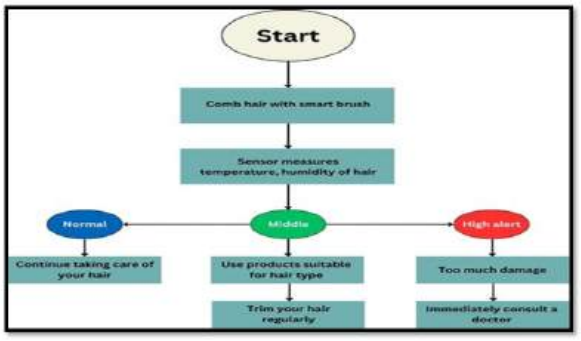


Figure 5: - Flowchart

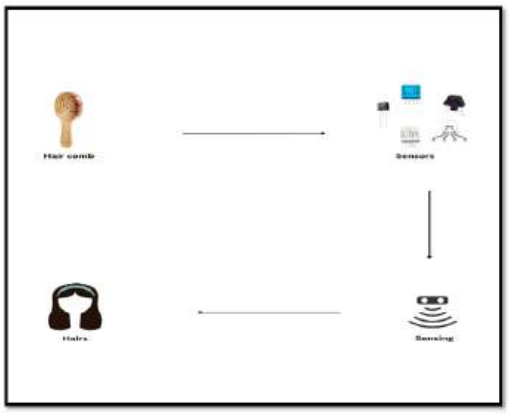


Figure 6: - Proposed Design Flow

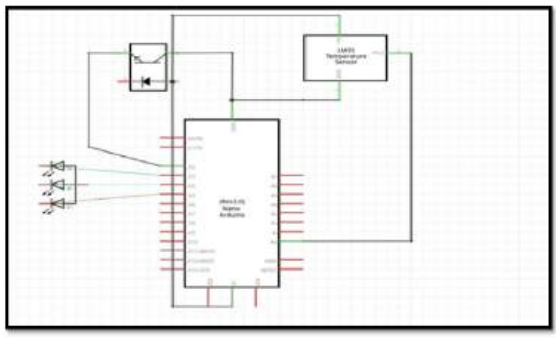


Figure 7: - Proposed Schematic

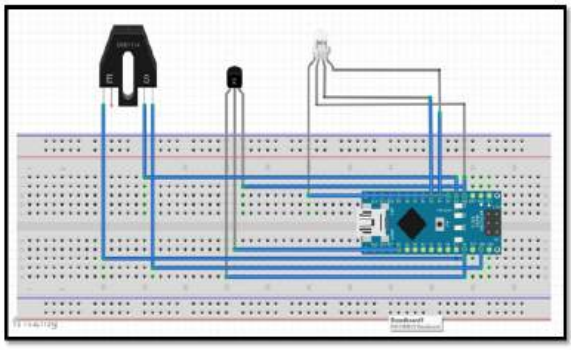


Figure 8: Proposed Design Circuit

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RESEARCH ARTICLE

The Intersection of Cyber security and Digital Forensics: A Comprehensive Guide to Safeguarding Computer Systems and Data

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ABSTRACT

Digital forensics, or the process of detecting, storing, evaluating, and presenting digital evidence, has become critical in combating cybercrime, data breaches, and other digital security challenges. As digital technologies evolve, forensic professionals face new obstacles when dealing with rising trends like cloud computing, the Internet of Things (IoT), cryptocurrency, and artificial intelligence. These technologies generate huge volumes of data, use advanced encryption methods, and build decentralized infrastructures, complicating forensic investigations. Because of the growing use of blockchain-based systems for criminal transactions, cryptocurrency forensics has emerged as a critical area of attention. Investigators must track and understand transactions, which, while publicly recorded, are frequently anonymized. Artificial intelligence and machine learning are being used to improve forensic processes by automating data analysis and anomaly detection, making forensic investigations faster and more accurate. This paper emphasizes the importance of improving forensic procedures to keep up with technological changes, provide strong Cyber security frameworks, and enhance law enforcement capabilities. Future directions include standardizing methodology, collaborating with legal systems to handle jurisdictional problems, and continuing to create AI-powered tools for effectively processing large amounts of data in digital forensics.

Keywords: Cyberattacks - Anti-forensics - Cyber dangers - Digital forensics.

INTRODUCTION

Digital forensics, an important part of information technology, is critical for detecting and mitigating cyber-attacks. This profession, which is closely tied to computer forensic science, requires rigorous techniques to gather, analyze, and archive digital evidence. This paper examines the complexities of digital forensics, shedding light on its components, procedures, and undeniable value in protecting digital data and systems. This paper looks into digital forensics' complexities, giving light to its components, procedures, and indisputable value in protecting digital data and systems. However, its societal impact is significantly higher. Digital forensics has been around since the 1980s, making it a relatively recent profession. Despite its relatively recent start, the field has come a long way. It has gradually evolved into a crucial component of law enforcement, cybersecurity, and court proceedings. Its establishment and success have benefited the entire community.

CYBERSECURITY: PROACTIVE DEFENCE

Proactive cybersecurity comprises looking for threats and discovering vulnerabilities in your security posture before an event or breach occurs. Thus, offensive cyber capabilities can be developed in partnership with industry and aided by the private sector; these activities are frequently conducted by nation-states.

Network Security Architecture

A security mastermind is responsible for relating and mollifying implicit cyber pitfalls to an association's network and systems. As part of their position, security engineers should produce a network and security armature that gives the visibility and control needed to describe and respond to cyber pitfalls in an association's systems. This includes contriving a strategy for locating security controls to maximize their value to the establishment. In digital forensics, network security architecture plays a critical role in ensuring that evidence is properly preserved, collected, and analyzed. It serves as the foundation for detecting, responding to, and investigating cyber incidents, allowing forensic investigators to trace back attacks and gain a comprehensive understanding of how they occurred.

Encryption and Data Protection:

Crypto is a serious subject that presents both obstacles and opportunity to digital forensics investigators. Investigators must find ways to decrypt or bypass encryption to access critical data, often using forensic tools or by obtaining decryption keys through legal processes. During the inquiry, digital forensic professionals deal with sensitive and confidential information. Protecting this information is critical to preventing hacking or leaks. Protecting the data entails keeping a clear chain of custody, documenting who has accessed the evidence, and verifying that it has not been changed.

DIGITAL FORENSICS: REACTIVE INVESTIGATION

Reactive investigation is the traditional or posthumous fashion to probe digital crimes after they've passed. This includes relating, conserving, collecting, assaying, and preparing the final report. This element gathers two feathers of substantiation.

- Active substantiation is the collection of all live(dynamic) substantiation that exists following an incident. Processes executed in memory are an illustration of this type of substantiation.
- Reactive collects all remaining stationary substantiation, similar to a hard drive image.

Data Analysis and Recovery

Data recovery is the process of rescuing, retrieving, or restoring data that is inaccessible, lost, corrupted, damaged, or formatted on storage media such as hard disks, USB drives, or memory cards. This process can be carried out on a variety of platforms, including computers, smartphones, and other digital devices. Data is raw information, and data analysis is the methodical process of analyzing and translating it into useful insights. In a data-driven environment, analysis entails using statistical, mathematical, or computational methods to uncover patterns, trends, and correlations from databases. It entails using numerous approaches and tools to extract useful insights from raw data, which aids in recognizing patterns, trends, and relationships within a dataset.

Evidence Collection and Preservation

Those in charge of obtaining and collecting evidence should prioritize evidence preservation. Both pre-collection and post-collection evidence are collected using the same techniques. Evidence that has not been adequately kept before gathering may be contaminated or destroyed. Before disturbing the scene to gather larger, heavier, or less delicate substantiation, an investigator should meticulously gather the most delicate substantiation first. An investigator should use sterile instruments akin to tweezers to gather evidence in an aseptic, meticulous, and precise manner.

Best Practices for Integrating Cyber Security and Digital Forensics

Safeguarding computer systems and data requires efficient integration of digital forensics and cyber security. This integration guarantees that systems are safe from assaults as well as the ability to efficiently collect and evaluate the evidence in the event of an incident.

Implemented Automated Tools and Processes

Automated forensic technologies, such as EnCase, FTK, and Autopsy, help investigators speed up the process by quickly producing forensic photos, retrieving lost data, and analysing massive amounts of digital evidence. Furthermore, automated techniques allow for speedier discovery of important evidence across large datasets, such as network logs and email archives, minimizing the time required for manual examination.

Fostering Collaboration between Security and Forensic Teams:

Collaboration between security and forensic teams is critical for successful incident response and threat mitigation. Organizations can promote regular communication and collaborative training sessions to ensure that both teams understand each other's roles and responsibilities, resulting in a more integrated approach to security incident management. Sharing tools and procedures can also increase investigative efficiency and overall security posture.

DIGITAL FORENSICS DOMAIN AND ITS IMPACT

As technology advances, so do the tools and procedures needed to meet the complex and diverse difficulties confronting digital forensic investigators. Working in digital forensics might involve a variety of jobs and obligations, depending on the profession in which they operate. Some of the most popular types of digital forensics are:

Network Forensics

The study of computer-to-computer communication on networks is called network forensics. It verifies the data that travels across computers. This facilitates the investigation of possible computer-related crimes. The primary task of network forensics is to locate and preserve digital evidence that can be utilized as evidence in court.

Computer Forensics

Computer forensics is a scientific process of inquiry and analysis used to collect evidence from digital devices, computer networks, and components suitable for presentation in a court of law or legal authority. Computer forensics combines law and computer science to collect and analyze data from computer systems, networks, wireless communications, and storage devices for admissible evidence in court.

Database Forensics

Database forensics is a branch of forensic science that specializes in preserving and analyzing artifacts from relational and non relational database platforms. This inquiry attempts to audit and test the database for correctness, as well as validate the behaviours of a certain database user.

Email Forensics

Email forensics is a subset of digital forensics that focuses on investigating emails to acquire evidence in cybercrime, fraud, and legal matters. Recent developments in the subject are driven by the need to resist sophisticated email-based threats including phishing, spoofing, and ransomware.

Cloud Forensics

Cloud forensics is rapidly expanding to meet the problems provided by increasingly complex cloud settings, as well as the demand for faster, more efficient, and legally compliant forensic investigations. Due to the worldwide nature of cloud services, legal and jurisdictional difficulties occur, therefore digital forensics professionals must be familiar with a wide range of data privacy legislation.

IMPROVING FORENSICS PROCEDURES:

Improving forensics procedures entails improving both the technological and procedural aspects of forensic investigations in order to get more accurate, efficient, and dependable results. This encompasses everything from evidence gathering to analysis and reporting.

- Create clear, established protocols for evidence gathering, management, and analysis. Ensure that these protocols are thoroughly recorded and easily accessible to all forensic personnel.
- Provide continual training for forensic specialists to ensure they are up to date on the newest processes and technologies. Conduct regular workshops and simulations to ensure that the protocols are understood.
- Maintain a strict chain of custody to document every person who handles the evidence. This guarantees that evidence is not compromised and that its integrity is maintained.

BEST CYBER SECURITY FRAMEWORK

(NIST) FRAMEWORK

NIST stands for National Institute of Standards and Technologies. The NIST CSF has been widely implemented due to its flexibility and applicability across sectors. The framework is constantly updated to reflect emerging threats and technology. The next generation of cyber security must concentrate on quantum risks as quantum computers become powerful enough to break traditional encryption methods.

Key Features

- Five fundamental functions: identification, protection, detection, response, and recovery.
- Designed for businesses of any size and industry.
- Integrates seamlessly with existing cybersecurity standards and best practices.

Future Applications

NIST's adaptability will help enterprises stay resilient against sophisticated threats such as ransom ware and AI-driven attacks.

Challenges

Addressing these issues through enhanced advice, automation, and integration with privacy and threat intelligence frameworks would assist firms in better managing future cyber security threats.

Core Program

Research, Development, and Specifications

- Security Mechanisms: protocols, cryptography, access control, auditing/logging, and applications.
- Maintain confidentiality.
- Integrity and Availability.

NIST Focus

Computer Security Division: Standards, Guidance, Tools and Metrics.

- The National Initiative for Cyber security Education provides cyber security outreach and education.
- Improving Critical Infrastructure Cyber security: An Executive Order.

CHALLENGES AND SOLUTIONS

Encryption and Data Access Challenges

Challenges

One of the most significant challenges to digital forensics is the widespread usage of strong encryption. Investigators may be unable to access data on encrypted devices or communications without the necessary decryption keys.

Solutions

One of the most significant challenges to digital forensics is the widespread usage of strong encryption. Investigators may be unable to access data on encrypted devices or communications without the necessary decryption keys.

Growing Volume of Data(Big Data Forensics)

Challenges

The volume of data collected today is staggering. With greater datasets and more complicated systems, digital forensics investigations frequently experience considerable delays and problems sifting pertinent data.

Solutions

- Automated Forensic Tools: AI-powered tools and machine learning algorithms are increasingly being utilized to more efficiently examine large datasets, allowing forensic investigators to filter out unnecessary material and focus on essential evidence.

Anti-Forensics Techniques

Challenges

Cybercriminals are increasingly using anti-forensic measures to conceal or destroy evidence, such as data obfuscation, steganography, file wiping, and malware payload encryption.

Solutions

Artificial intelligence for anti-forensics detection: Artificial intelligence can help detect trends and anomalies that suggest the usage of anti-forensics.

Complexities in Cloud Forensics

Challenges

Cloud forensics presents unique issues, such as shared infrastructures, multi-tenancy, and limited control over data. Traditional forensic techniques frequently fail when applied to the cloud.

Solutions

Cloud-optimized Forensic Tools: New forensic tools, such as Amazon's CloudTrail and Azure Monitor, are being developed expressly for cloud contexts. These tools improve logging and auditing capabilities, enabling more effective forensic investigations.

IoT and Embedded Device Forensics:

Challenges

Forensics of IoT and embedded devices poses a new challenge. These gadgets have limited processing power and storage, which makes evidence collecting and analysis more challenging. Many IoT devices also lack built-in logging and data retention capabilities.

Solutions

IoT forensic tools are being developed to retrieve data from embedded systems, including firmware memory dumps and sensor data. Researchers are working on lightweight approaches to collect and analyze forensic evidence from low-power devices.

CASE STUDIES

Healthcare Organization: Securing Patient Data and Forensics Analysis

Securing client information in healthcare businesses necessitates strong security controls, regulatory compliance, and proactive incident response plans. Forensic analysis is critical for investigating breaches, determining how patient data was compromised, and ensuring appropriate remediation.

Data Breach Evaluation

Forensics assists in determining the scope of the breach, such as how many patient records were exposed, whether the attackers had access to financial or insurance information, and whether sensitive medical data was affected.

CONCLUSION

Digital forensics is critical in modern criminal investigations, acting as a foundation for discovering and evaluating digital evidence in cybercrime, data breaches, and other digital offenses. As technology advances, the profession must constantly develop and adapt to solve the complexity brought on by breakthroughs such as cloud computing, IoT, cryptocurrencies, and AI. These technologies bring both obstacles and opportunities, requiring forensic professionals to create new tools and procedures for dealing with encrypted data, decentralized networks, and massive amounts of data. By encouraging innovation and collaboration among the technical, legal, and law enforcement sectors, digital forensics will remain a key the ever-changing digital landscape, this is a critical component in ensuring justice and combating future dangers.

FUTURE RESEARCH

The use of AI techniques in digital forensics has the potential to alter the industry by increasing inquiry efficiency, accuracy, and scope. As AI technology progresses, several major themes and advancements are expected to affect the future of digital forensics:

AI-TOOLS IN DIGITAL FORENSICS:

Advanced Pattern Recognition and Anomaly Detection

Description

AI will increasingly use sophisticated algorithms to find patterns and abnormalities in data that older approaches cannot detect.

Future Implications

Predictive Analytics: By identifying patterns and trends in massive datasets, AI can forecast possible criminal behaviour.

Enhanced Natural Language Processing (NLP):

Description

Future AI systems will use powerful NLP to understand, categorize, and analyse textual material.

Future Implications

Contextual Analysis: Better context comprehension will make it easier to analyze complex communications and locate useful information.

Standardizing Methodology

Increased Use of Blockchain Technology

Immutable Records: Blockchain technology will be utilized to establish immutable records of procedures and transactions, ensuring transparency and accountability in standardization initiatives.

Protection and ethical concern

Create standardized procedures for balancing privacy rights and forensic investigations, particularly in nations with strict data protection regulations.

Automated Forensic Tools and Validation

- **Current state:** Automated digital forensics technologies are widely employed, however there is a lack of uniformity in their implementation, testing and validation.
- **Future Research:** Create established benchmarks for forensic tools and ensure that they can be tested consistently in various situations.

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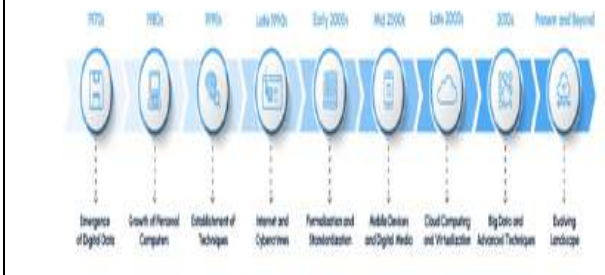


Fig.1. Evolution of Digital Forensics

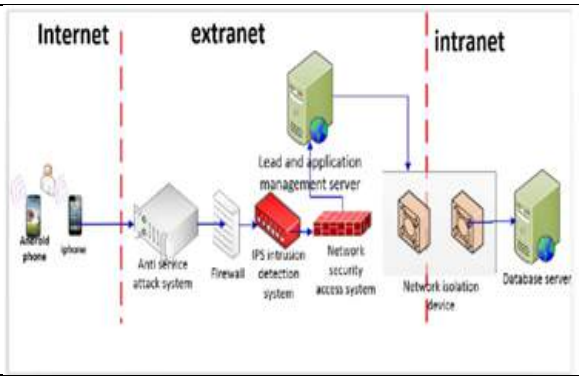


Fig.2. Architecture of Network Security

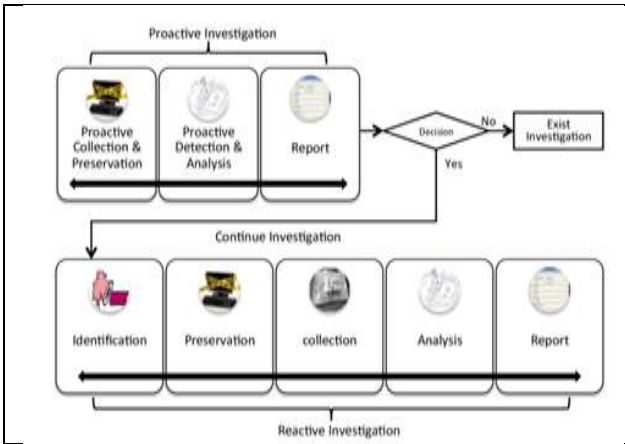


Fig. 3. Digital Forensic Framework

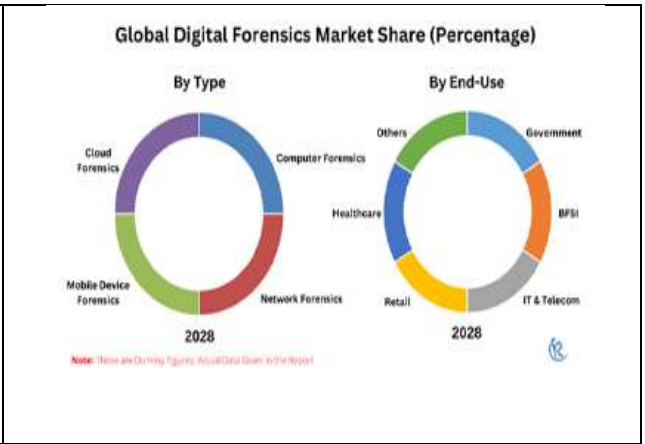


Fig. 4. Digital Forensics Market Value



Fig. 5. NIST Framework

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RESEARCH ARTICLE

Intelligent Stock Market Prediction using A Hybrid ADAMW - Optimized LSTM Model for Enhanced Forecasting Accuracy with Reduced Over Fitting

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ABSTRACT

Accurate modeling of stock market trends along with adequate generalization remains a fundamental requirement for market trend predictions. The proposed research implements AdamW optimizer integration with Long Short-Term Memory (LSTM) networks to confront the overfitting issues present in standard stock prediction systems. AdamW optimizer delivers weight decay separability from gradient updates which enables improved learning stability and generalization when it operates with LSTM. This research performs an extensive performance test among existing solutions like LSTM and AdamW and CNNs to examine network effectiveness for both overfitting reduction and stock prediction precision enhancement. The time-series data performance of LSTM remains effective yet it has high vulnerability to overfitting with small datasets even when using dropout regularization techniques. LSTM performance benefits from AdamW implementation because it enables better management of large parameter spaces. The visual performance of CNNs allows them to resist overfitting behaviors yet they need large quantities of data and augmentation techniques to be effective for stock predictions. The proposed hybrid solution delivers superior results by reaching better predictive accuracy together with reduced overfitting problems when used independently thus establishing itself as a promising stock prediction solution. This research presents evidence about how combining sophisticated optimizers with sequence models shows promise to boost market trend forecasts without encountering fitting problems.

Keywords: Stock Market Forecasting; Hybrid Approach; AdamW Optimizer; Long Short-Term Memory (LSTM); Overfitting Mitigation; Convolutional Neural Networks (CNNs)

INTRODUCTION

Stock market trend prediction remains a sophisticated challenge because of unpredictable market movements which has sparked widespread researcher and practitioner involvement. The fundamental patterns present within financial data frequently elude detection when using traditional forecasting systems based on technical analysis with statistical models. Set indicators used in these prediction approaches prove inadequate for adjusting to fast-market fluctuations. Machine learning (ML) algorithms serve as an emerging effective method which allows models to analyze extensive datasets and detect previously hidden patterns for enhancing forecasting accuracy. People now examine hybrid machine learning methods which combine optimization techniques with deep learning models to reduce overfitting. AdamW operates as an upgraded version of Adam which succeeds in controlling weight decay to stabilize training and strengthen generalization abilities. The integration between AdamW and LSTM networks provides an effective combined methodology that maintains accurate prediction and maintains model stability for stock market forecasting. The joint application controls overfitting while it optimally handles big parameter spaces to achieve effective results on new data samples. The hybrid approach of combining LSTM with AdamW enhances adaptive capabilities to market alterations which improves its forecasting abilities beyond standard forecasting systems. The developed research targets overfitting reduction and sequence learning optimization to create a resilient stock prediction system that improves its accuracy levels. The precise tools developed in this approach help traders make informed decisions that boost their likelihood of obtaining profitable investments. Financial market navigation and forecasting reliability improvement depend heavily on the use of intelligent algorithms according to this research's conclusion.

LITERATURE REVIEW

Overfitting poses a major challenge in machine learning, especially in predictive modeling, where a model performs well on training data but fails to generalize to new, unseen data. This problem is particularly evident when using complex models that have a high number of parameters. As machine learning methods like AdamW, LSTM, and CNN become more popular across different fields, their tendency to overfit necessitates specific strategies for mitigation. Each type of model has its own advantages and disadvantages, making it crucial to understand their behaviors in order to implement effective regularization techniques. Model architectures with optimization algorithms create major performance changes for deep learning systems. The wide adoption of AdamW and LSTM together with CNNs stems from their specific domain advantages. The assessment examines how these techniques perform and the ways overfitting occurs and the available mitigation strategies.

AdamW Optimization and Performance Evaluation

The implementation of decoupled weight decay in AdamW leads to better generalization along with accelerated convergence speed according to research findings [1]. Scientific research has demonstrated that this method effectively reduces overfitting during weight update procedures while performing image classification and NLP operations [2] [3]. Achieving the best possible outcome needs precise adjustment of all parameters [4].

LSTM in Sequential Data Processing

The ability of LSTM networks to handle sequence modeling with time-series forecasting comes from their solution of the vanishing gradient issue [5]. These networks excel better than regular recurrent networks yet developers need dropout and batch normalization to stop overfitting [6] [7]. The merging of LSTM networks with CNN approaches leads to effective models for both listening systems [8] along with stock market solution predictions.

CNNs in Feature Extraction and Overfitting Mitigation

Spatial features become easily accessible through CNNs which makes them necessary for computer vision applications [9]. Each hierarchical model level automatically learns features yet deep networks present the risk of

overfitting which requires overfitting reduction techniques including dropout along with batch normalization and data augmentation [10] [11]. The performance of EfficientNet and ResNet increases through their use of adaptive learning rate systems [12].

Comparative Analysis of Overfitting in AdamW, LSTM, and CNN

Weight decay capabilities of AdamW help reduce overfitting but LSTMs need supplemental generalization elements [13]. Feature extraction through CNNs needs precise architectural adjustments since improper tuning leads to overfitting [14]. Using AdamW with CNNs or LSTMs strengthens model resilience which delivers better results to medical imaging along with financial forecasting systems [15]. To combat overfitting, various strategies are implemented across these models. Early stopping is a technique that halts training as soon as the model begins to overfit, thereby optimizing generalization. Cross-validation enhances model performance by testing it on different subsets of data, which helps reduce the likelihood of memorizing specific training examples. Dropout is another method that mitigates overfitting by randomly turning off units during training, while weight decay discourages large weights, further aiding in overfitting prevention for AdamW and CNNs. Data augmentation is also employed to artificially expand the training dataset, which fosters better generalization, especially for CNNs Through weight decay control AdamW achieves effective optimization but the sequential data processing and feature extraction capabilities belong to LSTM and CNN. Research paths for enhancing deep learning models now focus on implementing AdamW optimization together with CNNs or LSTMs as unified solutions. In summary, effectively managing overfitting across models such as AdamW, LSTM, and CNN is essential for enhancing their generalization capabilities. By using specific regularization methods like early stopping, dropout, weight decay, and data augmentation, along with investigating transfer learning, researchers can strengthen the reliability of stock prediction models. These approaches are crucial for creating dependable prediction systems that can tackle the complexities of financial markets and aid investors and traders in making better decisions.

INTELLIGENT STOCK PREDICTION: HYBRID MECHANISM OF ADAMW AND LSTM

In intelligent stock prediction, the combination of the AdamW optimizer with LSTM (Long Short-Term Memory) networks presents a robust solution for forecasting stock prices while mitigating overfitting. The hybrid approach enhances model performance by leveraging the strengths of both AdamW for effective optimization and LSTM for capturing temporal dependencies in stock market data. Below, we outline the algorithm, computational equations, and reasoning behind the hybrid approach.

Algorithm for Hybrid Approach of AdamW and LSTM

Data Preparation

- **Input:** Historical stock price data (open, close, high, low, volume) for a specified time range.
- **Output:** Preprocessed dataset with features such as moving averages, RSI, etc., used as input for the model.

Steps

Normalization: Normalize stock price data using Min-Max scaling to bring values between [0, 1].

$$Z_{norm} = \frac{Z - \min(Z)}{\max(Z) - \min(Z)}$$ **,,,(Eq.1)**

Feature Engineering

Compute additional features such as: Moving average (MA), Relative Strength Index (RSI), and Bollinger Bands.

Data Split

Split data into training, validation, and test sets.

Model Architecture

Input Layer: Input time-series data (e.g., stock prices and features).

LSTM Layers: Capture sequential patterns and temporal dependencies in stock prices.

Fully Connected Layers: After LSTM layers, a dense layer connects to the output layer.
Dropout Layer: Regularization technique to prevent overfitting by randomly dropping some units during training.
Output Layer: Predicts future stock prices or price change.

AdamW Optimizer

AdamW optimizes the parameters using the decoupled weight decay technique. Objective Function: Minimize the loss function with AdamW's adaptive learning rate.

The weight update rule for the AdamW optimizer is defined as:

$\theta_t = \theta_{t-1} - \rho(\frac{g_t}{\sqrt{v_t}+\varepsilon} + \lambda.\theta_{t-1})$,,,(Eq.2)

θ_t is the parameter at time t.
g_t and v_t are the estimates of the first and second moments of the gradient
η is the learning rate
ϵ is a small constant to avoid division by zero,
λ is the weight decay parameter (regularization term).

LSTM Equation

LSTM networks consist of memory cells that maintain long-term dependencies. The LSTM equations are defined as:

Forget Gate

$G_t = \sigma(W_G . [h_{t-1}, x_t] + b_G)$ …(Eq.3)

where $G_t$represents the forget gate, σ is the sigmoid activation function, W_G is the weight matrix, h_{t-1} is the previous hidden state, and $x_t$is the current input.

Input Gate

$I_t = \sigma(W_I . [h_{t-1}, x_t] + b_I)$ …(Eq.4)

where $I_t$is the input gate controlling which values will be updated in the memory cell.

Cell State

$C_t = G_t . C_{t-1} + I_t . \tanh(W_C . [h_{t-1}, x_t] + b_C)$ …(Eq.5)

where C_t is the current cell state, which stores the information.

Output Gate

$O_t = \sigma(W_O . [h_{t-1}, x_t] + b_O)$ …(Eq.6)

where O_t is the output gate that regulates the output from the cell state.

Hidden State

$H_t = O_t . \tanh(C_t)$ …(Eq.7)

where H_t is the output hidden state at time t.

Loss Function

The loss function measures the discrepancy between the predicted and actual stock price. For regression tasks, Mean Squared Error (MSE) is commonly used:

$MSE = \frac{1}{Z}\sum_{i=1}^{Z}(p_{true}^{(i)} - p_{pred}^{(i)})^2$ …(Eq.8)

where $p_{true}^{(i)}$is the actual stock price and $p_{pred}^{(i)}$ is the predicted stock price.

Training Process

- **Forward Pass:** Input the stock price data through the LSTM layers and compute the predictions.
- **Back propagation:** Calculate the gradient of the loss function with respect to the model parameters and update the weights using AdamW optimization.

- **Epochs:** Repeat the process for multiple epochs until the model converges.

Regularization and Overfitting Prevention

- **Dropout:** Randomly drop a percentage of the LSTM units to prevent overfitting.
- **Early Stopping:** Monitor the validation loss and stop training when the loss starts to increase, signaling overfitting.
- **L2 Regularization:** Applied through AdamW optimizer to constrain large weight values.

Stock prediction becomes more accurate when the AdamW optimizer joins LSTM networks through hybrid application since this method controls overfitting effectively. Stock price predictions in volatile market conditions become achievable through the combination of AdamW regularization features with LSTM temporal learning abilities. Through the implementation of dropout combined with early stopping and L2 regularization the developed model shows good generalization abilities while avoiding overfitting which makes it an effective solution for smart stock prediction tasks.

PERFORMANCE ANALYSIS METRICS

Performance analysis metrics for stock price prediction assess model accuracy, efficiency, and reliability. Key metrics include MSE, training time, prediction accuracy, and overfitting measures.

Mean Squared Error (MSE):

- Measures the average squared difference between the predicted and actual stock prices.
- Lower MSE indicates better prediction accuracy.

Training Time

- The time taken by each model (LSTM, AdamW+LSTM, etc.) to converge.

Prediction Accuracy

- The percentage of predictions within a specified error margin (e.g., 5% error range).

Overfitting Measure

- Difference between training and validation error. A large gap indicates overfitting.

LSTM

The basic LSTM model demonstrates reasonable accuracy, but suffers from overfitting as seen in the gap between training and validation MSE.

AdamW + LSTM

The hybrid approach significantly reduces the MSE, showing improved prediction accuracy. The optimizer's regularization techniques help prevent overfitting, as reflected in the minimal training-validation gap.

AdamW and CNN

These traditional models have higher MSE and lower prediction accuracy compared to LSTM-based methods, highlighting the advantage of deep learning in stock prediction tasks. A performance analysis for the intelligent stock prediction hybrid mechanism based on AdamW and LSTM can be presented through both visual charts and analytical tabulated results to demonstrate performance measurement results. The analysis evaluates the hybrid model together with MSE results and prediction accuracy and training duration while comparing with simple LSTM along with traditional forecasting methods. The process to build the performance analysis chart follows these steps alongside the results tabulation procedure.

CONCLUSION AND FURTHER ENHANCEMENTS

This research demonstrates the efficacy of a hybrid mechanism combining the AdamW optimizer with Long Short-Term Memory (LSTM) networks for intelligent stock prediction. By integrating AdamW's robust regularization capabilities with the sequential modeling strengths of LSTM, the proposed model addresses common challenges such as overfitting and instability in traditional prediction models. The results indicate that this hybrid approach outperforms standalone models, including AdamW, LSTM, and CNN, in terms of accuracy and generalization, especially when faced with limited or noisy data. Through a careful combination of advanced optimizers and sequence modeling, the proposed model provides a more reliable and efficient solution for stock market forecasting. This hybrid mechanism achieves superior predictive performance, reducing overfitting and enhancing robustness, making it a promising tool for financial decision-making and risk management in an ever-changing market landscape. The hybrid AdamW-LSTM model can be enhanced with attention mechanisms, transfer learning, and ensemble learning for improved accuracy. Dynamic hyperparameter optimization further boosts performance, strengthening robustness and prediction capability.

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Table-1: Overfitting Analysis

Model	Overfitting Characteristics	Mitigation Techniques
AdamW	- Prone to overfitting with inadequate regularization. - Overfitting can occur in highly complex models.	- Use weight decay to control complexity. - Adjust learning rate. - Apply early stopping or cross-validation.
LSTM	- Overfitting due to the large number of parameters. - Can memorize the sequence without generalizing.	- Use dropout to prevent memorization. - Apply L2 regularization. - Utilize early stopping.
CNN	- Overfitting in deeper networks with limited data. - High capacity networks may overfit the training data.	- Use dropout, batch normalization. - Data augmentation. - Implement early stopping or regularization techniques.

Table-2: Analysis of the performance of the proposed technique (AdamW+LSTM)

Model	MSE (Validation)	MSE (Test)	Training Time (Epochs)	Prediction Accuracy (%)	Overfitting Measure
LSTM	0.025	0.028	100	90%	0.003
AdamW	0.035	0.037	50	85%	0.002
CNN	0.04	0.042	60	83%	0.003
AdamW + LSTM	0.018	0.02	50	94%	0.002

Table-3: Analysis of Overfitting Risk

Model	Training Accuracy (%)	Test Accuracy (%)	Generalization Gap (%)	Overfitting Risk
LSTM	94	79	15	High
AdamW	92	88	4	Moderate
CNN	91	81	10	Moderate
AdamW + LSTM	96	90	4	Low

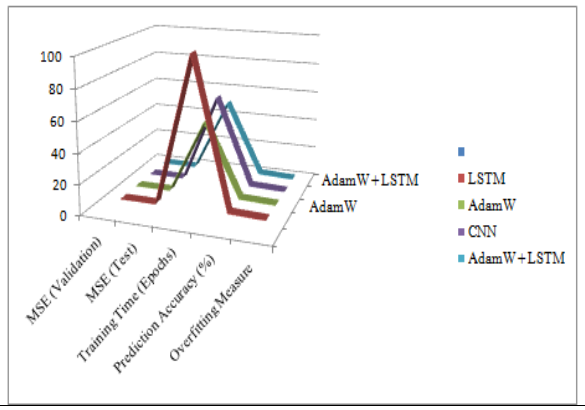


Figure-1: Representation of the performance of the proposed technique (AdamW+LSTM)

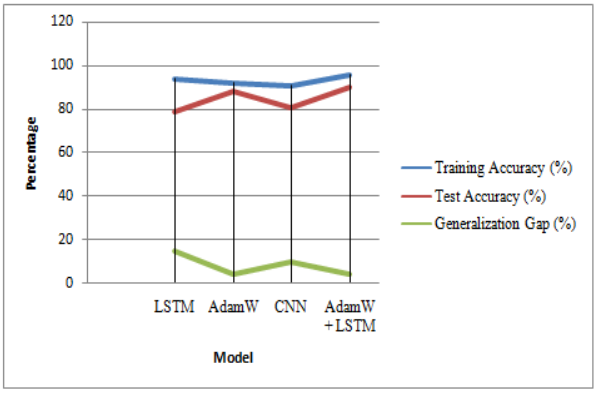


Figure-2: Analysis of Training, Testing accuracy and Generalization gap

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REVIEW ARTICLE

An Effective Plants Disease Prediction System : A Review

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ABSTRACT

Agriculture is a cornerstone of India's economy, providing employment and sustenance for millions of people. As we move towards more advanced farming methods, the adoption of *smart farming* is becoming increasingly essential. This shift is driven by the need to overcome persistent challenges faced by farmers, particularly those related to plant diseases and harmful pests. Effective prediction and early detection of plant diseases are vital for minimizing crop losses and reducing the economic impact on farmers. By identifying diseases at an early stage, farmers can take preventive measures to protect their crops, thereby improving yield and profitability. In recent years, machine learning (ML) and artificial intelligence (AI) have emerged as powerful tools for disease prediction, offering potential solutions to these challenges. Various machine learning techniques have been explored for predicting plant diseases, but there is still much room for improvement. In this review paper, we will examine and compare the current systems for plant disease prediction and discuss future directions for research in this area, aiming to enhance the accuracy and efficiency of these technologies.

Keywords: Image processing, Plant disease detection, Classification, Leaf disease.

INTRODUCTION

A country's development is closely linked to its agriculture and business sectors. Agriculture is crucial as it provides food and raw materials for both humans and the food industry. Since food is a basic necessity, plant diseases become a significant challenge for farmers, potentially occurring at any stage between sowing and harvesting. These diseases can result in major crop losses and economic harm. Therefore, timely disease detection is critical in agriculture.

Researchers have conducted studies on various plant leaves, including those of tomatoes, potatoes, roses, beans, lemons, and bananas, to understand plant diseases. Machine learning has empowered researchers to enhance disease prediction, detection, and recognition systems. Traditional methods of detecting leaf diseases relied solely on human visual observation, which is limited in accuracy and efficiency. Machine learning, a subset of artificial intelligence, enables automated disease detection, improving the precision of these systems. In machine learning, models are trained with data, which can then be used to provide actionable insights. For plant disease detection, features such as leaf color, the number of damaged leaves, and the area affected by disease can be used for classification. To achieve optimal accuracy, researchers have examined various machine learning algorithms to identify diseases across different plant leaves. The process of detecting plant diseases through machine learning involves multiple steps: image acquisition, preprocessing, segmentation, feature extraction, and classification. Each of these stages plays an important role in ensuring accurate detection and diagnosis of plant diseases. [40-45]. Plants fulfill the essential needs of human as well as animals like food, shield, building material, ayurveda medicines, fuels, woods etc and also minimize the air pollution. Environment should be protected by the human from problems n caused by floods, fire, human development etc. Cultivation of plants is important as it gives us the different types of fruits, vegetables, grain, nuts and medicines. We need wood for the construction purpose, furniture, for making paper etc. Bio-fuel production can be done by the decaying of plant as it forms the fertilizer, also used for generating the electricity. The agriculture field deals with many difficulties the big one is losses in crop yield. It affects the economy of the country. Because of plant diseases the quality and also the quantity is being affected. There are many diseases in agricultural plants, if we can control it than we will control the production of wastage. Due to these reasons it will be good to detect diseases timely. Many different methods are there to check diseases are man base and technology base checking. Some diseases can be seen by human eyes. The plant diseases like pathogen, microorganisms which are living, bacterial problem, fungi infected plant, nematodes, viruses affected problems in plants cannot be easily detect by human eyes. We should use some technology. With the help of machine learning technique we will process the images of the plants and try to predict plant disease.

LITERATURE REVIEW

The growth of a country depends on its business and also agriculture. Agriculture provides food and raw materials to the human and food industry. Food is essential need of human and plant diseases are big issue for farmers, it can be happened any time between sowing and harvesting. Plant disease does huge loss of crop and economy. Hence disease detection plays an important role in agriculture. Traditional method for leaf disease detection only is empty eye observation by human. Machine learning can be used for detecting diseases on plants. Machine learning is one of the sub parts of Artificial Intelligence to work automatically or give instructions to do a particular work. In machine learning we have to train the data and fit that trained data into models that it will result in useful information to the human. So we can use machine learning to detect diseases in plants. For the classification we can use colors of leaves, damaged amount of leaves, and area of the unhealthy plant leaf. For best accuracy we overviewed different machine learning algorithms to identifying different plant leaves diseases. Here, we take some of the papers related to Plant leaf diseases detection using various advanced techniques and some of them shown below, Rakesh Kaundal *et. al.* [2006] authors concluded that support vector machine(SVM) based regression approach has led to a better description of the relationship between the environmental conditions and disease level. It could be useful for disease management. A comparison is done between the performance of conventional multiple regression, artificial neural network (back propagation neural network, generalized regression neural network) and support vector machine (SVM).[3] Bashir Sabah *et. al*.[2012] authors proposed disease detection in Malus domestica by the method K-mean clustering, texture and color analysis. Here texture and color features used which are generally appear in affected areas; for the classification and recognition of different agriculture.[8] Sushma *et.al.* (2012) proposed that early detection if disease will help farmers do not use harmful chemicals on plants. In this research first to segregate images then detect pests process quality can be reduced by proposed algorithm.[6] Kulkarni Anand H. *et. al*.[2012] author describes a methodology for early and accurately detect plant diseases by using the combination of textures, color and features to recognize those diseases. Here the proposed approach is to use neural network (ANN) and

diverse image processing techniques. The result of recognition rate is up to 91%.[7] DS Gaikwad *et.al.* (2016) author chooses pomegranate fruit for his examination, very colorful fruit. So using color problem empty eye can be detected. It is being affected very early because of its sweetness. Image processing in the disease detection methodology is used here.[13] Preetha *et.al.* (2016) proposed SVM algorithm for image processing, colors as an attribute in dataset. For classification of data photos author removed the morphological elements.[15] Fenghua Mei *et. al.* [2017] described a wheat disease automatic diagnosis system based on deep learning framework which is weekly supervised, i.e. deep multiple instance learning, which give result on plants image basis is detection of wheat diseases. Wheat Disease Database 2017 (WDD2017) is collected to verify the effectiveness of this system. The proposed system outperforms conventional CNN architectures on recognition accuracy under the same amount of parameters; it also specifies exact location for corresponding disease areas. The proposed system has been packed into a real time mobile app to provide support for agricultural disease diagnosis.[22] Andreas Kamilaris *et. al*.[2018], author discussed and perform a survey of 40 researches efforts that employ deep learning techniques, applied to various agricultural and food production challenges. To study the agricultural problems stated under each work, the specific models and frameworks employed the sources, nature and used dataset and overall performance achieved with help of used methods, comparison of deep learning with other techniques also done. It is stated that deep learning provides high accuracy by using image processing techniques.[25] Konstantinos P. Ferentinos *et. al.*[2018], author discussed about convolutional neural network models were developed to perform plant disease detection and diagnosis through deep learning methodologies using plants leaves images. Training of proposed models was done with the use of an open database of 87,848 images, containing 25 different plants in a set of 58 distinct classes of [plant, disease] combinations. Some models gets success 99.53% in detecting the corresponding combination [plant, disease]. High rate of success model is very usefull to early detection tool and also have possibilities of further expanded by researchers.[26] Budiarianto *et.al.* (2018) proposes Machine Learning techniques for recognition of disease in corn plant which is a main source of carbohydrate. CNN technique is used to improve plant disease. Researcher used different algorithms and use support vector machines (SVM), Decision Tree (DT), Random Forest (RF), and Naive Bayes (NB) to compare the results. By normal seeing of plant we can understand the problem like color difference. Different parameters are used for dataset attribute.[30]

Shima *et.al.* (2018) proposed that plant disease cause decrease in food production. For detection purpose machine learning techniques are used by many researchers like RF processes, SVM processes, K-means processes, CNN processes. The random forest algorithm does the classification. The aim of author is to detect the disease with random forest classifier. We have to convert RGB type images to an HSV types images.[27] Prem *et.al.* (2018) proposed that some symptoms are visible from the eyes are wilting, spot, powdery mildew, galls, and dryness. Different attributes are taken in dataset, different techniques are used and different plots like box plot, bar plot are performed. With the help of statistical tests the prediction is done on inbuilt dataset. Many techniques are compared and the accuracy is different from each sample dataset.[28] Sherly *et.al.* (2019) proposed there are different type's bacteria or fungus is responsible for many different plant diseases. It can be predict using algorithm of Machine Learning. Many researchers try many algorithms and get differ results. The classification of diseases is hard to done by algorithms. By CNN technique we can identify the mulberry plant disease.[31] Balwant J Gorad et al.(2019)gives a better disease prediction system for brinjal plant. K-means clustering used to split the data that is provided by the farmers. Farmers collect images from their phone, tablet, camera and other sources that is forwarded to the system and then system create dataset from that and periodically it is done and hence plants diseases predicted by the system.[35] Monalisa Saha *et al.* (2020) takes the tomato and potato plants leaves to predict plant diseases. They collect both plant leaves images from internet sites and some images they collect with their digital camera from farming places. In proposed system after clustering if we give it(cluster) in multiple SVM classes then it gives better results and the performance analysis is 99% and the individual algorithm efficiency like k-means gives 88.6% and SVM gives 91%. Hence the proposed system is better than k-means and SVM.[36] Sridevi Sakhamuri *et al.* (2020)describe that there are three types of plant leaves diseases so they collect the leaves and maintain dataset according disease type. They collect different plants leaves like jasmine, grape, apple, beans, rose etc. and used different methods to detect leaves disease and get different accuracy like with k-means algorithm the accuracy was 88.8%, through SVM 95% accuracy was achieved and through ANN it was 70% to 95% for different diseases.[37]

Krishnaswamy Rangarajan *et al*. (2020) proposed an automated disease diagnostic system for ten diseases of four crops (eggplant, hyacinth beans, lime, lady finger). Author used six pre-trained deep learning models for training and validation of created dataset.[38] Pranesh Kulkarni *et al.* (2021) had taken public dataset for their research in which healthy and unhealthy images of apple, corn, grapes, potato and tomato plants were included. For the classification they used Random Forest Classifier. They got 93% accuracy through the system they developed.[39] Sahil Thakur *et al*.(2021) authors develop the model with CNN to identify the plant diseases with image processing. They used plants like potato, grape, corn, apple etc. [40] Gianni Fenu *et al*.(2021) review the researches from past 10 years in which different plants and crops were used like cherry, coffee, barley, grape etc. and used methods were SVM, SVR, KNN, ANN and many. Author observed that researchers need high quality labeled data for their research work.[41] Kow shik *et al.* (2021) used Convolutional Neural Network and Deep Neural Network to detect plant diseases. Author detect similar diseases from different plants like banana, beans, jackfruit, lemon, mango etc. The proposed method with CNN and DNN is feasible for early plant disease detection.[42] Jayashri *et al*. (2021) review the existing image processing techniques for disease prediction of pomegranate. They used SVM, ANN, KNN and PNN classifier to detect bacterial, fungal and viral diseases in fruit. K-means clustering for image segmentation, Fuzzy c means gives highest accuracy. According to them very few diseases were covered in the existing system.[43] Punitha *et al*.(2021) reviewed many research papers on detection of plants disease using image processing techniques. For image processing they follow the procedure image acquisition, image pre-processing, image segmentation, feature extraction and disease classification. After comparison of many different models (which used SVM, ANN, KNN and other approaches on different plants) they found that SVM is most accurate method followed by ANN. [44]

CONCLUSION

Many research methods are there in deep learning to detect plant diseases in early stage. In existing methods SVM, ANN, CNN, KNN and other techniques are used. Effectiveness of each method may vary from one to another and it also depends on the dataset that how it is collected and trained. Plants used for research work are like tomato, potato, rice, beans, apple, pomegranate, maize etc. Plants disease detection research and applications is developing rapidly, still needed an application that works effectively for farmer of the nation of any region. Researchers should choose the crop or plant which is widely used for the human living like wheat, rice, potato etc. so that the productivity of that crop will be improved. Researchers should improve the quality of dataset they will use with the help of method of collecting data. We will take plants like we discuss earlier and will try to collect data (images) by self.

FUTURE DIRECTIONS

While the plant disease identification model based on machine learning and deep learning discussed in this paper can address environmental complexities and improve identification accuracy, there are still some issues to consider. For example, the algorithm requires repetitive iterative calculations, leading to longer processing times, which can delay the identification results. In future research, we aim to leverage neural networks to generate initial zero sets for different types of leaves. This approach will reduce the computational iterations required by certain algorithms, thus accelerating the training process and allowing for earlier termination of iterations. Based on the findings of this study, the potential future directions of research include: (i) The development of an advanced plant disease prediction system utilizing enhanced image processing techniques. (ii) A comparative analysis between existing prediction models and the newly proposed system, focusing on their effectiveness.

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RESEARCH ARTICLE

Development and Optimization of Polymeric Anti-Wrinkle Dermal Patches Containing Rutin: A Novel Cosmeceutical Approach

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ABSTRACT

Skin aging is a multifactorial process characterized by oxidative stress, collagen degradation, and reduced skin elasticity, leading to wrinkle formation. Traditional anti-aging formulations, such as creams and serums, often suffer from limited penetration and require frequent application. Dermal patches offer a novel approach for sustained drug release and enhanced skin permeation. This study focuses on the formulation and evaluation of rutin-loaded anti-wrinkle dermal patches using polymeric matrices to improve drug stability, dermal absorption, and anti-aging efficacy. Rutin-loaded matrix-type dermal patches were prepared using polyvinyl alcohol (PVA), hydroxypropyl methylcellulose (HPMC), and ethyl cellulose (EC) via the solvent casting method. Plasticizers (glycerine, propylene glycol) and solvents (ethanol, acetone, chloroform) were optimized to achieve desired patch characteristics. Preformulation studies, including FTIR and DSC, confirmed drug-polymer compatibility. The patches were evaluated for thickness, weight variation, moisture uptake, folding endurance, drug content uniformity, in-vitro drug release (Franz diffusion cell), and skin permeation efficiency. Anti-wrinkle efficacy was assessed through collagen synthesis and antioxidant activity studies. The optimized formulation (F6) demonstrated uniform thickness (0.19 ± 0.2 mm), optimal folding endurance (11.5 ± 0.2), and sustained drug release (90.5% over 24 hours). FTIR and DSC studies confirmed the absence of significant drug-polymer interactions. In-vitro permeation studies indicated enhanced dermal absorption, while anti-wrinkle

efficacy studies revealed increased collagen production and reduced oxidative stress. The formulation exhibited excellent dermatological compatibility, ensuring safe topical application. The developed rutin-based dermal patches provide an effective and non-invasive alternative to conventional anti-aging treatments. Their sustained release profile, enhanced dermal penetration, and biocompatibility highlight their potential in anti-wrinkle therapy. Further studies, including clinical validation, are recommended to establish long-term efficacy and commercial viability.

Keywords: Rutin, anti-wrinkle, dermal patches, dermal delivery, collagen synthesis, matrix formulation, sustained release Introduction

INTRODUCTION

Skin Aging and the Role of Antioxidants

Aging is a complex, multifactorial process influenced by both intrinsic and extrinsic factors. Intrinsic aging, also known as chronological aging, is primarily governed by genetic and metabolic factors, leading to progressive structural and functional deterioration of the skin. Extrinsic aging, often referred to as photoaging, is influenced by environmental factors such as ultraviolet (UV) radiation, pollution, smoking, poor nutrition, and oxidative stress, which significantly accelerate skin damage and wrinkle formation (1). The skin's extracellular matrix (ECM) is primarily composed of collagen, elastin, and glycosaminoglycans, which provide structural integrity and hydration. As aging progresses, fibroblast activity decreases, leading to reduced collagen synthesis, loss of elasticity, and increased formation of wrinkles (2). Furthermore, oxidative stress induced by reactive oxygen species (ROS) plays a crucial role in degrading ECM proteins. UV radiation stimulates ROS production, leading to lipid peroxidation, DNA damage, and the upregulation of matrix metalloproteinases (MMPs), which degrade collagen and elastin fibers (3).

The skin has endogenous defense mechanisms, such as superoxide dismutase, catalase, and glutathione peroxidase, that neutralize oxidative stress. However, these mechanisms become less effective with age, necessitating exogenous antioxidant supplementation to mitigate oxidative damage and maintain skin integrity (4). Antioxidants, especially flavonoids, have gained considerable attention due to their ability to scavenge free radicals, inhibit MMPs, and stimulate collagen biosynthesis, making them promising agents for anti-aging therapies (5).

Rutin: A Potent Anti-Wrinkle Bioflavonoid

Rutin (quercetin-3-rutinoside) is a flavonoid glycoside found in various plant sources, including citrus fruits, buckwheat, and apples. It possesses strong antioxidant, anti-inflammatory, and anti-aging properties, making it an ideal candidate for dermatological formulations (6). Rutin exhibits several skin-beneficial properties:

Antioxidant effects

Rutin neutralizes ROS, reducing oxidative stress and preventing DNA damage (7).

Inhibition of matrix metalloproteinases (MMPs)

Rutin suppresses the activity of MMP-1, MMP-3, and MMP-9, preventing collagen degradation and preserving skin elasticity (8).

UV protection

Rutin exhibits photoprotective effects by reducing UV-induced erythema and protecting against solar radiation damage (9).

Anti-inflammatory action

Rutin inhibits inflammatory mediators such as TNF-α, IL-1β, and IL-6, reducing redness, irritation, and skin inflammation (10).

Despite its significant dermatological benefits, rutin's poor aqueous solubility, low permeability, and limited bioavailability hinder its effectiveness in conventional topical formulations. This necessitates the development of advanced delivery systems that enhance its solubility, stability, and skin penetration (11).

Dermal Patches

A Novel Approach for Skin Rejuvenation Traditional topical formulations such as creams, gels, and ointments often suffer from limited drug penetration, low retention time, and inconsistent absorption (12). Dermal patches have emerged as an innovative alternative to overcome these challenges by providing controlled drug release, prolonged skin contact, and enhanced bioavailability (13). A matrix-type dermal patch consists of a drug-loaded polymeric film, where the drug is uniformly dispersed within a polymer matrix. Upon application to the skin, the drug diffuses from the matrix into the skin layers, bypassing the stratum corneum barrier and ensuring effective drug delivery (14). This controlled release mechanism improves drug stability, minimizes systemic side effects, and enhances therapeutic outcomes.

Key advantages of dermal patches over conventional formulations include

Sustained drug release, reducing the frequency of application and improving patient compliance (15). Enhanced drug penetration, leading to better bioavailability (16). Minimized drug loss, as the occlusive nature of patches prevents drug degradation due to environmental exposure (17).

Formulation Strategies for Enhanced Rutin Delivery

Given rutin's limited solubility and permeability, various formulation strategies have been explored to enhance its bioavailability and efficacy. The present study utilizes the following approaches:

Selection of Biocompatible Polymers

Polymers play a crucial role in drug dispersion, film formation, and controlled drug release. The following biodegradable polymers were selected for the formulation: Polyvinyl Alcohol (PVA): A water-soluble polymer known for its excellent film-forming properties and mechanical strength (18). Hydroxypropyl Methylcellulose

(HPMC)

A semi-synthetic polymer with bioadhesive properties, enhancing patch adherence to the skin (19).

Ethyl Cellulose (EC)

A hydrophobic polymer that modulates drug release and prevents excessive water absorption (20).

Use of Plasticizers for Patch Flexibility

Glycerine and Propylene Glycol were incorporated to enhance the flexibility, elasticity, and skin adhesion of the patches (21).

Optimization of Solvent System

Ethanol, Acetone, and Chloroform were used as solvents to improve polymer dissolution, enhance drug dispersion, and facilitate patch formation (22).

Buffer System for pH Stability

Disodium Hydrogen Phosphate, Potassium Dihydrogen Phosphate, and Sodium Hydroxide were used to maintain the pH stability of rutin, optimizing its solubility and drug release profile (23).

OBJECTIVE OF THE STUDY

This study focuses on the formulation and evaluation of Rutin-loaded dermal patches using a matrix-type polymeric system to achieve optimal anti-wrinkle and antioxidant efficacy. The specific objectives include: Developing an optimized dermal patch using a solvent-casting method.

Characterizing the physicochemical properties of the patches, including thickness, folding endurance, tensile strength, and moisture content. Assessing *in-vitro* drug release to determine the kinetics and mechanism of drug diffusion.

MATERIALS AND METHODS

MATERIALS

Rutin was selected as the active pharmaceutical ingredient (API) due to its well-established antioxidant, anti-inflammatory, and anti-aging properties [24]. The polymers chosen for the dermal patch formulation were Hydroxypropyl Methylcellulose (HPMC) and Ethyl Cellulose (EC), which have been widely studied for their film-forming abilities and controlled drug release potential [25,26]. Glycerine and Propylene Glycol were employed as plasticizers to enhance film flexibility and mechanical strength [27]. The solvent system consisted of Ethanol, Acetone, and Chloroform, known for their ability to dissolve both hydrophilic and hydrophobic components, ensuring homogeneous polymer dispersion [28]. Buffer components, including Disodium Hydrogen Phosphate, Potassium Dihydrogen Phosphate, and Sodium Hydroxide, were used to maintain the pH stability of the formulation [29].

METHODS

Preparation of Rutin Dermal Patches

The rutin dermal patches were prepared using the solvent casting method, which is widely used in transdermal and dermal drug delivery systems due to its simplicity and ability to produce uniform films [30]. The steps involved were as follows:

Polymer Solution Preparation

Accurately weighed amounts of HPMC and EC were dissolved in a selected solvent system (ethanol, acetone, and chloroform).

The polymer concentration was varied in different formulations to study its effect on mechanical properties and drug release.

Incorporation of Active Ingredient and Plasticizers

Rutin was dissolved and uniformly dispersed within the polymer solution using magnetic stirring to ensure homogeneity. Plasticizers (glycerine and propylene glycol) were added to improve the flexibility and mechanical integrity of the patches.

Casting and Drying

The homogenous solution was poured into petri dishes and dried at room temperature under controlled conditions to prevent solvent evaporation defects. After complete drying, the films were carefully peeled and cut into uniform sizes for further evaluation.

Evaluation of Rutin Dermal Patches

The formulated patches underwent various physicochemical and mechanical evaluations to determine their suitability for dermal application. The results are summarized in Table 7.4.

Physical Appearance

The physical characteristics of the patches, including color, surface texture, and uniformity, were visually examined. All formulations exhibited a smooth, brown appearance, indicating homogenous rutin distribution within the polymeric matrix [31].

Thickness Measurement

Patch thickness was determined using a digital micrometer screw gauge at different points of the film, and the mean value was recorded [32]. The thickness ranged from 0.16 ± 0.2 mm to 0.19 ± 0.2 mm, with F6 showing the highest thickness (0.19 ± 0.2 mm).

Weight Variation

Each patch was individually weighed using an analytical balance to assess uniformity in mass. Minimal variation in weight across different batches confirmed consistency in the formulation process [33].

Moisture Content and Moisture Uptake

The moisture content was determined by weighing patches before and after drying in a desiccator, while moisture uptake was evaluated by exposing them to a humid environment [34]. The results showed moisture content values ranging from 2.7 ± 0.6% to 4.5 ± 0.3%, and moisture uptake values between 2.4 ± 0.8% and 4.0 ± 0.4%, indicating moderate water absorption capacity.

Folding Endurance

The mechanical flexibility of the patches was assessed by folding them at the same spot repeatedly until they broke [35]. The results ranged from 113 ± 0.6 to 124 ± 0.5 folds, confirming excellent mechanical strength. The F6 formulation exhibited the highest folding endurance (113 ± 0.6).

Drug Content Uniformity

The rutin content in each patch was measured using UV-Vis spectrophotometry at 360 nm, and uniformity was expressed as a percentage [36]. The drug content across all formulations was within 98.2 ± 0.3% to 99.7 ± 0.3%, ensuring homogenous drug dispersion.

***In-vitro* Drug Release**

In-vitro drug release studies were conducted using a Franz diffusion cell with phosphate buffer (pH 7.4) as the receptor medium [37]. Samples were withdrawn at regular intervals and analyzed using UV spectroscopy. Drug release varied among formulations, with F6 showing the highest drug release (90.5%), while other formulations exhibited release values between 72% and 88.4%.

***Ex-vivo* Permeation Studies**

Ex-vivo permeation studies were performed using excised rat skin mounted on a Franz diffusion cell to assess rutin permeation through biological membranes [38]. Cumulative drug permeation was measured over 24 hours, and the results indicated sustained release patterns, with F6 demonstrating the most favorable permeation profile.

RESULTS AND DISCUSSION

Preformulation studies

Identification of drug

FTIR spectroscopy

FTIR study was performed on Rutin for determination of functional groups that will describe the identity. The sample used for FTIR and their results shown in Figure below for Rutin, PVA, HPMC and EC respectively. Interpretation of FTIR spectra of Rutin, PVA, HPMC and EC suggests that the observed peak list meets with that of the reference peak list (Fig 7.1, 7.2, 7.3, 7.4)

UV Spectroscopy

Determination of lambda max

The absorption maximum of Rutin was measured by UV/Visible spectrophotometer and found to be 355 nm in methanol which was found to be very near to the reported value.

Melting Point

Melting point of the drug was found to be similar to the reported value which proved that the received drug samples meet the reported properties. Any impurity, if present, will cause variation in the melting point of a given drug substance. Reported melting point of Rutin is 195°C. When melting point of drug was carried out using capillary method drug starts to melt at 192°C and completely melted at 195°C. From the above test it was found that the sample drug complies with the standard test of Rutin.

Organoleptic Properties

Rutinis Greenish-yellow fine powder with characteristic odor.

Solubility

The solubility of Rutin was determined in different media. The results of the solubility of Rutin are given in table 7.1. From the solubility profile it can be concluded that the drug is very slightly soluble in water however soluble in methanol.

Partition coefficient

Partition coefficient values of Rutin were found to be at 7.04 (octanol/water). It indicates that it is preferentially soluble in octanol compared to water. This means that rutin is more lipophilic (fat-soluble) than hydrophilic (water-soluble). Specifically, for a partition coefficient of 7.04, the concentration of rutin in octanol is about 7.04 times higher than in water. This property is important for understanding how rutin might behave in biological systems, such as its ability to cross cell membranes, which are lipid bilayers. A higher partition coefficient suggests that rutin may have a better potential to be absorbed through cell membranes and interact with lipophilic (fat-based) structures, though its hydrophobicity could limit its water solubility and bioavailability.

Drug Excipients Compatibility Studies

This study was performed to determine any physical change in the drug when kept in contact with various excipients. From the above interpretation it is found that the major functional groups present in the reported structure of Rutin are also present in the FTIR of HPMC, EC and PVA, Observing the results of drug-carrier compatibility study, it was concluded that there was no physical incompatibility between drug and selected formulation excipients.

Preparation of calibration curve

Calibration curve of Rutin in methanol

Formulation of Dermal patches

Formulation table of dermal patches (by QbD software)

Evaluation of Rutin patches

The table provides detailed information on the formulation characteristics of various batches (F1 to F9) prepared using different concentrations of Hydroxypropyl Methylcellulose (HPMC) and Ethyl Cellulose (EC). The parameters analyzed include physical appearance, thickness, weight variation, moisture content, moisture uptake, folding endurance, drug content, and the percentage of drug release. Let's break down and analyze these results systematically:

Physical Appearance and General Characteristics

All formulations exhibit a smooth, brown appearance, indicating consistency in the appearance and texture of the tablets across the batches. This uniformity could suggest that the excipients (HPMC and EC) are well-blended and provide stable formulations.

Thickness

The thickness of the formulations ranges from 0.16 mm to 0.19 mm, with F3 and F6 having the highest thickness (0.19 mm). These slight variations may be attributed to the different proportions of HPMC and EC used. The relatively consistent thickness across the formulations indicates good control over the manufacturing process, ensuring uniformity in the final product.

Weight Variation

The weight variation of the formulations is between 2.91±0.3 mg (F1) and 3.05±0.7 mg (F3). The weight variation remains relatively consistent, demonstrating that the formulations have been manufactured with good precision and are likely to be compliant with the quality control standards typically required for tablet dosage forms.

Moisture Content and Moisture Uptake

- Moisture Content: The moisture content ranges from 2.4% (F3) to 3.9% (F4). Moisture content is critical in tablet formulations, as it impacts the stability and integrity of the tablets. Generally, lower moisture content is preferable to avoid degradation or microbial growth, while excessive moisture could affect tablet dissolution and drug release.
- Moisture Uptake: This parameter measures how much moisture the tablet absorbs under certain conditions. Most formulations show a moisture uptake of around 21.47%, except for F6, which has a slightly lower uptake (18.29%). This could indicate that the balance of HPMC and EC in F6 contributes to lower moisture retention compared to the others, possibly enhancing stability.

Folding Endurance

Folding endurance reflects the mechanical strength and flexibility of the film or tablet. Higher folding endurance values indicate better resistance to cracking, which is vital for tablet durability. Formulations such as F4 (45.22 ± 0.4) stand out with significantly higher folding endurance, which could be attributed to the higher concentration of EC (100 mg). EC, known for its film-forming and protective properties, likely improves the mechanical properties of the tablet.

Drug Content

The drug content of the tablets remains consistent across formulations, with all formulations showing values close to the targeted drug content. The variation is minimal (11.2 ± 0.7 to 12.5 ± 0.8), indicating uniform distribution of the active pharmaceutical ingredient (API) in the tablets. This is crucial to ensure that each tablet delivers the correct dose to the patient.

Percentage Drug Release

- Drug Release Profile: The percentage of drug released varies across the formulations, with values ranging from 72% (F1) to 90.5% (F6). Formulation F6, containing 150 mg of HPMC and 50 mg of EC, shows the highest drug release (90.5%), which suggests that the combination of HPMC and EC in this formulation creates a more favorable environment for faster drug dissolution.
- Release Trends: Generally, formulations with higher HPMC concentrations (such as F3, F6, and F9) tend to release the drug more efficiently, with values nearing 90%. Formulations with higher EC concentrations, like F4 and F7, exhibit slightly slower drug release, indicating that EC could be controlling the release rate due to its hydrophobic nature, which tends to slow down the dissolution process.

Observations and Insights

- Impact of HPMC and EC Concentrations: From the data, it can be observed that increasing the concentration of HPMC (from F1 to F9) leads to an increase in the percentage of drug released, particularly in formulations with 150 mg of HPMC. This suggests that HPMC plays a significant role in enhancing the dissolution rate of the drug. On the other hand, EC acts as a controlling agent for the release, as formulations with higher EC (like F4 and F7) tend to release the drug more slowly.
- Formulation F6: This formulation (150 mg HPMC, 50 mg EC) shows the best performance in terms of drug release (90.5%). The combination of higher HPMC content and lower EC content likely provides an optimal balance between drug release and stability. F6 could be considered as one of the most efficient formulations in this batch, offering fast drug release without compromising the stability of the tablet.
- Formulation F4: While F4 (100 mg HPMC, 100 mg EC) has a relatively high moisture content and folding endurance, the drug release is slightly lower (77%). The higher EC content here may slow down the drug release compared to formulations with less EC, which is consistent with the hydrophobic nature of EC.
- Other Formulations: The remaining formulations (F2, F3, F5, F7, F8) show moderate drug release profiles (between 76% and 84%), and the slight differences in drug release could be due to varying HPMC and EC concentrations. These formulations balance the stability and release rate of the drug but do not outperform F6 in terms of release.

CONCLUSION

Rutin, a flavonoid glycoside with known antioxidant and anti-inflammatory properties, was selected as the active ingredient for the preparation of dermal patches due to its potential therapeutic benefits for skin-related conditions. The identification and evaluation of Rutin were carried out through various characterization techniques to ensure its purity and suitability for patch formulation. Fourier Transform Infrared (FTIR) spectroscopy was employed to confirm the identity and purity of Rutin. The characteristic peaks observed in the FTIR spectra for Rutin at 3428 cm-1 (OH stretching), 2928 cm-1 (CH2 stretching), and 1487 cm-1 (C=O bending) are in alignment with the functional groups expected in Rutin's molecular structure. These peaks confirm the presence of hydroxyl, methylene, and carbonyl groups, respectively, which are consistent with the reported spectroscopic data for pure Rutin. The absence of any additional or unexpected peaks further suggests that the drug is pure and has not undergone any degradation or chemical transformation during the extraction process. The absorption maximum (λ_max) of Rutin was measured using a UV/Visible spectrophotometer in methanol and was found to be 355 nm, which is in close agreement with the reported value for Rutin. This confirms the reliability of the measurement and validates the purity of the compound. The absorbance peak at 355 nm serves as a reference for quantification of Rutin in the dermal patch formulation, enabling accurate dosage during patch preparation. The melting point of Rutin was determined using the capillary method and found to be 192°C to 195°C. This observed range is consistent with the known melting point of pure Rutin, which typically falls around 191-193°C. The close match further supports the purity of the compound and provides additional evidence that Rutin has retained its physical characteristics during the formulation process. The organoleptic evaluation of Rutin revealed that it is a greenish-yellow fine powder with a characteristic odor. This sensory characteristic is a useful quality control parameter, as it provides a visual and olfactory means of identifying Rutin in its raw form. The color and fine texture of the powder suggest good solubility potential, which is important for its formulation into dermal patches, where consistent drug release is essential for efficacy. The results from FTIR, UV/Visible spectroscopy, melting point determination, and organoleptic evaluation confirm that Rutin is pure, stable, and suitable for use as an active ingredient in dermal patch formulations. The accurate identification and characterization of Rutin are crucial steps in ensuring the quality, consistency, and efficacy of the final dosage form. These evaluations provide a solid foundation for further development and optimization of Rutin-based dermal patches for therapeutic use. Partition coefficient values of Rutin were found to be at 7.04 (octanol/water). It indicates that it is preferentially soluble in octanol compared to water. This means that rutin is more lipophilic(fat-soluble) than hydrophilic (water-soluble). Specifically, for a partition coefficient of 7.04, the concentration of rutin in octanol is about 7.04 times higher than in water.

The solubility of Rutin in various solvents was evaluated to understand its potential for formulation in different drug delivery systems. The results show significant variation in Rutin's solubility across different solvents, highlighting its compatibility with both organic and aqueous systems. Methanol (55 mg/ml) stands out as the most suitable solvent, offering the highest solubility, which may be advantageous for preparing concentrated formulations or solutions for further processing. Dimethyl Formamide (25 mg/ml) and DMSO (20 mg/ml) also show high solubility, suggesting they can be useful for dissolving Rutin in more specialized or organic-based formulations, such as topical or injectable drug delivery systems. Ethanol (0.55 mg/ml) provides moderate solubility, which may limit its use for highly concentrated formulations but could still be useful in combination with other solvents for drug formulations. Water (0.125 mg/ml) exhibits the lowest solubility, which may pose challenges for formulations intended for aqueous-based delivery systems unless the solubility is enhanced by excipients or other solubilizing agents. PBS (pH 7.4) (16 mg/ml) demonstrates reasonable solubility and is ideal for formulations targeting physiological environments, such as dermal or transdermal patches, where the drug needs to be stable at body pH. These solubility profiles indicate that Rutin has a better affinity for organic solvents, but its moderate solubility in aqueous media like PBS suggests its potential for use in systems where drug release needs to be controlled in a physiological setting. Evaluation of Rutin patches was performed using various parameters, results revealed that on increasing the concentration of HPMC (from F1 to F9) leads to an increase in the percentage of drug released, particularly in formulations with 150 mg of HPMC. This suggests that HPMC plays a significant role in enhancing the dissolution rate of the drug. On the other hand, EC acts as a controlling agent for the release, as formulations with higher EC (like F4 and F7) tend to release the drug more slowly.

Formulation F6

This formulation (150 mg HPMC, 50 mg EC) shows the best performance in terms of drug release (90.5%). The combination of higher HPMC content and lower EC content likely provides an optimal balance between drug release and stability. F6 could be considered as one of the most efficient formulations in this batch, offering fast drug release without compromising the stability of the tablet.

Formulation F4

While F4 (100 mg HPMC, 100 mg EC) has a relatively high moisture content and folding endurance, the drug release is slightly lower (77%). The higher EC content here may slow down the drug release compared to formulations with less EC, which is consistent with the hydrophobic nature of EC. The remaining formulations (F2, F3, F5, F7, F8) show moderate drug release profiles (between 76% and 84%), and the slight differences in drug release could be due to varying HPMC and EC concentrations. These formulations balance the stability and release rate of the drug but do not outperform F6 in terms of release.

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Table 1:IR peaks of Rutin and Polymers used

Standard	Sample	Element
Rutin		
3300-3400 cm^{-1}	3428cm^{-1}	OH stretching
2900-3000 cm^{-1}	2928 cm^{-1}	CH2 stretching
1400-1500 cm^{-1}	1487cm^{-1}	C=O Bending
1300-1400 cm^{-1}	1361 cm^{-1}	O-H Vibration
PVA		
3300-3400cm^{-1}	3302cm^{-1}	OH stretching
2950-3050-cm^{-1}	3022cm^{-1}	CH stretch
1700-1800cm^{-1}	1751cm^{-1}	CO stretch
800-900cm^{-1}	814cm^{-1}	CC strech
HPMC		
3300-3400 cm^{-1}	3315.4 cm^{-1}	OH stretching
2800-2900 cm^{-1}	2879.2 cm^{-1}	CH stretching
1300-1400 cm^{-1}	1373.3 cm^{-1}	OH Vibration
1050-1150 cm^{-1}	1055.5cm^{-1}	CO Vibration
EC		
1700-1800 cm^{-1}	1700.1cm^{-1}	C=O stretching
1600-1650 cm^{-1}	1620cm^{-1}	C=N stretching
2800-2900 cm^{-1}	2860 cm^{-1}	CH stretching

Table:2 Solubility analysis of Rutin in different solvents

Element	Quantitative solubility(mg/ml)
Ethanol	0.55
Methanol	55
Dimethyl Formamide	25
DMSO	20
Water	0.125
PBS 7.4 pH	16

Table:3 Calibration curve of Rutin in methanol

S. No.	Drug Conc. (µg /ml)	Absorbance
1.	2	0.214
2.	4	0.461
3.	6	0.727
4.	8	1.024
5.	10	1.287

Table:4 Formulation table of dermal patches (by QbD software)

Formulation code	HPMC (in mg)	EC (in mg)	Propylene glycol (% w/w)	Glycerin (% w/w)
1	100	50	5	10
2	**125**	**75**	5	10
3	150	75	5	10
4	100	100	5	10
5	100	75	5	10
6	150	50	5	10
7	125	100	5	10
8	125	50	5	10
9	150	100	5	10

Table: 5 Results of evaluation of Rutin dermal patches

Formulation code	HPMC (in mg)	EC (in mg)	Appearance	Thickness	Weight Variation	% moisture content	% moisture uptake	Folding endurance	Drug Content	Percentage drug release
F1	100	50	Smooth, Brown	0.16± 0.2	2.91± 0.3	3.4 ± 0.8	21.47 ± 0.3	11.7 ± 0.4	98.7 ± 0.3	72
F2	125	75	Smooth, Brown	0.17± 0.3	3.01 ± 0.5	3.9 ± 0.1	21.35 ± 0.4	12.3± 0.8	97.3 ± 0.1	81.4
F3	150	75	Smooth, Brown	0.19± 0.2	3.05± 0.7	2.4 ± 0.4	18.48 ± 0.3	12.5± 0.8	99.2 ± 0.3	83.5
F4	100	100	Smooth, Brown	0.17± 0.1	3.02 ± 0.3	3.9 ± 0.2	45.22 ± 0.4	11.3 ± 0.5	96.3 ± 0.8	77
F5	100	75	Smooth, Brown	0.16± 0.2	2.95± 0.6	3.4 ± 0.8	21.47 ± 0.3	11.7 ± 0.6	96.8 ± 0.6	81.4
F6	150	50	Smooth, Brown	0.19± 0.2	2.99 ± 0.3	2.7 ± 0.6	18.29 ± 0.4	11.5 ± 0.2	99.7 ± 0.3	90.5
F7	125	100	Smooth, Brown	0.16± 0.2	3.02± 0.5	3.4 ± 0.8	21.47 ± 0.3	11.6 ± 0.4	96.8 ± 0.6	76.8
F8	125	50	Smooth, Brown	0.16± 0.2	2.95± 0.5	3.4 ± 0.8	21.47 ± 0.3	11.2 ± 0.7	96.5 ± 0.6	84.8
F9	150	100	Smooth, Brown	0.18± 0.2	2.99± 0.7	2.4 ± 0.2	21.24 ± 0.8	12.4 ± 0.5	94.2 ± 0.3	78.4

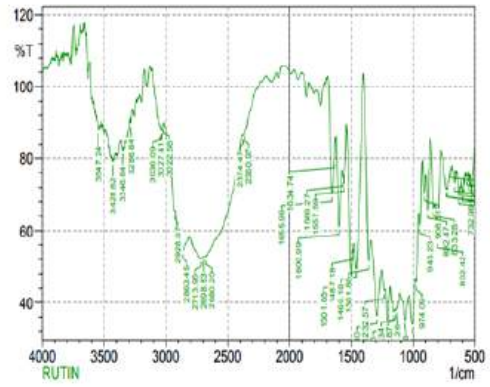


Fig:1 FTIR spectra of Rutin

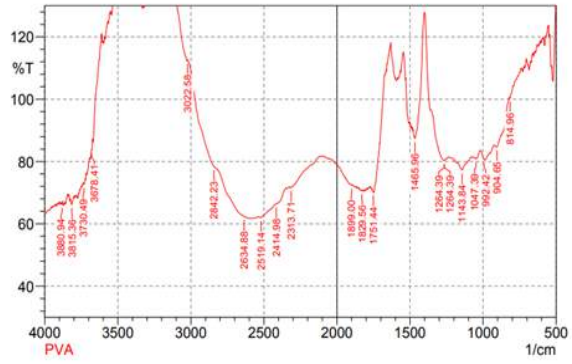


Fig:2 FTIR spectra of Polyvinyl alcohol

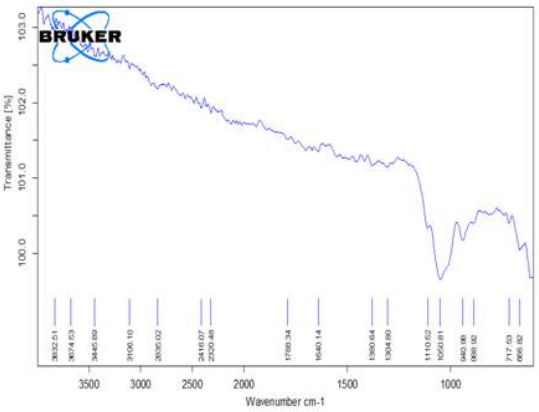


Fig: 3 FTIR spectra of HPMC

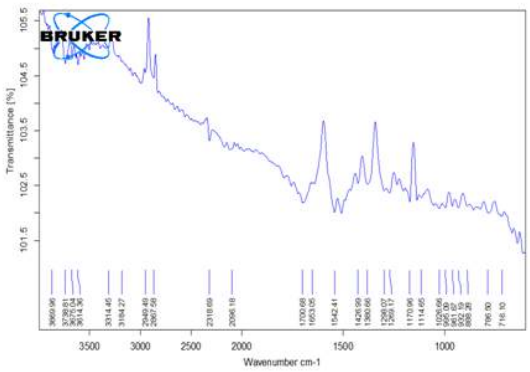


Fig: 4 FTIR spectra of Ethyl Cellulose

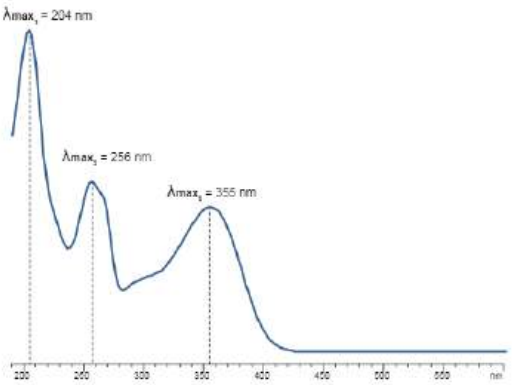


Fig: 5 Lambda max determination of Rutin by UV spectroscopy

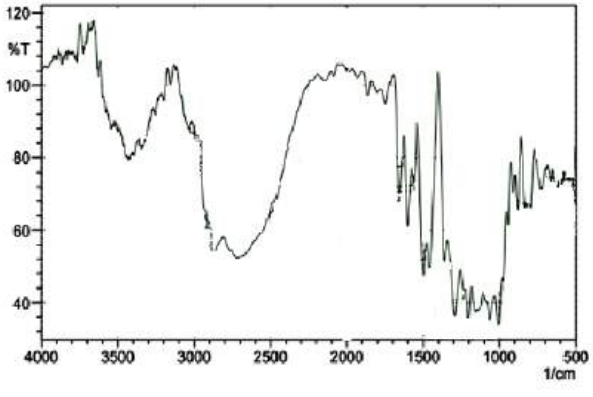


Fig: 6 FTIR spectra of Blend

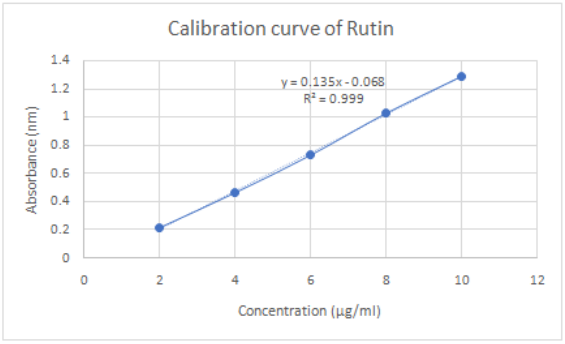


Fig:7 Calibration curve of Rutin

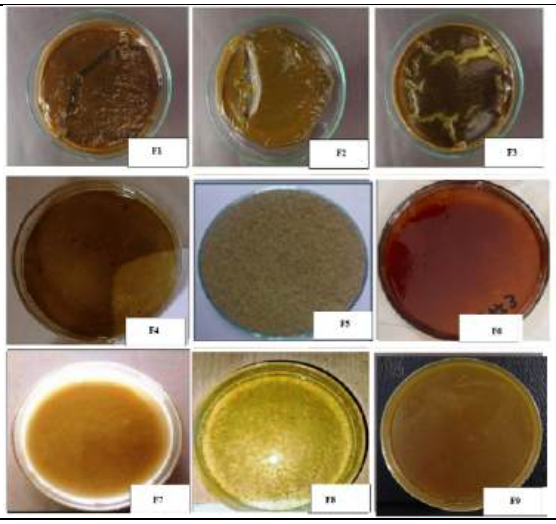


Fig:8 Evaluation of Rutin patches

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RESEARCH ARTICLE

Administration and Evaluation of Diet and Exercise Intervention on Subjects Suffering From Metabolic Syndrome

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ABSTRACT

In Metabolic Syndrome (MetS), one finds a strong link between lifestyle and health issues of an individual. The goal of this study was to find the separate and combined impact of dietary and exercise intervention on subjects (n=89) with MetS in Punjabi community. The MetS patients were randomly assigned into experimental groups that received counseling ongroup I: diet, group II: exercise, group III diet and exercise for 90 days. Whilefourth group received one-time diet-exercise counseling. After intervention, they were assessed for anthropometric measurements, blood pressure and biochemical evaluation and compared with pretest results based on IDF (International Diabetes Federation) criterion for MetS. Diet and exercise intervention group presented the highest reduction: 50% in MetS, among all groups.; 21.7%.Diet intervention lowered body weight ($p=0.002$), BMI ($p=0.002$), and waist circumference ($p<0.001$). Exercise intervention lowered body weight ($p<0.001$), BMI ($p<0.001$), waist circumference ($p=0.001$). Combined diet-exercise intervention decreased body weight ($p<0.001$), BMI ($p<0.001$), and waist circumference ($p<0.001$). Reductions in systolic and diastolic blood pressure were seen in diet ($p=0.006$, $p=0.013$), exercise ($p=0.008$, $p=0.043$), and diet-exercise ($p=0.02$, $p=0.003$) groups. Biochemical improvements were seen in diet group's HDL-cholesterol ($p<0.001$), LDL-cholesterol ($p=0.009$); exercise group's triglycerides ($p=0.04$), HDL-cholesterol ($p<0.001$), LDL-cholesterol ($p=0.005$); diet-exercise group's HDL-cholesterol ($p<0.001$), LDL-cholesterol ($p=0.039$).

Keywords: metabolic syndrome, Punjabi community, diet, exercise.

INTRODUCTION

MetSis a combination of health problems bunched together share common cardio-metabolic risk factors including "abdominal obesity, dyslipidemia, hypertension, and type2 diabetes" (Aguilar-Salinas & Viveros-Ruiz, 2019).In MetS, one finds a profound relationship between lifestyle and pathology of an individual (Verma *et al.,* 2018). The most generally definition used in studies is given by IDF which agreed that a combination of three or more components of MetS must be present. The definition given by IDF states that "for a person to be defined as having the MetS they must have central obesity (defined as waist circumference with ethnicity specific values; for Indian males ≥90 cm and females≥80cm plus any two of the following four factors: raised triglycerides ≥ 50 mg/dL (1.7 mmol/L) or specific treatment for this lipid abnormality, reduced HDL cholesterol<40mg/dL (1.03mmol/L) in males, <50 mg/dL (1.29 mmol/L) in females, or specific treatment for this lipid abnormality, raised blood pressure: systolic BP≥130 or diastolic BP≥85mmHg, or treatment of previously diagnosed hypertension, raised Fasting Plasma Glucose (FPG)≥ 100 mg/dL (5.6 mmol/L), or previously diagnosed type 2 diabetes If above 5.6 mmol/L or 100 mg/dL, OGTT (Oral Glucose Tolerance Test) is strongly recommended but is not necessary to define presence of the syndrome" (IDF, 2005). Lifestyle and type of food consumed can have a lasting impact on the development of non-communicable diseases and MetS (Anderssen *et al.,* 2007). Culture and social activities followed by different communities all over the world is a major factor which influences the health of the people (Duggal, 2013). One such is the Punjabi community, which has a rich culture and may live an unhealthy lifestyle, especially in urban areas. The effect of lifestyle has been reported in studies making the Punjabi community a vulnerable group for non-communicable diseases and MetS. A study on the Punjabi community (Jaipur), had a high incidence of coronary risk factors indicating poor cardio-vascular health (Gupta *et al.,* 2004). In another research, alcohol consumption patterns were identified in the Punjabi community in which men had alcohol-use-related problems while women abstained from it (Weber, 1996). In a study conducted on the Punjabi Sikh community in Amritsar found the prevalence of MetS: 34.3% with a higher incidence in females (41.4%) in comparison to males (28.2%) (Singh et al., 2016). Prevalence of obesity and several other non-communicable diseases were also assessed in children and their parents of the Punjabi community linking genetics and lifestyle risk factors together (Sangha *et al.,* 2006). It's prevention and management in Punjabi community, a vulnerable group, call for awareness, promotion of healthy lifestyle and eating behavior.

The management of MetS lies in lifestyle changes including following healthy behavioral, dietary, and physical activity patterns as given in statement by Korean Society of Cardiometabolic Syndrome (Kim et al., 2022). Several studies have been done to understand the impact of lifestyle modification in community-based study but comparative studies like the present one clarifies different approaches to mitigate risk as depicted in figure 1. A hospital study in Ethiopia demonstrated that people with type2 diabetes are at an elevated risk for MetS calling for urgency for early intervention programs through diet and exercise discipline (Charkos *et al.,* 2023). Another investigation in a cluster randomized control trial adopted a comprehensive strategy to mitigate the risk of MetS, incorporating dietary regulation, heightened physical activity and exercise, self-assessment, problem-solving, and a training regimen (Chang et al., 2023). A substantial cohort investigation revealed that adopting a nutritious plant-based diet rich in fruits, vegetables, whole grains, and legumes, while minimizing intake of refined and processed sweets, salty and fatty foods, as well as animal-based products, is associated with a reduced risk of cardiovascular diseases, type 2 diabetes, and MetS. These findings underscore the efficacy of high-quality plant-based diets in preventing MetS and underscore the importance of incorporating them into dietary intervention programs (Vajdi, *et al.,* 2023). Recent reviews have highlighted the potential use of plant-based foods involving nutraceuticals extracted from plants like herbs, spices, condiments, fruits, and vegetables to manage MetS (Mohamed *et al.,* 2023). Physical activity has emerged as the primary preventive measure in recent research for addressing MetS and managing diabetes (Syeda et al., 2023). Consequently, the current study incorporates exercise, recognizing that dietary interventions alone may not yield substantial impact. The goal of this study was to find the separate and combined impact of dietary and exercise intervention on subjects (n=89) with MetS in Punjabi community.

Participants and Methods

Participation and Data Collection

The sample size was calculated by placing the significance criterion at 0.5 and power at 0.80, using a previous study (Bansal & Joshi, 2015) and a larger sample size of 500 subjects against the calculated was employed (Charan & Biswas, 2013). In total 48 sample's data was removed due to missing information and unwillingness to participate in the study. Stratified random sampling method was employed and the subjects were allocated into strata, grounded on geographical areas (districts of West Delhi), age, and sex based on population by religious community of NCT Delhi data (Open Government Data, 2020; Investopedia, 2022). The health camp was organized in Gurdwara of West Delhi districts- Punjabi Bagh, Patel Nagar, Rajouri Garden. The information requisite to socio-demographic characteristics, health status, physical activity score (Sharkey & Gaskill, 2009) and dietary record was collected through pre-tested questionnaire. The anthropometric data including height, weight, and waist circumference was measured using standard protocols (Casadei & Kiel, 2021). The systolic and diastolic blood pressure was measured by taking at least two consecutive readings (Ogedegbe & Pickering, 2010). The subjects with raised waist circumference were further screened and asked to complete 12 hours fasting, after which 5mL of blood sample was drawn by trained personnel intravenously. The analysis of blood sample was done to detect fasting blood glucose level and lipid profile in a standard laboratory using spectrophotometry and enzymatic kit method (Dingeon, 1975; McGowan et al., 1983; Burstein et al., 1970; Knopfholz *et al.,* 2014; Allain *et al.,* 1974). A signed informed consent was obtained prior to the initiation of screening from all the subjects willing to participate after brief explanation about the purpose of the study. The study was approved by institutional ethics committee, protocol number: Ph.D./2019/272 on date 22.04.2019, prior to the commencement of the study.

Intervention

Subjects diagnosed with MetS and interested to participate (89) were randomly allocated into four groups: diet, exercise, combined diet and exercise and control. The purpose of this experiment was to create awareness about the management of MetS to alleviate the effects of modifiable primary risk factors like obesity, low physical activity, and high carbohydrate/fat diet through the implementation of an intervention program. A pre-test, post-test experimental design with control was employed to evaluate the impact of the intervention program. The sub sample of 89 participants who met the criteria of MetS were enrolled in the intervention program and received a comprehensive intensive counseling once in every two weeks for a period of three months. The 89 participants were divided into four groups and the separate and shared effects of diet and exercise counseling for the risk factors of MetS were examined. Participants who showed genuine interest in the intervention were assigned into any one of the counseling activities of their choice.

Experimental Group I- Participants who received periodic intensive counseling on diet

The participants of group I had to go through a dietary intervention and an individualized nutritional follow up on a fortnightly basis. The educational sessions were designed to discuss changes in eating habits and impart nutritional guidelines to promote weight loss and to improve the nutritional status and lifestyle. A personalized written/soft copy calorie modified metabolic customized weekly diet plan, according to the participant's weight and height, and informed dietary habits. The macronutrient distribution involved up to 50-60% carbohydrates, about 15-20% proteins, and less than 30% fat in which <10% saturated fat, up to 10% polyunsaturated fat. At least 20 to 30g fiber was recommended in the daily diet. Dietary guidelines about cooking preparation methods, limiting fat consumption, cutting on salt, avoiding drinks and foods that may become hidden sources of sugars and limiting alcoholic beverages. In addition to this, alternatives when eating out like making healthy food choices were told to them. Corresponding to diagnosed symptoms of MetS, dietary restrictions were posed. A list of healthy foods was provided to guide them with food choices (Khanna et al., 2016, Zivkovic *et al.,* 2007).Recommendations for physical activity. A copy of the educational pamphlets.Explanation about benefits of optimal dietary habits and physical activity in alleviating the danger of MetS was provided. Interactive sessions with the investigator via phone call on the following aspects were also organized to educate the subjects. The dietary guidance was tailored and modified corresponding to their dietary patterns and metabolic profile. Participants were recommended to focus on eating vegetables, fruits, and fibres from whole grains and pulses/legumes.

Experimental Group Il- Participants who received periodic intensive counseling on exercise

The participants of this group were counseled on the benefits of physical activity and taught ways to increase their daily physical activity and to incorporate bodily movements into a habit. In this study, the term "physical activity" ("bodily movement that significantly increases energy expenditure") is interchanged with "exercise", that is a subcategory of physical activity performed with the purpose of improving physical fitness like in increasing cardiovascular strength and flexibility exercise (Colberg et al., 2010). Every subject in this group was advised to go for a "brisk walk for 60 minutes for 5 to 6 days in a week". The participants were left to decide how, where, and when would they walk. The participants were regularly contacted and asked to record the date and duration of each session. Altogether, this exercise corresponded to "an average of 150-300 minutes of physical activity/week" throughout the intervention period of 90 days as per WHO guidelines (WHO, 2020). In addition to this, participants were asked to do one type of sport/yoga/exercise of their choice daily for at least 30 minutes/day.

Experimental Group III- Participants who received periodic intensive nutrition and exercise

This group received a comprehensive intensive nutritional counseling that combined the guidelines imparted to subjects of Groups I and II**.**

Control Group- Participants who served as control group

At the beginning of the study, this group received only one time counseling. The participants in this group did not alter their diet or physical activity pattern for the period of three months. The counseling sessions were organized for all the experimental groups once in every two weeks for a period of three months (90 days). During the entire study period individual meetings via phone call at regular fortnightly intervals were conducted to reinforce the importance of eating habits modifications and regular physical activity and to answer any questions related to all the subjects prescribed dietary plan. Telephonic reminders and SMS alerts were given regularly to all the subjects asking them to attend the review sessions that served as astimulus to improve the participant's adherence to the intervention. Anthropometric measurements, blood pressure levels and all the biochemical parameters of the participants belonging to all the experimental and control groups were reassessed after the three-month period was over. Arrangements for blood and laboratory examinations were performed in the standard laboratory. The investigation team included the investigator, lab technician for collecting blood sample, and one trained personnel for assisting in data collection and taking anthropometric measurements.

Post Intervention

After the intervention period, the participants representing improvement in metabolic syndrome were awarded with a certificate of championship and asked to set up of community health group in the gurudwara premises to advocate the importance of diet and exercise by sharing guidelines, what they have learnt in the intervention program. Online community groups were made, and champions were asked to conduct monthly meetings with people to share their knowledge and resource materials provided to them that will motivate others to practice diet and exercise as a way of living. This has helped them to practice long term sustainability by 'learning by doing method community approach' and allowed self-intervention. Further, champions were asked to become health ambassadors of their community and incorporate special sessions on religious events and distribute healthy meals and refrain from fried/fatty/sugary foods as offerings during prayers.

Data Analysis

The data obtained was analyzed using SPSS ver. 20 software. A p value <0.05 was considered statistically significant. Continuous variables are presented as mean and standard deviation (SD). Categorical variables are presented as absolute, relative frequencies or prevalence. Students t-test and paired t-test were used as appropriate for testing statistical significance. The paired t-test was used to analyze different outcomes between intervention baseline and endpoint for variables.

RESULTS

Mean anthropometric measurements of the subjects across groups pre and post intervention. In group I, before diet intervention, the mean body weight was 84.2kg, BMI was 29.4kg/m^2 and waist circumference was 99.6cm. A marginal decline in mean body weight: 82.7kg, BMI: 28.9kg/m^2 and waist circumference: 97.4cm after diet intervention. The p values for body weight: 0.002, BMI: 0.002, waist circumference: p<0.001, representing a significant difference at p<0.05 in body weight, BMI, and waist circumference of subjects before and after diet intervention. In group II, before exercise intervention, the mean body weight was 79.1kg, BMI was 29.6kg/m^2 and waist circumference was 98.6cm. A marginal decline in average body weight: 77.6kg, BMI: 29.1kg/m^2 and waist circumference: 97.3cm after exercise intervention. The p values for body weight: p<0.001, BMI: p<0.001, waist circumference: 0.001, representing a significant difference at p<0.05 in body weight, BMI, and waist circumference of subjects before and after exercise intervention. In group III, before diet and exercise intervention, the mean body weight was 82.0kg, BMI was 30.0kg/m^2 and waist circumference was 100cm. A marginal decline in average body weight: 80.5kg, BMI: 29.4kg/m^2 and waist circumference: 99.5cm after diet and exercise intervention. The p values for body weight: p<0.001, BMI: p<0.001, waist circumference: p<0.001, representing significant difference at p<0.05 in body weight, BMI, and waist circumference of subjects before and after in diet and exercise group. In control group, before intervention period, the mean body weight was 82.9kg, BMI was 30.4kg/m^2 and waist circumference was 103cm. A marginal rise in average body weight: 83.0kg and BMI: 30.5kg/m^2 while no reduction in waist circumference: 103cm after the study period. The p values for body weight: 0.350, BMI: 0.300, waist circumference: 0.350, representing significant no difference at p<0.05 in body weight, BMI, and waist circumference of subjects as depicted in Table 1. There was significant reduction after intervention indicating that subjects benefited from intervention counseling in comparison to control group in body weight, BMI, and waist circumference. [1]

Significant at p<0.05; [2]Not Significant; p value indicates significant difference in body weight for group I, II, III; in BMI for group I, II, III; in waist circumference for group I, II, III; control group shows no significant difference. A comparison of the mean reduction/increment and test of significance in the anthropometric measurements among the intervention groups at the completion of the study period. It was found that there was highest reduction in body weight in diet-exercise intervention group (-1.6kg), increment in control group (+0.13kg) as represented in Table 2. There was a reduction in BMI in diet-exercise intervention group (-0.58kg/m^2) and increment in control group (+0.06kg/m^2). While the highest reduction in waist circumference in diet group (-2.2cm) and lowest in control group (-0.11cm). [a, b, c] within a row, means without a common sub script differ p < 0.05; highest reduction in body weight in diet-exercise intervention group (-1.6kg) & increment in control group (+0.13kg); reduction in BMI in diet-exercise intervention group (-0.58kg/m^2) & increment in control group (+0.06kg/m^2); highest reduction in waist circumference in diet group (-2.2cm) & lowest in control group (-0.11cm). The mean systolic and diastolic blood pressure of the subjects across groups pre and post-intervention. In group I, before diet intervention, the mean systolic blood pressure was 140mmHg and diastolic blood pressure was 86.4mmHg. A marginal decline in average systolic blood pressure was 134mmHg and diastolic blood pressure was 82.8mmHg after diet intervention. The p value for systolic: 0.006 and diastolic: 0.013, former shows significant difference, while the later has no significant difference before and after intervention period. In group II, before exercise intervention, the mean systolic blood pressure was 125mmHg and diastolic blood pressure was 81.0mmHg. A marginal decline in average systolic blood pressure was 120mmHg and diastolic blood pressure was 78.4mmHg after exercise intervention. The p value for systolic: 0.008 and diastolic: 0.043, shows significant difference before and after intervention period. In group III, before diet and exercise intervention, the mean systolic blood pressure was 132mmHg and diastolic blood pressure was 82.6mmHg. A marginal decline in average systolic blood pressure was 128mmHg and diastolic blood pressure was 79.5mmHg after diet-exercise intervention. The p value for systolic: 0.02 and diastolic: 0.003, shows significant difference before and after intervention period. In control group, before study period, the mean systolic blood pressure was 135mmHg and diastolic blood pressure was 85.4mmHg. A marginal decline in average systolic blood pressure was 134mmHg and diastolic blood pressure was 80.8mmHg after study period. The p value for systolic: 0.295 and diastolic: 0.006, former shows no significant difference, while the later has significant difference before and after study period as represented

in Table 3. [1]Significant at p<0.05; [2]Not Significant; p value indicates significant difference in systolic blood pressure for group I, II, III; in diastolic for group II, III, control; control group shows no significant difference for systolic; group I shows no significant difference for diastolic blood pressure. Table 4 represents a comparison of the mean reduction/increment and test of significance in the systolic and diastolic blood pressure among the intervention groups at the completion of the study period. It was found that there is highest reduction in systolic blood pressure in diet group (-6.0mmHg) and lowest in control group (-1.0mmHg). While highest reduction in diastolic blood pressure in control group (-4.6mmHg) and lowest in exercise group (-2.6mmHg). Table 4: Comparison of the mean reduction/increment and test of significance in the systolic and diastolic blood pressure among the intervention groups at the completion of the study period [a] within a row, means without a common subscript differ p < 0.05; highest reduction in systolic blood pressure in diet group (-6.0mmHg) & lowest in control group (-1.0mmHg); highest reduction in diastolic blood pressure in control group (-4.6mmHg) & lowest in exercise group (-2.6mmHg).
The mean biochemical profile of the subjects across groups pre and post diet intervention. In group I, before diet intervention, the mean fasting blood glucose was 93.3mg/dL, total triglycerides were 174mg/dL, HDL-cholesterol was 47.9mg/dL and LDL-cholesterol were 110mg/dL. A marginal decrease in mean fasting blood glucose 90.6mg/dL, total triglycerides 153mg/dL and LDL-cholesterol 104mg/dL and an increase in HDL-cholesterol was 50.5mg/dL after the diet intervention. The p value for fasting blood glucose: 0.186, triglycerides: 0.051, HDL-cholesterol: p<0.001and LDL-cholesterol: 0.009, significant at p<0.05. In group II, before exercise intervention, the mean fasting blood glucose was 103mg/dL, total triglycerides were 167mg/dL, HDL-cholesterol was 46.8mg/dL and LDL-cholesterol were 116mg/dL.

A marginal reduction in mean fasting blood glucose 99.8mg/dL, total triglycerides 159mg/dL and LDL-cholesterol 108mg/dL and an increase in HDL-cholesterol was 49.0mg/dL after the exercise intervention. The p value for fasting blood glucose: 0.06, triglycerides: 0.04, HDL-cholesterol: p<0.001 and LDL-cholesterol: 0.005, significant at p<0.05. In group III, before diet-exercise intervention, the mean fasting blood glucose was 122mg/dL, total triglycerides were 149mg/dL, HDL-cholesterol was 48.0mg/dL and LDL-cholesterol were 123mg/dL. A marginal decline in mean fasting blood glucose 106mg/dL, total triglycerides 147mg/dL and LDL-cholesterol 116mg/dL and an increase in HDL-cholesterol was 49.5mg/dL after the exercise intervention. The p value for fasting blood glucose:0.08, triglycerides: 0.324, HDL-cholesterol: 0.022 and LDL-cholesterol: 0.039, significant at p<0.05. In control group, before study period the mean fasting blood glucose was 109mg/dL, total triglycerides were 194mg/dL, HDL-cholesterol was 50.0mg/dL and LDL-cholesterol were 129mg/dL as represented in Table 5. A marginal decline in mean fasting blood glucose 105mg/dL, total triglycerides 182mg/dL and LDL-cholesterol 124mg/dL and a slight increase in HDL-cholesterol was 50.4mg/dL after the study period. The p value for fasting blood glucose:0.059, triglycerides: 0.019, HDL-cholesterol: 0.326 and LDL-cholesterol: 0.003, significant at p<0.05. [1]Significant at p<0.05; [2]Not Significant; p value indicates no significant difference in fasting blood glucose for group I, II, III & control; p value indicates significant difference in triglycerides for group II & control and no significant difference for group I & III; p value indicates significant difference in HDL-cholesterol for group I, II, III & no significant difference in control group; p value indicates significant difference in LDL-cholesterol for group I, II, III & control.

Table 6 represents a comparison of the mean reduction/increment and test of significance in the biochemical profile among the intervention groups at the completion of the study period. The highest reduction in fasting plasma glucose in diet-exercise intervention group (-16.0mg/dL) and lowest in diet group (-2.7mg/dL). The highest reduction in triglycerides in diet group (-21.0mg/dL) and lowest in diet-exercise (-2.0mg/dL). The highest increment in HDL cholesterol in diet group (+2.6mg/dL) and lowest in control group (+0.43mg/dL). While the highest reduction in LDL cholesterol was seen in exercise group (-8.0mg/dL) and lowest in control group (-5.9mg/dL). [a] within a row, means without a common subscript differ p < 0.05; highest reduction in fasting plasma glucose in diet-exercise intervention group (-16.0mg/dL) & lowest in diet group (-2.7mg/dL); highest reduction in triglycerides in diet group (-21.0mg/dL) & lowest in diet-exercise (-2.0mg/dL); highest increment in HDL cholesterol in diet group (+2.6mg/dL) & lowest in control group (+0.43mg/dL); highest reduction in LDL cholesterol was seen in exercise group (-8.0mg/dL) & lowest in control group (-5.9mg/dL). Table 7 represents the status of MetS after the intervention is over. It has been found that combined diet and exercise intervention group showed highest reduction in prevalence of MetS among diet, exercise, and control groups. Among 23 subjects, about 50% subjects did not suffer from MetS in diet and exercise group. The

diet intervention group also performed well, as 45.5% subjects did not have MetS after the study period. While, in exercise intervention, 36.4% subjects did not have MetS. The control group had highest prevalence of MetS, as only 21.7% subjects did not have MetS after the completion of the study. Group III, combined diet and exercise intervention group showed highest reduction: 50% in MetS, among diet, exercise, and control groups.

DISCUSSION

The subjects diagnosed with MetS were allocated into experimental groups- Diet, Exercise, and Diet-Exercise Intervention and Control, and thus subjected to comparative pre and post intervention analysis. Lifestyle intervention programs comprising diet and exercise intervention have been found to be effective in improving components of MetS in randomized control trials (Joseph et al., 2019; Luo et al., 2013). Here too, it was observed that the effect of diet-exercise intervention was helpful in weight loss, reducing BMI and managing abdominal obesity much like the observations of Chen et al., 2006. In the present study, paired t-test for anthropometric measurements for diet, exercise, and diet-exercise groups showed significant difference among groups except for the control group. The individual risk factors of MetS showed significant improvements and the most reduction in body weight was seen in diet-exercise intervention group (-1.6kg) vis-a-vis increment in control group (+0.13kg). Consequently, a corresponding reduction in BMI was seen in diet-exercise intervention group (-0.58kg/m^2) and an upswing in control group (+0.06kg/m^2). The highest reduction in waist circumference was seen in diet group (-2.2cm) and lowest in control group (-0.11cm). Another study indicated that diet intervention becomes helpful in managing blood pressure levels and dyslipidemia (Aude et al., 2004). In this study too, a comparison of results of pre and post intervention study period, revealed a significant difference for separate diet and exercise groups for systolic blood pressure. However, diet-exercise and control group did not perform as well. While for diastolic blood pressure, significant difference was seen in diet-exercise and control groups, the separate diet and exercise group did not lower it as well. The highest reduction in systolic blood pressure was seen in diet group (-6.0mmHg) and lowest in control group (-1.0mmHg). On the contrary, the highest reduction in diastolic blood pressure was seen in control group (-4.6mmHg) and lowest in exercise group (-2.6mmHg).

Education based intervention programs based on lifestyle modification, especially focused on diet and physical activity become helpful in managing hyperglycemia and dyslipidemia. A systematic review conducted by Peiris et al., (2021) found that such behavior-changing programs possess beneficial effects on MetS. While in the present study, the biochemical parameters showed significant difference in diet group, for HDL and LDL cholesterol, but fasting blood glucose and triglycerides could not register significant difference. While in exercise group, a significant difference was observed for triglycerides, HDL, and LDL cholesterol, fasting blood glucose did not show significant difference. In diet-exercise intervention group, a significant difference was observed in HDL and LDL cholesterol, but not in fasting blood glucose and triglycerides that differed non significantly. In control group, a significant difference was observed for triglycerides and LDL cholesterol, but not for fasting blood glucose and HDL cholesterol. Thus, in this study on people of Punjabi community, benefits of intervention program were seen and when groups were compared an improvement was found mostly in diet and diet-exercise intervention groups where the highest reduction in fasting plasma glucose was seen in diet-exercise intervention group (-16.0mg/dL) and lowest in diet group (-2.7mg/dL). Further, the highest reduction in triglycerides was seen in diet group (-21.0mg/dL) and lowest in diet-exercise (-2.0mg/dL). Also, the highest increment in HDL cholesterol was seen in diet group (+2.6mg/dL) and lowest in control group (+0.43mg/dL). However, the highest reduction in LDL cholesterol was seen in exercise group (-8.0mg/dL) and lowest in control group (-5.9mg/dL).A recent investigation implemented a 13-week intervention focusing on a plant-based diet, revealing a correlation with weight reduction and elevated levels of HDL cholesterol. Both outcomes are crucial factors in addressing MetS and present study underscores the use of plant-based foods in diet regimen (McGrath & Fernandez, 2022). A meta-analysis done on a group of studies among diabetic population provided with diet-exercise intervention found energy and fat restriction with moderate aerobic exercises, a significant reduction in BMI, blood pressure, triglycerides, HDL cholesterol and blood sugar levels, when done for one year period (Appuhammy et al.,2014). In the current study, the prevalence of MetS was reduced the most in diet-

exercise group as 50% of subjects did not suffer from it after study period. While lowest reduction was seen in control group as 21.7% of subjects have not had MetS after study period. It may be concluded that diet-exercise intervention group showed better improvement in MetS in comparison to other groups. A similar study done on subjects with MetS revealed that the combined diet and exercise intervention showed better reduction in MetS in comparison to separate interventions. However, the period of study was one year, much longer than the present study (Anderssen et al., 2007). While the limitation of this study was that the intervention period could have been for a more considerabletime and include a long-term follow-up program to get a persistent benefit.Machine leaning models can be developed to predict sustainability trends in similar studies but require larger population dataset with periodic intervention records on the same group. The present study had small size and single time intervention that limits the possibility to check sustainability trends. In a recent study involving African women, findings demonstrated that the implementation of a diabetes prevention lifestyle intervention resulted in a significant reduction of 10.86% in the risk of developing MetS (Mamun, et al., 2020).A recent study utilized technology-based lifestyle interventions, and a better adherence was observed in the management of MetS, while present study also used technology based communication channels (Lee et al., 2022). A systematic review on diet and lifestyle modification intervention in randomized control trials concluded that such intervention programs are of great potential especially when done on relatively younger population wherein MetS is at the early stage and patients are asymptomatically ill.

Previous studies show that practical guidance, trust between the researcher and participants and, above all, regular consultations are crucial for reducing symptoms of MetS in patients. Such studies allow better intervention sustainability and lifelong learning in participants promoting healthy lifestyle and wellbeing. These intervention-based studies also offer better evidence to the health professionals and public health policy makers (Kataria et al., 2013). Another recent systematic review and meta-analysis compared diet, exercise, and combined intervention groups to review health outcomes relating overweight, obesity and lipid profiles found risk reduction, that too maximum in exercise group (Khalafi *et al.,* 2023). The study emphasizes the usefulness of combined diet and exercise interventions in managing MetS-related indicators and are coherent with previous research and is aligned with early-stage intervention and promotes lifelong learning. The findings of the study have direct applications, that give insights for healthcare practitioners and policy makers, as it offers practical strategies to improve health outcomes in vulnerable populations. Community based intervention studies also have social implications on the population. The health camp organized in the Gurdwaras had a visible impact on the Punjabi community. They got benefitted from the health camps as their nutritional status was assessed. Besides, provision of on-the-spot verbal counseling, irrespective of presence or absence of MetS, helped them in clearing their doubts regarding diet and exercise modifications in their day-to-day life. The face-to-face feedback from the subjects also motivated other visitors to the Gurdwaras to actively participate in the study. While the subjects that received intensive counseling for three months also had a positive outlook towards lifestyle modification during the study as also in further follow-up after the completion of study period.

CONCLUSION

The multi-prolonged nature of MetS makes it a complex metabolic disease. It comprises risk factors that include raised waist circumference, blood pressure, triglycerides, fasting blood glucose, and low HDL cholesterol. Presence of abdominal obesity along with at least two other factors make the person qualify for being a victim of MetS. In the present study, abdominal obesity was found to be a predominant risk factor prevalent in the Punjabi community. The other risk factors had variable prevalence among the subjects. Most of the subjects seemed to have fallen prey to MetS due to imbalanced diet partaking owing to poor dietary habits. The low physical activity level has been a common behavioral denominator as many, if not all, did not follow a fitness regime. The subjects diagnosed with MetS when provided with behavior change intervention showed improvement in one or more components of MetS. The diet-exercise intervention proved more beneficial in reducing symptoms of MetS in comparison to diet or exercise intervention alone. Such interventions allow long-lasting effects on the community to manage MetS and the resultant non-communicable diseases with an augmented awareness level and its translation into improved dietary

and lifestyle practices. Building up of a resolve works wonders in transforming the hapless couch potatoes into shapely, healthy human beings.

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Table 1: Mean anthropometric measurements of the subjects across groups pre and post intervention

Anthropometric measurements	Mean± SD		p value
	Before	After	
Experimental Group I			
Body weight (kg)	84.2±16.8	82.7±16.1	0.002[1]
Body Mass Index (kg/m²)	29.4±5.0	28.9±4.9	0.002[1]
Waist circumference (cm)	99.6±15.2	97.4±14.5	p<0.001[1]
Experimental Group II			
Body weight (kg)	79.1±12.6	77.6±12.8	p<0.001[1]
Body Mass Index (kg/m²)	29.6±4.0	29.1±4.2	p<0.001[1]
Waist circumference (cm)	98.6±14.2	97.3±14.4	0.001[1]
Experimental Group III			
Body weight (kg)	82.0±13.9	80.5±13.9	p<0.001[1]
Body Mass Index (kg/m²)	30.0±4.3	29.4±4.2	p<0.001[1]
Waist circumference (cm)	100±16.3	99.5±16.3	p<0.001[1]
Control Group			
Body weight (kg)	82.9±12.7	83.0±12.7	0.350[2]
Body Mass Index (kg/m²)	30.4±4.6	30.5±4.8	0.300[2]
Waist circumference (cm)	103±16.6	103±16.9	0.350[2]

Table 2: Comparison of the mean reduction/increment and test of significance in the anthropometric measurements among the intervention groups at the completion of the study period

Anthropometric measurements	Group I	Group II	Group III	Control group
Body weight (kg)	-1.5[a]	-1.5[b]	-1.6[c]	0.13[abc]
Body Mass Index (kg/m²)	-0.50[a]	-0.54[b]	-0.58[c]	0.06[abc]
Waist circumference (cm)	-2.2[a]	-1.3[b]	-1.0[a]	-0.11[ab]

Table 3: Mean systolic and diastolic blood pressure of the subjects across groups pre and post-intervention

Blood Pressure (mmHg)	Mean± SD		p value
	Before	After	
Experimental Group I			
Systolic	140±20.4	134±15.0	0.006[1]

Diastolic	86.4±10.0	82.8±5.9	0.013[2]
Experimental Group II			
Systolic	125±17.1	120±14.0	0.008[1]
Diastolic	81.0±9.4	78.4±7.1	0.043[1]
Experimental Group III			
Systolic	132±13.0	128±10.0	0.02[1]
Diastolic	82.6±9.5	79.5±7.3	0.003[1]
Control Group			
Systolic	135±22.9	134±21.2	0.295[2]
Diastolic	85.4±10.8	80.8±8.1	0.006[1]

Table 4: Comparison of the mean reduction/increment and test of significance in the systolic and diastolic blood pressure among the intervention groups at the completion of the study period

Blood Pressure	Group I	Group II	Group III	Control group
Systolic	-6.0[a]	-4.3	-4.0	-1.0[a]
Diastolic	-3.6	-2.6	-4.2	-4.6

Table 5: Mean biochemical profile of the subjects across groups pre and post intervention

Biochemical Profile (mg/dL)	Mean± SD		p value
	Before	After	
Experimental Group I			
Fasting plasma glucose	93.3±23.4	90.6±11.3	0.186[2]
Triglycerides	174±132	153±75.5	0.051[2]
HDL-cholesterol	47.9±14.3	50.5±12.3	p<0.001[1]
LDL-cholesterol	110±25.8	104±23.3	0.009[1]
Experimental Group II			
Fasting plasma glucose	103±34.2	99.8±24.7	0.06[2]
Triglycerides	167±80.6	159±68.3	0.04[1]
HDL-cholesterol	46.8±10.3	49.0±9.2	p<0.001[1]
LDL-cholesterol	116±25.6	108±21.1	0.005[1]
Experimental Group III			
Fasting plasma glucose	122±79.1	106±33.0	0.08[2]
Triglycerides	149±80.1	147±66.2	0.324[2]
HDL-cholesterol	48.0±8.3	49.5±6.5	0.022[1]
LDL-cholesterol	123±33.7	116±23.3	0.039[1]
Control Group			
Fasting plasma glucose	109±39.6	105±30.6	0.059[2]
Triglycerides	194±113	182±91.7	0.019[1]
HDL-cholesterol	50.0±13.2	50.4±11.5	0.326[2]
LDL-cholesterol	129±30.5	124±25.7	0.003[1]

Table 6: Comparison of the mean reduction/increment and test of significance in the biochemical profile among the intervention groups at the completion of the study period

Biochemical profile	Group I	Group II	Group III	Control group
Fasting plasma glucose	-2.7	-3.5	-16.0	-4.7
Triglycerides	-21.0	-8.1	-2.0	-12.0
HDL-cholesterol	2.6[a]	2.2	1.5	0.43[a]
LDL-cholesterol	-6.7	-8.0	-6.5	-5.9

Table 7: Status of Metabolic Syndrome after intervention period among all groups

Status	Group I: Diet (N=22)	Group II: Exercise (N=22)	Group III: Diet and Exercise (N=23)	Control group: No Intervention (N=22)
Present	54.6	63.6	50.0	78.3
Absent	45.5	36.4	50.0	21.7

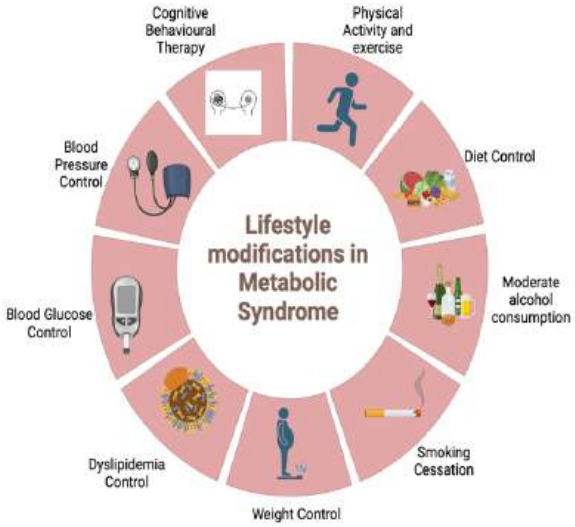


Figure 1: Lifestyle modifications in Metabolic Syndrome

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RESEARCH ARTICLE

Some Results based on Primary Complex Interval-Valued Intuitionistic Fuzzy *M* Group

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ABSTRACT

The concept of complex interval-valued intuitionistic fuzzyset is extended by introducing primary complex interval-valued intuitionistic fuzzy *M*group using this concept primary complex interval-valued intuitionistic fuzzy *M* groupis defined. We also proved some results of the above are established.

Keywords: Complex fuzzy set, Complex intuitionistic fuzzy set, Complex interval-valued intuitionistic fuzzy set, Primary complex interval-valued intuitionistic fuzzy M group.

INTRODUCTION

Ever since an introduction of fuzzy set by L.A.Zadeh [9], the fuzzy concept has invaded almost all branches of mathematics. The concept of IFS and IVIFS was introduced by K.T.Atanassov[1,2] as a generalization of the notion of fuzzy set. K.Chakrabarthy, R.Biswas and S.Nanda [3] discussed union and intersection of IFS.G.Prasannavengeteswari, K.Gunasekaran and .S.Nandakumar [5] introduced the definition of Primary Interval-Valued Intuitionistic Fuzzy M Group (PIVIFMG). Yanhong Su, Zengtai Gong, Na Qin [8] introduced complex

interval-valued intuitionistic fuzzy sets using this idea we define Primary complex interval-valued Intuitionistic Fuzzy M Group and some results are established.

PRELIMINARIES

Definition: 2.1

Let X be a universal set. A complex fuzzy set A over X is formed by $A = \{\langle x, \mu_A(x)\rangle : x \in X\}$,where the complex-valued membership function $\mu_A(x)$ has the form $r_A(x)e^{i\theta_{r_A}}$, where $i = \sqrt{-1}$, $r_A \in [0,1]$ and $\theta_{r_A}(x)$ is real-valued. The value of $\mu_A(x)$ lies in a unit circle in the complex plane.

Definition: 2.2

A complex intuitionistic fuzzy set A of a non-empty set X is an object of the form $A = \{\langle x, \mu_A(x), \nu_A(x)\rangle : x \in X\}$, where the membership function $\mu_A(x) = r_A(x)e^{i\theta_{r_A}}$and is defined as $\mu_A : X \to \{z \in C : |z| \leq 1\}$ and non-membership function $\nu_A(x) = k_A(x)e^{i\theta_{k_A}}$ and defined as $\nu_A : X \to \{z \in C : |z| \leq 1\}$,where C is set of complex numbers. These membership and non-membership function receive all degree of membership and non-membership from the unit disc on complex plane respectively, such that the sum of membership and non-membership values is also lies within unit disc of complex plane where $i = \sqrt{-1}$. $r_A(x), k_A(x), \theta_{r_A}$and θ_{k_A} are real valued such that $0 \leq r_A(x) + k_A(x) \leq 1$ and $0 \leq \theta_{r_A} + \theta_{k_A} \leq 2\pi$.

Definition: 2.3

Let$X$ be a universal set, Acomplex interval-valued intuitionistic fuzzy set defined on X is a set given by $A = \{\langle x, [\mu_A^-, \mu_A^+], [\nu_A^-, \nu_A^+]\rangle | x \in X\}$, where $\mu_A^-, \mu_A^+, \nu_A^-$ and ν_A^+ represent the degree of lower and upper bound of the membership and non-membership respectively, which are defined as $\mu_A^-(x) = z_1^- = r_A^-(x)e^{i\theta_{r_A}^-}$ and $\mu_A^+(x) = z_1^+ = r_A^+(x)e^{i\theta_{r_A}^+}$ such that $|z_1^-| \leq |z_1^+|$, while $\nu_A^-(x) = z_2^- = k_A^-(x)e^{i\theta_{k_A}^-}$ and $\nu_A^+(mxy) = z_2^+ = k_A^+(mxy)e^{i\theta_{k_A}^+}$ such that such that $|z_2^-| \leq |z_2^+|$. The amplitude terms are$r_A^-, r_A^+, k_A^-, k_A^+ \in [0,1]$ and satisfy the inequality $r_A^- \leq r_A^+, k_A^- \leq k_A^+$ and $r_A^+ + k_A^+ \leq 1$, $\forall x \in X$, other hand , the phase terms $\theta_{r_A}^-, \theta_{r_A}^+, \theta_{k_A}^-, \theta_{k_A}^+$ are real-valued which lie within the interval$[0,2\pi]$ and satisfy the inequality $\theta_{r_A}^- \leq \theta_{r_A}^+, \theta_{k_A}^- \leq \theta_{k_A}^+$ and $\theta_{r_A}^+ + \theta_{k_A}^+ \leq 2\pi$, $\forall x \in X$. Therefore, CIVIFS A defined on X can be represented as $A = \left\{\langle x, [r_A^-, r_A^+]e^{i[\theta_{r_A}^-, \theta_{r_A}^+]}, [k_A^-, k_A^+]e^{i[\theta_{k_A}^-, \theta_{k_A}^+]}\rangle | x \in X\right\}$.

Definition: 2.4

Let X be an M group and A is a complex interval-valued intuitionistic fuzzy subgroup of X, then A is called a primary complex interval-valued intuitionistic fuzzy M group of X. If for all $x, y \in X$ and $m \in M$, then either $\mu_A^+(mxy) = r_A^+(mxy)e^{i\theta_{r_A}^+} \leq r_A^+(x^p)|e^{i\theta}| = \mu_A^+(x^p)$ and $\nu_A^+(mxy) = k_A^+(mxy)e^{i\theta_{k_A}^+} \geq k_A^+(x^p)|e^{i\theta}| = \nu_A^+(x^p)$, for some $p \in Z_+$ or else $\mu_A^+(mxy) = r_A^+(mxy)e^{i\theta_{r_A}^+} \leq r_A^+(y^q)|e^{i\theta}| = \mu_A^+(y^q)$and $\nu_A^+(mxy) = k_A^+(mxy)e^{i\theta_{k_A}^+} \geq k_A^+(y^q)|e^{i\theta}| = \nu_A^+(y^q)$, for some $q \in Z_+$ and either $\mu_A^-(mxy) = r_A^-(mxy)e^{i\theta_{r_A}^-} \geq r_A^-(x^p)|e^{-i\theta}| = \mu_A^-(x^p)$ and $\nu_A^-(mxy) = k_A^-(mxy)e^{i\theta_{k_A}^-} \leq k_A^-(x^p)|e^{-i\theta}| = \nu_A^-(x^p)$, for some $p \in Z_+$ or else $\mu_A^-(mxy) = r_A^-(mxy)e^{i\theta_{r_A}^-} \geq r_A^-(y^q)|e^{-i\theta}| = \mu_A^-(y^q)$and $\nu_A^-(mxy) = k_A^-(mxy)e^{i\theta_{k_A}^-} \leq k_A^-(y^q)|e^{-i\theta}| = \nu_A^-(y^q)$, for some $q \in Z_+$. Where $r_A^-, r_A^+, k_A^-, k_A^+ \in [0,1]$ and satisfy $r_A^- \leq r_A^+, k_A^- \leq k_A^+, r_A^+ + k_A^+ \leq 1$, $\forall x \in X$. Other hand, $\theta_{r_A}^-, \theta_{r_A}^+, \theta_{k_A}^-, \theta_{k_A}^+$ are real-valued which lie within the interval $[0,2\pi]$and satisfy $\theta_{r_A}^- \leq \theta_{r_A}^+, \theta_{k_A}^- \leq \theta_{k_A}^+$ and $\theta_{r_A}^+ + \theta_{k_A}^+ \leq 2\pi$.

Some results on primary complex interval-valued intuitionistic fuzzy *M*group

Theorem: 3.1

If A is a primary complex interval-valued intuitionistic fuzzy$M$ group of X, then $\bar{\bar{A}} = A$ is a primary complex interval-valued intuitionistic fuzzy M group of X.

Proof:

Consider $x, y \in A$ and $m \in M$. Now

$\mu_{\bar{A}}^{+}(mxy) = \nu_{A}^{+}(mxy)$
$= \mu_{A}^{+}(mxy)$
$= r_{A}^{+}(mxy)e^{i\theta_{r_A}^{+}}$
$\leq r_{A}^{+}(x^p)\left|e^{i\theta}\right|$
$= \mu_{A}^{+}(x^p)$.
Therefore, $\mu_{\bar{A}}^{+}(mxy) \leq \mu_{A}^{+}(x^p)$, for some $p \in Z_+$. Consider
$\nu_{\bar{A}}^{+}(mxy) = \mu_{\bar{A}}^{+}(mxy)$
$= \upsilon_{A}^{+}(mxy)$
$= k_{A}^{+}(mxy)e^{i\theta_{k_A}^{+}}$
$\geq k_{A}^{+}(x^p)\left|e^{i\theta}\right|$
$= \nu_{A}^{+}(x^p)$
Therefore,$\nu_{\bar{A}}^{+}(mxy) \geq \nu_{A}^{+}(x^p)$, for some $p \in Z_+$. Consider
$\mu_{\bar{A}}^{-}(mxy) = \upsilon_{\bar{A}}^{-}(mxy)$
$= \mu_{A}^{-}(mxy)$
$= r_{A}^{-}(mxy)e^{i\theta_{r_A}^{-}}$
$\geq r_{A}^{-}(x^p)\left|e^{-i\theta}\right|$
$= \mu_{A}^{-}(x^p)$
Therefore, $\mu_{\bar{A}}^{-}(mxy) \geq \mu_{A}^{-}(x^p)$, for some $p \in Z_+$. Consider
$\nu_{\bar{A}}^{-}(mxy) = \mu_{\bar{A}}^{-}(mxy)$
$= \upsilon_{A}^{-}(mxy)$
$= k_{A}^{-}(mxy)e^{i\theta_{k_A}^{-}}$
$\leq k_{A}^{-}(x^p)\left|e^{-i\theta}\right|$
$= \nu_{A}^{-}(x^p)$
Therefore,$\nu_{\bar{A}}^{-}(mxy) \leq \nu_{A}^{-}(x^p)$, for some $p \in Z_+$.
Therefore $\bar{\bar{A}} = A$ is a primary complex interval-valued intuitionistic fuzzy Mgroup of X.

Theorem:3.2
Intersection of any two primary complex interval-valued intuitionistic fuzzy Mgroup is again a primary complex interval-valued intuitionistic fuzzy M group.

Proof:
Let A and Bbe two primary complex interval-valued intuitionistic fuzzy M group of X.
Consider $x, y \in A$ and $x, y \in B$and $m \in M$.Now
$\mu_{A\cap B}^{+}(mxy) = \min\left(\mu_{A}^{+}(mxy), \mu_{B}^{+}(mxy)\right)$
$= \min\left(r_{A}^{+}(mxy)e^{i\theta_{r_A}^{+}}, r_{B}^{+}(mxy)e^{i\theta_{r_B}^{+}}\right)$
$\leq \min\left(r_{A}^{+}(x^p)\left|e^{i\theta}\right|, r_{B}^{+}(x^p)\left|e^{i\theta}\right|\right)$
$= \min\left(\mu_{A}^{+}(x^p), \mu_{B}^{+}(x^p)\right)$
$= \mu_{A\cap B}^{+}(x^p)$.
Therefore, $\mu_{A\cap B}^{+}(mxy) \leq \mu_{A\cap B}^{+}(x^p)$, for some $p \in Z_+$. Consider
$\nu_{A\cap B}^{+}(mxy) = \max\left(\nu_{A}^{+}(mxy), \nu_{B}^{+}(mxy)\right)$
$= \max\left(k_{A}^{+}(mxy)e^{i\theta_{k_A}^{+}}, k_{B}^{+}(mxy)e^{i\theta_{k_B}^{+}}\right)$
$\geq \max\left(k_{A}^{+}(x^p)\left|e^{i\theta}\right|, k_{B}^{+}(x^p)\left|e^{i\theta}\right|\right)$
$= \max\left(\nu_{A}^{+}(x^p), \nu_{B}^{+}(x^p)\right)$
$= \nu_{A\cap B}^{+}(x^p)$.
Therefore,$\nu_{A\cap B}^{+}(mxy) \geq \nu_{A\cap B}^{+}(x^p)$, for some $p \in Z_+$. Consider
$\mu_{A\cap B}^{-}(mxy) = \max\left(\mu_{A}^{-}(mxy), \mu_{B}^{-}(mxy)\right)$
$= \max\left(r_{A}^{-}(mxy)e^{i\theta_{r_A}^{-}}, r_{B}^{-}(mxy)e^{i\theta_{r_B}^{-}}\right)$
$\geq \max\left(r_{A}^{-}(x^p)\left|e^{-i\theta}\right|, r_{B}^{-}(x^p)\left|e^{-i\theta}\right|\right)$
$= \max\left(\mu_{A}^{-}(x^p), \mu_{B}^{-}(x^p)\right)$
$= \mu_{A\cap B}^{-}(x^p)$
Therefore, $\mu_{A\cap B}^{-}(mxy) \geq \mu_{A\cap B}^{-}(x^p)$, for some $p \in Z_+$. Consider

$v^-_{A\cap B}(mxy) = \min\,(v^-_A(mxy), v^-_B(mxy))$
$= \min\,(k^-_A(mxy)e^{i\theta^-_{k_A}}, k^-_B(mxy)e^{i\theta^-_{k_B}})$
$\leq \min\,(k^-_A(x^p)\left|e^{-i\theta}\right|, k^-_A(x^p)\left|e^{-i\theta}\right|)$
$= \min\,(v^-_A(x^p), v^-_B(x^p))$
$= v^-_{A\cap B}(x^p)$
Therefore,$v^-_{A\cap B}(mxy) \leq v^-_{A\cap B}(x^p)$, for some $p \in Z_+$.
Therefore,$A \cap B$ is a primary complex interval-valued intuitionistic fuzzy$M$group of X.

Theorem: 3.3

If $A$and B are primary complex interval-valued intuitionistic fuzzy M group, then $\overline{A} \cap \overline{B} = \overline{A \cup B}$ is also a primary complex interval- valued intuitionistic fuzzy M group.

Proof

Let A and B be two primary complex interval-valued intuitionistic fuzzy M group of X.
Consider $x, y \in A$ and $x, y \in B$and $m \in M$.
Consider $\mu^+_{A\cap\overline{B}}(mxy) = \min\left(\mu^+_{\overline{A}}(mxy), \mu^+_{\overline{B}}(mxy)\right)$
$= \min(v^+_A(mxy), v^+_B(mxy))$
$= \min(k^+_A(mxy)e^{i\theta^+_{k_A}}, k^+_B(mxy)e^{i\theta^+_{k_B}})$
$\leq \min(k^+_A(x^p)\left|e^{i\theta}\right|, k^+_B(x^p)\left|e^{i\theta}\right|)$
$= \min\left(v^+_A(x^p), v^+_B(x^p)\right)$
$= v^+_{A\cup B}(x^p)$
$= \mu^+_{\overline{A\cup B}}(x^p)$
Therefore$\mu^+_{A\cap\overline{B}}(mxy) \leq \mu^+_{\overline{A\cup B}}(x^p)$,for some$p \in Z_+$
Consider$v^+_{A\cap\overline{B}}(mxy) = \max(v^+_{\overline{A}}(mxy), v^+_{\overline{B}}(mxy))$
$= \max(\mu^+_A(mxy), \mu^+_B(mxy))$
$= \max(r^+_A(mxy)e^{i\theta^+_{r_A}}, r^+_B(mxy)e^{i\theta^+_{r_B}})$
$\geq \max(r^+_A(x^p)\left|e^{i\theta}\right|, r^+_B(x^p)\left|e^{i\theta}\right|)$
$= \max(\mu^+_A(x^p), \mu^+_B(x^p))$
$= \mu^+_{A\cup B}(x^p)$
$= v^+_{\overline{A\cup B}}(x^p)$.
Therefore$v^+_{A\cap\overline{B}}(mxy) \geq v^+_{\overline{A\cup B}}(x^p)$, for some$p \in Z_+$
Consider $\mu^-_{A\cap\overline{B}}(mxy) = \max\left(\mu^-_{\overline{A}}(mxy), \mu^-_{\overline{B}}(mxy)\right)$
$= \max(v^-_A(mxy), v^-_B(mxy))$
$= \max\,(k^-_A(mxy)e^{i\theta^-_{k_A}}, k^-_B(mxy)e^{i\theta^-_{k_B}})$
$\geq \max\,(k^-_A(x^p)\left|e^{-i\theta}\right|, k^-_B(x^p)\left|e^{-i\theta}\right|)$
$= \max\left(v^-_A(x^p), v^-_B(x^p)\right)$
$= v^-_{A\cup B}(x^p)$
$= \mu^-_{\overline{A\cup B}}(x^p)$
Therefore$\mu^-_{A\cap\overline{B}}(mxy) \geq \mu^-_{\overline{A\cup B}}(x^p)$,for some$p \in Z_+$
Consider$v^-_{A\cap\overline{B}}(mxy) = \min(v^-_{\overline{A}}(mxy), v^-_{\overline{B}}(mxy))$
$= \min(\mu^-_A(mxy), \mu^-_B(mxy))$
$= \min\,(r^-_A(mxy)e^{i\theta^-_{r_A}}, r^-_B(mxy)e^{i\theta^-_{r_B}})$
$\leq \min\,(r^-_A(x^p)\left|e^{-i\theta}\right|, r^-_B(x^p)\left|e^{-i\theta}\right|)$
$= \min(\mu^-_A(x^p), \mu^-_B(x^p))$
$= \mu^-_{A\cup B}(x^p)$
$= v^-_{\overline{A\cup B}}(x^p)$.
Therefore$v^-_{A\cap\overline{B}}(mxy) \leq v^-_{\overline{A\cup B}}(x^p)$, for some$p \in Z_+$
Therefore, $\overline{A} \cap \overline{B} = \overline{A \cup B}$ is a primary complex interval-valued intuitionistic fuzzy$M$group of X. □

Theorem: 3.4

If $A$and B are primary complex interval-valued intuitionistic fuzzy M group, then $\overline{A} \cup \overline{B} = \overline{A \cap B}$ is also a primary complex interval- valued intuitionistic fuzzy M group.

Proof

Let A and B be two primary complex interval-valued intuitionistic fuzzy M group of X.

Consider $x, y \in A$ and $x, y \in B$and $m \in M$.

Consider $\mu^{+}_{\overline{A \cup B}}(mxy) = \max\left(\mu^{+}_{\overline{A}}(mxy), \mu^{+}_{\overline{B}}(mxy)\right)$

$= \max(\nu^{+}_{A}(mxy), \nu^{+}_{B}(mxy))$

$= \max(k^{+}_{A}(mxy)e^{i\theta^{+}_{k_A}}, k^{+}_{B}(mxy)e^{i\theta^{+}_{k_B}})$

$\leq \max(k^{+}_{A}(x^p)\left|e^{i\theta}\right|, k^{+}_{B}(x^p)\left|e^{i\theta}\right|)$

$= \max\left(\nu^{+}_{A}(x^p), \nu^{+}_{B}(x^p)\right)$

$= \nu^{+}_{A \cap B}(x^p)$

$= \mu^{+}_{\overline{A \cap B}}(x^p)$

Therefore$\mu^{+}_{\overline{A \cup B}}(mxy) \leq \mu^{+}_{\overline{A \cap B}}(x^p)$,for some$p \in Z_+$

Consider$\nu^{+}_{\overline{A \cup B}}(mxy) = \min(\nu^{+}_{\overline{A}}(mxy), \nu^{+}_{\overline{B}}(mxy))$

$= \min(\mu^{+}_{A}(mxy), \mu^{+}_{B}(mxy))$

$= \min(r^{+}_{A}(mxy)e^{i\theta^{+}_{r_A}}, r^{+}_{B}(mxy)e^{i\theta^{+}_{r_B}})$

$\geq \min(r^{+}_{A}(x^p)\left|e^{i\theta}\right|, r^{+}_{B}(x^p)\left|e^{i\theta}\right|)$

$= \min(\mu^{+}_{A}(x^p), \mu^{+}_{B}(x^p))$

$= \mu^{+}_{A \cap B}(x^p)$

$= \nu^{+}_{\overline{A \cap B}}(x^p)$.

Therefore$\nu^{+}_{\overline{A \cup B}}(mxy) \geq \nu^{+}_{\overline{A \cap B}}(x^p)$, for some$p \in Z_+$

Consider $\mu^{-}_{\overline{A \cup B}}(mxy) = \min\left(\mu^{-}_{\overline{A}}(mxy), \mu^{-}_{\overline{B}}(mxy)\right)$

$= \min(\nu^{-}_{A}(mxy), \nu^{-}_{B}(mxy))$

$= \min\ (k^{-}_{A}(mxy)e^{i\theta^{-}_{k_A}}, k^{-}_{B}(mxy)e^{i\theta^{-}_{k_B}})$

$\geq \min\ (k^{-}_{A}(x^p)\left|e^{-i\theta}\right|, k^{-}_{B}(x^p)\left|e^{-i\theta}\right|)$

$= \min\left(\nu^{-}_{A}(x^p), \nu^{-}_{B}(x^p)\right)$

$= \nu^{-}_{A \cap B}(x^p)$

$= \mu^{-}_{\overline{A \cap B}}(x^p)$

Therefore$\mu^{-}_{\overline{A \cup B}}(mxy) \geq \mu^{-}_{\overline{A \cap B}}(x^p)$,for some$p \in Z_+$

Consider$\nu^{-}_{\overline{A \cup B}}(mxy) = \max(\nu^{-}_{\overline{A}}(mxy), \nu^{-}_{\overline{B}}(mxy))$

$= \max(\mu^{-}_{A}(mxy), \mu^{-}_{B}(mxy))$

$= \max\ (r^{-}_{A}(mxy)e^{i\theta^{-}_{r_A}}, r^{-}_{B}(mxy)e^{i\theta^{-}_{r_B}})$

$\leq \max\ (r^{-}_{A}(x^p)\left|e^{-i\theta}\right|, r^{-}_{B}(x^p)\left|e^{-i\theta}\right|)$

$= \max(\mu^{-}_{A}(x^p), \mu^{-}_{B}(x^p))$

$= \mu^{-}_{A \cap B}(x^p)$

$= \nu^{-}_{\overline{A \cap B}}(x^p)$.

Therefore$\nu^{-}_{\overline{A \cup B}}(mxy) \leq \nu^{-}_{\overline{A \cap B}}(x^p)$, for some$p \in Z_+$

Therefore $\overline{A} \cup \overline{B} = \overline{A \cap B}$ is a primary complex interval-valued intuitionistic fuzzy$M$group of X.

Theorem: 3.5

If A is a primary complex interval-valued intuitionistic fuzzy M group of X, then $\Box A$is also a primary complex interval-valued intuitionistic fuzzy M group of X.

Proof

Consider $x, y \in A$and $m \in M$. Consider

$\mu^{+}_{\Box A}(mxy) = \mu^{+}_{A}(mxy)$

$= r^{+}_{A}(mxy)e^{i\theta^{+}_{r_A}}$

$\leq r_A^+(x^p)\left|e^{i\theta}\right|$
$= \mu_A^+(x^p)$
$= \mu_{\Box A}^+(x^p)$
Therefore, $\mu_{\Box A}^+(mxy) \leq \mu_{\Box A}^+(x^p)$, for some $p \in Z_+$. Consider
$\nu_{\Box A}^+(mxy) = 1 - \mu_A^+(mxy)$
$= 1 - {}^+()^+$
$\geq 1 - {}^+()||$
$= 1 - \mu_A^+()$
$= {}^+_{\Box A}()$
Therefore, ${}^+_{\Box A}() \geq {}^+_{\Box A}()$, for some $\in {}_+$. Consider
$\mu_{\Box A}^-() = {}^-()$
$= {}^-()^-$
$\geq {}^-()|^-|$
$= {}^-()$
$= \mu_{\Box A}^-(x^p)$
Therefore, $\mu_{\Box A}^-(mxy) \geq \mu_{\Box A}^-(x^p)$, for some $p \in Z_+$. Consider
$\nu_{\Box A}^-(mxy) = 1 - \mu_A^-(mxy)$
$= 1 - r_A^-(mxy)e^{i\theta_{r_A}^-}$
$\leq 1 - r_A^-(x^p)\left|e^{-i\theta}\right|$
$= 1 - \mu_A^-(x^p)$
$= \nu_{\Box A}^-(x^p)$
Therefore, $\nu_{\Box A}^-(mxy) \leq \nu_{\Box A}^-(x^p)$, for some $p \in Z_+$.
Therefore, $\Box A$ is a primary complex interval-valued intuitionistic fuzzy M group of X.

Theorem: 3.6
If A is a primary complex interval-valued intuitionistic fuzzy M group of X, then $\Diamond A$ is also a primary complex interval-valued intuitionistic fuzzy M group of X.

Proof
Consider $x, y \in A$ and $m \in M$. Consider
$\mu_{\Diamond A}^+(mxy) = 1 - \nu_A^+(mxy)$
$= 1 - k_A^+(mxy)e^{i\theta_{k_A}^+}$
$\leq 1 - k_A^+(x^p)\left|e^{i\theta}\right|$
$= 1 - \nu_A^+(x^p)$
$= \mu_{\Diamond A}^+(x^p)$.
Therefore, $\mu_{\Diamond A}^+(mxy) \leq \mu_{\Diamond A}^+(x^p)$, for some $p \in Z_+$. Consider
$\nu_{\Diamond A}^+(mxy) = \nu_A^+(mxy)$
$= k_A^+(mxy)e^{i\theta_{k_A}^+}$
$\geq k_A^+(x^p)\left|e^{i\theta}\right|$
$= \nu_A^+(x^p)$
$= \nu_{\Diamond A}^+(x^p)$
Therefore, $\nu_{\Diamond A}^+(mxy) \geq \nu_{\Diamond A}^+(x^p)$, for some $p \in Z_+$. Consider
$\mu_{\Diamond A}^-(mxy) = 1 - \nu_A^-(mxy)$
$= 1 - k_A^-(mxy)e^{i\theta_{k_A}^-}$
$\geq 1 - k_A^-(x^p)\left|e^{-i\theta}\right|$
$= 1 - \nu_A^-(x^p)$
$= \mu_{\Diamond A}^-(x^p)$
Therefore $\mu_{\Diamond A}^-(mxy) \geq \mu_{\Diamond A}^-(x^p)$, for some $p \in Z_+$. Consider
$\nu_{\Diamond A}^-(mxy) = \nu_A^-(mxy)$

$= k_A^-(mxy)e^{i\theta_{k_A}^-}$
$\leq k_A^-(x^p)\left|e^{-i\theta}\right|$
$= \nu_A^-(x^p)$
$= \nu_{\Diamond A}^-(x^p)$.
Therefore,$\nu_{\Diamond A}^-(mxy) \leq \nu_{\Diamond A}^-(x^p)$, for some$p \in Z_+$
Therefore,$\Diamond A$ is a primary complex interval-valued intuitionistic fuzzy$M$ group of X.

CONCLUSION

In this paper the main idea of primary complex interval-valued intuitionistic fuzzyM group is a new algebraic structures of fuzzy algebra and it is used through the some results of the above. We believe that our ideas can also applied for other algebraic system.

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RESEARCH ARTICLE

Solving Quadratic Diophantine Equation of the form $au^2 + bv^2 = (a + b\alpha^2)^n$

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ABSTRACT

This paper proposes a simple and effective method to solve the quadratic Diophantine equation of the form $au^2 + bv^2 = (a + b\alpha^2)^n$, whose solutions are positive integers, where n, a, α are positive integers and b is any positive non-square integer. The solution is obtained by an analytical method, and the answers are verified by using a python program.

Keywords: Quadratic Diophantine equation, Euler's formula, Polar form, Positive integer Solutions

INTRODUCTION

The concept of solving equations whose solutions are in integers is of very practical importance not only in the world of mathematics but also required for addressing social problems with meaningful solutions. Generally, equations whose solutions are in integers are termed as Diophantine Equations named after ancient Greek mathematician Diophantus. Solving Diophantine equations created great interest among mathematicians of all times. Diophantus himself has provided few techniques to solve Diophantine equations whose solutions involve practical usage. Euler

has done enormous work in solving Diophantine Equations and some of his techniques are used even today. Particularly his idea of using polar form of complex numbers in solving quadratic Diophantine Equations is quite remarkable and several mathematicians has adopted his techniques since then. For example, see **[1, 2]**.In this paper, we consider family of Quadratic Diophantine Equations and adopt the technique of choosing particular complex numbers to obtain the solutions. A Python coding is provided, in order to verify the results obtained.

Theorem 1

If n, a, α are positive integers, and if b is any positive non-square integer then the positive integer solutions u, v of the quadratic Diophantine equation of the form $au^2 + bv^2 = (a + b\alpha^2)^n$ are given by the following expressions

$u = \frac{(a+b\alpha^2)^{\frac{n}{2}}}{\sqrt{a}} sin\left\{ntan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)\right\}$ and $v = \frac{(a+b\alpha^2)^{\frac{n}{2}}}{\sqrt{b}} cos\left\{ntan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)\right\}$ (1)

Proof

First, we will determine the polar form of the complex number $\alpha\sqrt{b} + i\sqrt{a}$.

Using Euler's Formula we can express $\alpha\sqrt{b} + i\sqrt{a} = r(cos\theta + isin\theta) = re^{i\theta}$

$rcos\theta = \alpha\sqrt{b};\ rsin\theta = \sqrt{a}$

$r^2 = a + b\alpha^2$

$r = \sqrt{a + b\alpha^2};\ \theta = tan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)$

$\left[\alpha\sqrt{b} + i\sqrt{a}\right]^n = r^n e^{in\theta}$

$\left[\alpha\sqrt{b} + i\sqrt{a}\right]^n = (a + b\alpha^2)^{\frac{n}{2}}\ exp\left\{i\ n\ tan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)\right\}$

Let us consider

$\sqrt{b}v + i\sqrt{a}u = \left[\alpha\sqrt{b} + i\sqrt{a}\right]^n$

Then $\sqrt{b}v - i\sqrt{a}u = \left[\alpha\sqrt{b} - i\sqrt{a}\right]^n$

$\left(\sqrt{b}v + i\sqrt{a}u\right)\left(\sqrt{b}v - i\sqrt{a}u\right) = \left[\alpha\sqrt{b} + i\sqrt{a}\right]^n\left[\alpha\sqrt{b} - i\sqrt{a}\right]^n$

$au^2 + bv^2 = (a + b\alpha^2)^n$

Now,

$\sqrt{b}v + i\sqrt{a}u = \left[\alpha\sqrt{b} + i\sqrt{a}\right]^n = (a + b\alpha^2)^{\frac{n}{2}}\ exp\left\{in\ tan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)\right\}$

$\sqrt{b}v + i\sqrt{a}u = (a + b\alpha^2)^{\frac{n}{2}}\ exp\left\{in\ tan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)\right\}$

$\sqrt{b}v + i\sqrt{a}u = (a + b\alpha^2)^{\frac{n}{2}}\left[cos\left\{ntan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)\right\} + isin\left\{ntan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)\right\}\right]$

Equating the real and imaginary parts, we get

$u = \frac{(a + b\alpha^2)^{\frac{n}{2}}}{\sqrt{a}} sin\left\{ntan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)\right\}$

$v = \frac{(a + b\alpha^2)^{\frac{n}{2}}}{\sqrt{b}} cos\left\{ntan^{-1}\left(\frac{\sqrt{a}}{\alpha\sqrt{b}}\right)\right\}$

This proves (1). If we now consider $(|u|, |v|)$, from above values, then we always obtain the positive integer solutions to the quadratic Diophantine equation $au^2 + bv^2 = (a + b\alpha^2)^n$. For knowing more details about solving Diophantine equations refer **[3 – 10]** We now present few examples to obtain solutions of certain quadratic Diophantine equations.

Consider the quadratic Diophantine equation $4u^2 + 5v^2 = 9^n$

Comparing the general equation we have, $a = 4, b = 5, \alpha = 1$

The solutions according to (1) in Theorem are given by

$u = \frac{(9)^{\frac{n}{2}}}{\sqrt{4}} sin\left\{ntan^{-1}\left(\frac{\sqrt{4}}{\sqrt{5}}\right)\right\} = \frac{(9)^{\frac{n}{2}}}{2} sin\left\{ntan^{-1}\left(\frac{2}{\sqrt{5}}\right)\right\}$

$v = \frac{(9)^{\frac{n}{2}}}{\sqrt{5}} cos\left\{ntan^{-1}\left(\frac{\sqrt{4}}{\sqrt{5}}\right)\right\} = \frac{(9)^{\frac{n}{2}}}{\sqrt{5}} cos\left\{ntan^{-1}\left(\frac{2}{\sqrt{5}}\right)\right\}$

When $n = 1$ then the corresponding positive integer solution is $(1,1)$
When $n = 2$ then the corresponding positive integer solution is $(3,3)$
When $n = 3$ then the corresponding positive integer solution is$(9,9),(11,7)$
When $n = 4$ then the corresponding positive integer solutions are$(27,27),(33,21)$
When $n = 5$ then the corresponding positive integer solutions are$(59,85),(81,81),(99,63)$

Consider the quadratic Diophantine equation $4u^2 + 5v^2 = 24^n$
Here $a = 4, b = 5, \alpha = 2$
The solutions according to (1) in Theorem are given by

$u = \frac{(24)^{\frac{n}{2}}}{\sqrt{4}} sin\left\{ntan^{-1}\left(\frac{\sqrt{4}}{2\sqrt{5}}\right)\right\} = \frac{(24)^{\frac{n}{2}}}{2} sin\left\{ntan^{-1}\left(\frac{2}{2\sqrt{5}}\right)\right\}$

$v = \frac{(24)^{\frac{n}{2}}}{\sqrt{5}} cos\left\{ntan^{-1}\left(\frac{\sqrt{4}}{2\sqrt{5}}\right)\right\} = \frac{(24)^{\frac{n}{2}}}{\sqrt{5}} cos\left\{ntan^{-1}\left(\frac{2}{2\sqrt{5}}\right)\right\}$

When $n = 1$ then the corresponding positive integer solution is $(1,2)$
-When $n = 2$ then the corresponding positive integer solutions are$(8,8),(12,0)$
When $n = 3$ then the corresponding positive integer solutions are$(24,48),(56,16)$
When $n = 4$ then the corresponding positive integer solutions are$(32,256),(192,92),(288,0)$

Consider the quadratic Diophantine equation $4u^2 + 3v^2 = 16^n$
Here $a = 4, b = 3, \alpha = 2$
The solutions according to (1) in Theorem are given by

$u = \frac{(16)^{\frac{n}{2}}}{\sqrt{4}} sin\left\{ntan^{-1}\left(\frac{\sqrt{4}}{2\sqrt{3}}\right)\right\} = \frac{(16)^{\frac{n}{2}}}{2} sin\left\{ntan^{-1}\left(\frac{1}{\sqrt{3}}\right)\right\}$

$v = \frac{(16)^{\frac{n}{2}}}{\sqrt{3}} cos\left\{ntan^{-1}\left(\frac{\sqrt{4}}{2\sqrt{3}}\right)\right\} = \frac{(16)^{\frac{n}{2}}}{\sqrt{3}} cos\left\{ntan^{-1}\left(\frac{1}{\sqrt{3}}\right)\right\}$

When $n = 1$ then the corresponding positive integer solutions are$(1,2),(2,0)$
When $n = 2$ then the corresponding positive solutions are$(4,8),(8,0)$
When $n = 3$ then the corresponding positive integer solutions are$(16,32),(32,0)$
When $n = 4$ then the corresponding positive integer solutions are$(64,128),(128,0)$
When $n = 5$ then the corresponding positive integer solutions are$(256,512),(512,0)$

Consider the quadratic Diophantine equation $17u^2 + 3v^2 = 29^n$
Here $a = 17, b = 3, \alpha = 2$
The solutions according to (1) in Theorem are given by

$u = \frac{(29)^{\frac{n}{2}}}{\sqrt{17}} sin\left\{ntan^{-1}\left(\frac{\sqrt{17}}{2\sqrt{3}}\right)\right\} = \frac{(29)^{\frac{n}{2}}}{\sqrt{17}} sin\left\{ntan^{-1}\left(\frac{\sqrt{17}}{2\sqrt{3}}\right)\right\}$

$v = \frac{(29)^{\frac{n}{2}}}{\sqrt{3}} cos\left\{ntan^{-1}\left(\frac{\sqrt{17}}{2\sqrt{3}}\right)\right\} = \frac{(29)^{\frac{n}{2}}}{\sqrt{3}} cos\left\{ntan^{-1}\left(\frac{\sqrt{17}}{2\sqrt{3}}\right)\right\}$

When $n = 1$ then the corresponding positive integer solution is $(1,2)$
When $n = 3$ then the corresponding positive integer solutions are$(19,78), (29,58)$
When $n = 5$ then the corresponding positive integer solutions are $(551,2262), (841,1682), (1031,902)$
We now provide the following coding of Python program to verify the solutions obtained above for the quadratic Diophantine equations considered.

Python program

```
a = int(input("enter the positive integer value of a:"))
l = int(input("enter the positive integer value of l:"))
n = int(input("enter the positive integer value of n:"))
b = int(input("enter the positive non-square integer value of b:"))
b1 = pow(b,1/2)
if b1 == int(b1):
  print("the number square positive integer")
  b = int(input("enter the positive non-square integer value of b:"))
else:
   print("the number is positive non square integer")
   print(a,b,l,n)
u = int(input("enter the positive integer value of u:"))
v = int(input("enter the positive integer value of v:"))
for k in range(0,n+1):
    for i in range(0, u+1):
        for j in range(0, v+1):
            L = (a * i * i)+(b * j * j)
            R= pow((a + b * l * l),k)
            if L==R:
                print(k)
                print(i,j)
```

CONCLUSION

Using Euler's formula and elementary complex analysis, we have proved a theorem for solving a particular family of quadratic Diophantine equations whose solutions are given in (1). We have considered four examples to justify our solutions and have presented a Python program to verify such results. It is interesting to note that for certain equations for given value of *n*, we have multiple solutions indicating the multi-valued property of complex valued functions. Moreover, for certain equations like in Example 4 of this paper, we could obtain solutions only for odd values of *n*, indicating that it has no solutions when *n* is even. Thus using (1) of the theorem proved in this paper, it is possible to determine positive integer solutions of several quadratic Diophantine equations satisfying the given type. These ideas can be adopted to solve other class of quadratic Diophantine equations by choosing appropriate complex numbers yielding required solutions.

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RESEARCH ARTICLE

Blended Cooperative Learning : A Comprehensive Approach to Fostering Student Engagement and Academic Success

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ABSTRACT

The incorporation of technology in education has revolutionized conventional teaching methodologies, leading to the emergence of blended cooperative learning as a potent strategy for enhancing student outcomes. This approach combines the flexibility and interactivity of digital learning with the collaborative and social benefits of cooperative group work. Blended learning integrates conventional face-to-face instruction with online components, offering a customized approach learning that caters to diverse student needs. Cooperative learning, on the other hand, emphasizes structured group work where students collaborate to achieve shared academic goals, fostering critical thinking, communication, and teamwork skills. By merging these two approaches, blended cooperative learning creates a dynamic and inclusive learning environment that supports continuous engagement, both inside and outside the classroom. Research indicates that this strategy can significantly improve academic achievement among secondary school students by offering multiple avenues for engagement, promoting deeper understanding, and enhancing motivation. This study investigates how blended cooperative learning influences student outcomes, supported by empirical evidence that showcases its effectiveness as a current educational approach. As the educational landscape continues to evolve, blended cooperative learning stands out as a promising approach for fostering academic success in today's diverse and technologically driven classrooms.

Keywords: Blended Cooperative Learning; Education; Digital Learning; Academic Achievement; Inclusive Learning

INTRODUCTION

In the rapidly changing scenario of education, the combination of technology and cutting-edge teaching methods has emerged as a key trend increasingly important (Koehler et al., 2013). One such pedagogical approach that has gained significant traction is the combination of blended learning with cooperative learning, resulting in what is known as blended cooperative learning (Dziuban *et al.,* 2018). This strategy merges the best of both worlds: the flexibility and interactivity of digital learning with the collaborative and social benefits of group-based learning. By definition, blended learning merges conventional classroom instruction with digital learning components to create a unified educational experience (Dziuban *et al.,* 2018). This method allows for a more personalized learning journey, enabling students to learn at their own personal pace and revisit content as needed. The online aspect of blended learning offers a range of digital tools and resources, i.e. videos, quizzes, and interactive simulations, which can cater to diverse learning, styles (Dziuban *et al.,* 2018). Additionally, it provides opportunities for students to engage with content outside the constraints of the classroom, facilitating a more continuous learning experience. Cooperative learning, in contrast, is a structured form of group work where students work together to achieve mutual academic goals. This approach emphasizes interaction, communication, and mutual support among students (Gillies, 2023). In cooperative learning settings, students are often assigned roles within their groups, encouraging them to contribute actively and take responsibility for their own learning as well as the learning of their peers (Gillies, 2023). Research has shown that cooperative learning encourages the growth of critical thinking, boosts student motivation, and deepens their understanding of the subject (Siregar *et al.,* 2024). Furthermore, it supports students in building essential social skills like teamwork, effective communication, and conflict resolution, which are essential for success in both academic and professional settings (Gillies, 2023; Siregar *et al.,* 2024).

When these two approaches are combined, the result is a blended cooperative learning strategy that leverages the strengths of both methodologies to enhance student learning outcomes (Munoz et al., 2021; Siregar *et al.,* 2024). In this model, students engage in collaborative activities both in-person and online, allowing for a more vibrant and mutual learning experience. The digital tools and resources provided in the online component can be used to bolster and expand the collaborative task done in the classroom (Singh et al., 2023). For example, students might use online discussion forums to continue conversations started in class, or they might work together on a shared digital project using collaborative software. The influence of blended cooperative learning on academic success, particularly at the secondary school level, has been the subject of increasing research interest. Studies have shown that this approach can lead to improved student outcomes, including higher levels of engagement, better retention of information, and greater academic success (Hussain *et al.,* 2023). Moreover, the collaborative aspect of this approach motivates students to engage actively in their learning process, fostering increased motivation and a more profound comprehension of the material or content.When students work together in a cooperative setting, they are more likely to engage in meaningful discussions, ask questions, and challenge each other's ideas, leading to a richer learning experience(Singh et al., 2021). The online component of blended cooperative learning further enhances this by providing a platform for continuous collaboration and communication, even outside of the classroom (Okaz, 2015; Munoz et al., 2021). The integration of blended learning with cooperative learning represents a promising pedagogical strategy for improving the academic achievement of secondary school students. By combining the strengths of both approaches, blended cooperative learning offers a flexible, interactive, and collaborative learning environment that can address the varied requirements of today's learners (Okaz, 2015; Siregar *et al.,* 2024). This paper delves into the various ways in which blended cooperative learning can impact student outcomes, drawing on empirical evidence and theoretical insights to provide a comprehensive understanding of this innovative educational approach. As education continues to evolve in response to technological advancements and changing student needs, blended cooperative learning stands out as a powerful tool for enhancing student engagement and academic success.

METHODOLOGY

This review paper employs a qualitative methodology, systematically analyzing existing literature on blended cooperative learning to evaluate its impact on student outcomes. A comprehensive search of peer-reviewed articles, conference papers, and educational reports was conducted using databases such as ERIC, JSTOR, and Google Scholar, focusing on studies published in the last few decades. The selection criteria emphasized empirical research that demonstrates the effectiveness of blended cooperative learning in secondary education. Data extraction involved identifying key themes related to academic achievement, engagement, and skill development. The synthesis of findings aims to provide a cohesive understanding of how this approach enhances educational practices and student success.

Theoretical Foundations of Blended Cooperative Learning

Blended cooperative learning is rooted in the foundational principles of social constructivism and experiential learning, two theories that offer a robust framework for understanding the dynamics of this educational approach. Social constructivism, primarily developed by Lev Vygotsky, emphasizes the critical role of social interaction in the formation of knowledge (Valverde-Bersocoso & Fernandez-Sanchez, 2020; Li et al., 2024). Vygotsky theory posits that learning is inherently a social process, where individuals construct knowledge through collaborative dialogue and shared experiences. In the context of blended cooperative learning, this theory is operationalized by creating environments where students engage in collaborative activities, both in online settings and face-to-face interactions (Valverde-Bersocoso & Fernandez-Sanchez, 2020). These dual modes of engagement enable students to learn from one another, share diverse perspectives, and collectively build understanding, thereby enriching the learning experience. Experiential learning, as theorized by David Kolb, underscores the significance of learning through experience (Kolb, 1984). Kolb's model advocates for a cyclical process where learners engage in concrete experiences, reflect on these experiences, conceptualize the underlying principles, and then apply this knowledge in new situations. Blended cooperative learning aligns closely with this model by offering students opportunities to apply theoretical knowledge in practical, collaborative contexts (Dziuban, et al., 2018). The incorporation of digital tools in blended learning environments further strengthens the alignment with constructivist principles (Singh et al., 2023). These tools provide students with access to a wide array of resources and interactive platforms that support diverse learning styles. Moreover, the ability to receive immediate feedback, either from peers or instructors, fosters an iterative learning process where students can continuously refine their understanding. This blend of technology and collaboration not only increases student autonomy but also facilitates deeper engagement with complex concepts (Yang et al., 2021, Munoz et al., 2021). By working together, students can tackle challenging problems, reflect on different viewpoints, and gain a deeper and more sophisticated comprehension of the topic.

Blended Cooperative Learning Strategies

Blended cooperative learning strategies represent an innovative approach to education, integrating both online and offline interactions to enhance the learning experience. These strategies are intentionally designed to foster collaboration, critical thinking, and active participation among students. Here's a detailed exploration of some key blended cooperative learning strategies:

- **Flipped Classroom:** The flipped classroom model is a transformative approach that redefines the traditional classroom dynamic. Instead of using class time for direct instruction, students first encounter new material online, often through video lectures, readings, or interactive modules, before they attend the physical classroom. This shift allows classroom time to be utilized for more engaging, collaborative activities, such as group discussions, problem-solving exercises, and hands-on projects (Hussain et al., 2023). By encountering the material beforehand, students come prepared to delve deeper into the subject matter during face-to-face sessions, thus facilitating a more active and participatory learning environment. This method not only maximizes the use of class time but also helps in accommodating different learning styles, as students can learn at their own pace before engaging in group activities.

- **Jigsaw Method:** The jigsaw method is another powerful cooperative learning strategy that can be effectively implemented in a blended learning environment. In this approach, a topic is divided into several segments, and each student or group is tasked with mastering one specific segment. After becoming experts on their assigned portion, they then teach what they have learned to their peers. The blended aspect comes into play when students use online resources to research their topics, engage in digital collaboration, and prepare their presentations (Cochon-Drouet et al., 2023). For instance, students might use online discussion boards, shared documents, or video conferencing tools to collaborate and exchange ideas before presenting their findings in a face-to-face classroom setting. This method not only enhances understanding of the content but also develops communication, teamwork, and leadership skills.
- **Online Collaborative Projects:** Online collaborative projects are a cornerstone of blended learning, leveraging technology to facilitate group work. Tools such as Google Classroom, Microsoft Teams, or other collaborative platforms enable students to work together on assignments, even when they are not physically co-located (Hussain et al., 2023; Siregar et al., 2024). These platforms provide spaces for students to share resources, divide tasks, and provide feedback on each other's work, all within an organized and accessible digital environment. The asynchronous nature of these tools allows students to contribute at their own pace, making it easier to accommodate diverse learning speeds and schedules (Herrera-Pavo & Bolivar, 2021). Furthermore, online collaborative projects prepare students for the increasingly digital and collaborative nature of the modern workplace, equipping them with essential skills in communication, collaboration, and digital literacy.
- **Peer Tutoring and Peer Assessment:** Peer tutoring and assessment are integral to cooperative learning, offering students the opportunity to deepen their understanding by teaching others and critically evaluating their peers' work. In a blended learning environment, these activities can extend beyond the classroom through the use of online forums, discussion boards, and video conferencing tools (Toulia et al., 2021). Students can provide tutoring or feedback at any time, facilitating continuous learning and reflection. This approach encourages a deeper engagement with the subject matter, as students must not only understand the content themselves but also be able to explain it clearly to others. Additionally, peer assessment fosters critical thinking and self-reflection, as students learn to evaluate the quality of their own and others' work.

Empirical Evidence on the Impact of Blended Cooperative Learning

Blended cooperative learning has emerged as a powerful pedagogical approach, significantly impacting the academic achievement of secondary school students. The interactive effect of combining traditional face-to-face instruction with online collaborative activities fosters an environment conducive to deep learning and skill development (Dziuban *et al.,* 2018). Several studies have provided empirical evidence supporting the efficacy of this blended approach. Gillies (2023) conducted a pivotal study that highlighted the benefits of cooperative learning in a blended format. Their research revealed those students who participated in both online and offline cooperative learning activities outperformed their peers who were engaged in traditional, non-collaborative learning methods. The key to this success lies in the dual modality of instruction, which leverages the strengths of both in-person and digital interactions. In a face-to-face setting, students benefit from immediate feedback, personal interaction, and the shared social experience of learning together. Online, they have the flexibility to engage with content at their own pace, revisit complex concepts, and collaborate with peers in a more reflective manner. This combination was found to be particularly effective in enhancing students' comprehension of complex subjects, where multiple perspectives and iterative discussion are crucial for mastery. Similarly, Siregar *et al.* (2024) reported significant improvements in student engagement and motivation when cooperative learning was integrated into a blended learning environment. The online component offered flexibility, allowing students to access materials and collaborate at times that suited their individual needs. This flexibility, when paired with the social interaction inherent in cooperative learning, created a learning environment where students felt more in control of their educational journey. They were not only more engaged but also more motivated to participate actively. This increased motivation was found to correlate strongly with improved academic outcomes. Furthermore, Siregar *et al.* (2024) study emphasized the role of blended cooperative learning in developing critical thinking skills. Students were regularly challenged to analyze information critically, work collaboratively to solve problems, and apply their knowledge to real-world situations. This practical application of knowledge is a cornerstone of effective education, and blended cooperative learning provides a fertile

ground for its development. Kyndt *et al.* (2013) conducted a comprehensive meta-analysis that further underscores the positive impact of cooperative learning, especially within blended learning environments. Their analysis, which synthesized findings from numerous studies, concluded that cooperative learning strategies consistently led to higher academic performance. This was particularly evident in subjects requiring problem-solving and critical thinking. The collaborative nature of cooperative learning, combined with the diverse learning opportunities provided by a blended approach, enables students to engage with complex problems more effectively. They benefit from the collective intelligence of the group, while also having the opportunity to explore and refine their understanding individually.

Challenges and Considerations in Implementing Blended Cooperative Learning

Implementing blended cooperative learning, despite its potential benefits, presents a set of challenges that educators and institutions must carefully navigate. One of the most significant challenges lies in ensuring that all students have equitable access to the necessary technology and internet resources (Dziuban *et al.,* 2018). In a world where digital learning is increasingly essential, disparities in access can create a digital divide, leading to uneven academic outcomes. Students from socioeconomically disadvantaged backgrounds may struggle to keep pace with their peers, not because of a lack of ability, but due to a lack of resources. This inequity can undermine the very essence of cooperative learning, which thrives on equal participation and collaboration among students. Therefore, it is crucial for schools and policymakers to address these gaps by providing adequate resources and support to all students, ensuring that no one is left behind (Siregar *et al.,* 2024). Another significant challenge in the implementation of blended cooperative learning is the need for comprehensive teacher training and ongoing support. The shift to blended learning requires educators to be proficient not only in their subject matter but also in the use of digital tools and platforms that facilitate both online and offline learning. This dual proficiency is not inherently present in all educators, particularly those who may be less familiar with new technologies (Jean & Lee, 2023). As such, professional development programs that focus on the pedagogy of blended learning and the practical integration of technology into the classroom are essential. These programs should be designed to empower teachers with the skills and confidence needed to create effective and engaging collaborative activities.

Without proper training and support, teachers may struggle to implement blended cooperative learning effectively, potentially leading to suboptimal educational outcomes. Maintaining student engagement in a blended cooperative learning environment also poses a considerable challenge. The flexibility of online activities, while beneficial, can sometimes lead to reduced face-to-face interaction, which is a core element of cooperative learning (Kyndth *et al.,* 2013). The physical presence of peers and teachers often fosters a sense of community and accountability, which can be harder to achieve in an online setting. Therefore, educators must strike a careful balance between online and offline activities to keep students actively engaged. This balance is critical in maintaining the social dynamics that make cooperative learning effective, such as peer support, collaboration, and the shared responsibility for learning. Educators might need to employ innovative strategies, such as synchronous online sessions that mimic the interactivity of a physical classroom, or hybrid models that ensure regular in-person meetings to sustain the cooperative spirit (Jean & Lee, 2023. Additionally, the design and structure of blended cooperative learning activities require thoughtful consideration. The integration of online and offline components must be seamless, ensuring that both environments complement each other rather than operate in silos. Activities should be designed to leverage the strengths of each mode of learning—online tools can facilitate research, communication, and the sharing of resources, while face-to-face interactions can enhance critical discussions, problem-solving, and the building of interpersonal skills (Valverde-Bersocoso & Fernandez-Sanchez, 2020). Educators must be adept at creating assignments and projects that not only align with the learning objectives but also promote active participation from all students, regardless of their preferred learning mode.

Recommendations for Effective Implementation of Blended Cooperative Learning

To fully realize the potential of blended cooperative learning in enhancing academic achievement, a strategic approach is necessary. The following recommendations outline key strategies to ensure the successful implementation of this instructional model:

- **Ensuring Equitable Access:** One of the primary concerns in implementing blended cooperative learning is ensuring that all students have equitable access to necessary resources. This includes not only digital devices such as laptops or tablets but also a reliable internet connection. Schools must take proactive measures to identify students who may lack access and provide the necessary support. This might involve partnerships with community organizations, local businesses, or government initiatives aimed at closing the digital divide. For example, schools could collaborate with local libraries or community centres to offer students free or low-cost internet access. Additionally, schools could work with local government or nonprofit organizations to secure funding for providing digital devices to students in need. By addressing these disparities, schools can ensure that every student has the opportunity to engage fully in blended cooperative learning activities.
- **Professional Development for Educators:** Teachers are the cornerstone of effective blended cooperative learning, and their proficiency with digital tools and blended learning strategies is critical. Ongoing professional development should be a priority, with a focus on equipping teachers with the skills necessary to design and implement blended learning activities that seamlessly integrate online and offline components. This training should emphasize the creation of cooperative learning activities that foster collaboration among students, both in-person and online. Moreover, professional development should be iterative and responsive to the evolving educational landscape, allowing teachers to continuously refine their instructional practices. Peer collaboration and sharing of best practices should also be encouraged, creating a community of educators who are collectively working to enhance their blended learning strategies.
- **Promoting Student-Centred Learning:** Blended cooperative learning should be structured to place students at the centre of the learning process, promoting autonomy, active engagement, and ownership of their learning journey. Teachers can achieve this by designing activities that allow for student choice and foster collaboration. For instance, students could be given options in how they approach a project or which digital tools they use, thereby catering to different learning styles and preferences. Furthermore, incorporating self-assessment and reflection into the learning journey allows students to assess their growth and pinpoint areas needing improvement. This student-focused strategy not only boosts motivation but also fosters critical thinking and problem-solving abilities, which are vital for achieving academic success.
- **Maintaining a Balanced Approach:** While the online components of blended cooperative learning offer flexibility and access to a wealth of resources, the importance of face-to-face interactions should not be underestimated. A balanced approach that combines both online and offline interactions is crucial for developing social skills and building a sense of community among students. In-person activities allow students to engage in meaningful discussions, build relationships, and develop communication skills that are essential in both academic and real-world settings. Teachers should design blended learning experiences that leverage the strengths of both online and offline interactions, ensuring that students benefit from a holistic learning experience.
- **Implementing Continuous Assessment and Feedback:** The integration of continuous assessment and feedback mechanisms is vital for monitoring student progress and adjusting instructional strategies in real-time. Digital tools can be highly effective in facilitating formative assessment, offering educators real-time data on student performance. This data allows teachers to identify learning gaps, provide targeted support, and make informed decisions about instructional adjustments. Regular feedback, both from teachers and peers, should be a core component of blended cooperative learning, as it helps students stay on track and fosters a growth mindset. Teachers should also encourage students to engage in self-assessment, promoting reflection on their learning and empowering them to take an active role in their academic development. By following these recommendations, educators can create a robust framework for blended cooperative learning that supports equitable access, empowers teachers, and centres students in the learning process, ultimately leading to improved academic outcomes.

CONCLUSION

Blended cooperative learning is a dynamic pedagogical strategy that harnesses the advantages of both online and traditional classroom settings to create a more holistic educational experience. This approach not only facilitates collaboration among students but also nurtures critical thinking and fosters greater independence in learning. The potential of blended cooperative learning to improve academic outcomes for secondary school students is significant, as it merges the interactive elements of group work with the flexibility and resources available through digital platforms. However, the success of blended cooperative learning hinges on several critical factors. Effective implementation demands meticulous planning to integrate both digital and in-person components seamlessly. Ensuring equitable access to technology is also crucial, as disparities in resources can undermine the benefits of this approach. Furthermore, educators must receive ongoing support and training to adapt to the evolving demands of blended learning environments and to guide students in making the most of these opportunities. As educational institutions increasingly adopt blended learning models, it is imperative to focus on creating learning experiences that are inclusive, collaborative, and centered around the needs and abilities of all students. By doing so, blended cooperative learning not only boosts academic success but also equips students for the collaborative and digital challenges of the future.

FURTHER RESEARCH

For further research, it is essential to explore into the specific mechanisms by which blended cooperative learning influences student outcomes. Future studies should focus on identifying the key factors that optimize the integration of digital tools and collaborative methods, such as the role of teacher facilitation, the nature of digital content, and group dynamics within cooperative settings. Additionally, research should explore how blended cooperative learning impacts diverse student populations, including those from varying socio-economic backgrounds and with different learning abilities. Comparative studies that examine blended cooperative learning across different subjects and educational levels would also offer meaningful perspectives on its adaptability and effectiveness. Lastly, the enduring impactsof blended cooperative learning on student motivation, engagement, and retention of knowledge should be a priority to determine its sustainability as an educational model in evolving technological and pedagogical landscapes.

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RESEARCH ARTICLE

Product Eccentricity Energy of Graphs Related to Bistar Graph and Density Calculation of Antipyretic Drugs

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ABSTRACT

In this article we have investigated the product eccentricity energy of graphs related to Bistar graph. With the idea of E_{PE} (Product Eccentricity Energy) we compute the density of antipyretic drugs.

Keywords: Product eccentricity matrix, product eccentricity energy, eigen values, Bistar graph, Antipyretic drugs.

INTRODUCTION

Graph theory is the department of discrete arithmetic, it is the thinking about the structures with their properties, objectives and their relations. It was initially helpful in solving a variety of mathematical issues, but when it was used in complex science, computer science, chemistry, and other fields, it occasionally expanded into new areas of mathematical analysis. The graphs considered in this article are simple, loop less and connected graphs. The eccentricity of a vertex is an important idea within this framework, as it evaluates the maximum distance between 2 vertices. The distance between two vertices a and b in $V(G)$ is the shortest $a-b$ path length in G. The eccentricity of the vertex evaluates the maximum distance from a specific vertex to any other vertex in the graph. Formally, it can be expressed as:

$\xi(b) = \max\{d(b,a) | \forall\ a \in V(G)\}$

The eccentricity matrix $\xi(G)$of a graph$G$ is obtained from the distance matrix of G by retaining the largest distances in each row and each column and leaving zeros in the remaining ones. The eccentricity energy of G is the sum of the

absolute values of the eigenvalues of $\xi(G)$. Let G be a graph with n vertices and m edges. Denote the absolute eigen values of G as $\lambda_i, i = 1,2,\cdots n$ arranged in order that is not increasing as $|\lambda_1| \geq |\lambda_2| \geq \cdots \geq |\lambda_n|$. In 1978 Ivan Gutman [3] computed the energy of a graph G as $E(G) = \sum_{i=1}^{n} |\lambda_i|$. Li.X, Y. Shi and I. Gutman [4] introduced the energy of graph in 2012 in which the adjacency matrix of a graph $G$is defined as

$$a_{ij} = \begin{cases} 1 & if\ v_i v_j \in E \\ 0 & otherwise \end{cases}$$

Spectrum of the graph is denoted by

$$Spec(G) = \begin{bmatrix} \lambda_1 & \lambda_2 & \cdots & \lambda_n \\ m_1 & m_2 & \cdots & m_n \end{bmatrix}$$

Where $m_i^{'}s$ denote the multiplicities of the corresponding eigen value. The total of the absolute values of the adjacency matrix's eigenvalues equals the graph's energy. Later, in 2009, C. Adiga et al. [1] defined the graph's maximum degree energy, which is dependent on the related graph's maximum degree matrix. The maximum degree matrix is defined as

$$d_{ij} = \begin{cases} max\{d(v_i), d(v_j)\}, & if\ v_i v_j \in E \\ 0, & otheriwse \end{cases}$$

In 2016, Ahmed M. Naji et.al [2] defined the concept of maximum eccentricity matrix. Later, Mohammad Issa Sowaity and B.Sharada [5] in 2017 introduced the concept of sum-eccentricity energy of a graph in 2017. In 2025, Priya Karen S and Arokia Lancy A [6] introduced the concept of Product Eccentricity energy of graphs. The product eccentricity matrix of the graph G is denoted as $P_e(G)$, it is defined as

$$p_{ij} = \begin{cases} e(v_i).e(v_j) & if\ v_i \sim v_j \\ 0 & otherwise \end{cases}$$

The Characteristic polynomial of the product eccentricity matrix is defined by $|\eta\, I - P_e(G)|$ and the corresponding characteristic equation is $\eta I - P_e(G) = 0$.

$E_{PE}(G)$is defined as the sum of the absolute eigen values, $E_{PE}(G) = \sum_{i=1}^{n} |\eta_i|$

where, $\eta_1, \eta_2, \cdots \eta_n$ are the eigen values of the given product eccentricity matrix.

PRELIMINARIES

Definition 2.1. [3] A Bistar graph is the graph obtained by joining the center (apex) vertices of two copies of $K_{1,n}$by an edge and it is denoted by $B_{n,n}$.The vertex set of $B_{n,n}$ is $V(B_{n,n}) = \{a_1, a_2, \cdots, a_n, a, b, b_1, b_2, \cdots b_n\}$, where a, b are apex vertices and $a_1, a_2, \cdots, a_n, b_1, b_2, \cdots b_n$ are pendent vertices. The edge set of $B_{n,n}$ is $E(B_{n,n}) = \{aa_1, aa_2, \cdots, aa_n, bb_1, bb_2, \cdots bb_n\}$.

Definition 2.2 [8] Let G be a simple connected graph. Then the square graph of a graph G is denoted by G^2 and defined as the graph with the same vertex set as of G and two vertices are adjacent in G^2 if they are at a distance 1 or 2 in G.

Definition 2.3 [3] A shadow graph $D_2(G)$ of a connected graph G is constructed by taking two copies of G say $G^{'}$ and $G^{''}$ and join each vertex b in to $G^{'}$ the neighbours of the corresponding vertex $a^{'}$ in $G^{''}$

Definition 2.4 [7] A globe graph $Gl(n)$ is a graph obtained from two vertex that are isolated and are joined by n paths of length two.

PRODUCT ECCENTRICITY ENERGY OF BISTAR GRAPHS AND FEW BISTAR RELATED GRAPHS

Theorem 3.1

Let $n \in N$, $n \geq 1$, then $E_{PE}(B_{n,n}) = 8\sqrt{9n+1}$, where $E_{PE}(B_{n,n})$ is the product eccentricity energy of the Bistar Graph $B_{n,n}$.

Proof. Consider the vertex set of the Bistar graph as $a_1, a_2 \cdots a_n, a, b, b_1, b_2, \cdots, b_n$.Number of vertices of the bistar graph =$2n + 2$and the number of edges of the bistar graph= $2n + 1$

The product eccentricity energy matrix $B_{n,n}$ of obtained is

$$P_e(B_{n,n}) = \begin{bmatrix} 0 & 0 & \cdots & \cdots & 0 & 6 & 0 & \cdots & \cdots & 0 & 0 \\ \vdots & . & . & . & \vdots & \vdots & \vdots & . & . & . & \vdots \\ \vdots & . & . & . & \vdots & \vdots & \vdots & . & . & . & \vdots \\ 0 & 0 & \cdots & \cdots & 0 & 6 & 0 & \cdots & \cdots & 0 & 0 \\ 6 & 6 & \cdots & \cdots & 6 & 0 & 4 & 0 & \cdots & \cdots & 0 \\ 0 & 0 & \cdots & \cdots & 0 & 4 & 0 & 6 & \cdots & \cdots & 6 \\ \vdots & . & . & . & \vdots & 0 & 6 & 0 & \cdots & \cdots & 0 \\ \vdots & . & . & . & \vdots & \vdots & \vdots & \vdots & . & . & \vdots \\ 0 & 0 & \cdots & \cdots & 0 & 0 & 6 & 0 & \cdots & \cdots & 0 \end{bmatrix}$$

Spectrum of the bistar graph is found as

$$P_e(B_{3,3}) = \begin{pmatrix} 0 & 1-\sqrt{9n+1} & 1+\sqrt{9n+1} & -1+\sqrt{9n+1} & -1-\sqrt{9n+1} \\ 2(n-1) & 1 & 1 & 1 & 1 \end{pmatrix}$$

Eigen values are $0,0,\cdots 0\ (2(n-1)times), 2\left(1+\sqrt{9n+1}\right) 2\left(1-\sqrt{9n+1}\right), 2(-1+\sqrt{9n+1}), 2(-1-\sqrt{9n+1})$

$E_{PE}(B_{n,n}) = |0| + 2\left|1+\sqrt{9n+1}\right| + 2(1-\sqrt{9n+1}|) + 2|(-1+\sqrt{9n+1})| + 2\left(-1-\sqrt{9n+1}\right)|$

$E_{PE}(B_{n,n}) = 8(1+\sqrt{9n+1})$

Example 3.2. Product Eccentricity Energy of Bistar Graph $B_{3,3} = 8\sqrt{28} = 16\sqrt{7}$.

The Product Eccentricity matrix of the Bistar Graph $B_{3,3}$ is obtained as follows:

$$P_e(B_{n,n}) = \begin{bmatrix} 0 & 0 & 0 & 6 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 6 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 6 & 0 & 0 & 0 & 0 \\ 6 & 6 & 6 & 0 & 4 & 0 & 0 & 0 \\ 0 & 0 & 0 & 4 & 0 & 6 & 6 & 6 \\ 0 & 0 & 0 & 0 & 6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 6 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 6 & 0 & 0 & 0 \end{bmatrix}$$

The characteristic polynomial of the above matrix is $\eta^4(\eta-2)(2(\pm\eta\pm\sqrt{28}))$

The eigen values are $0,0,0,0,2\left(-1-\sqrt{28}\right), 2\left(-1+\sqrt{28}\right), 2\left(1-\sqrt{28}\right), 2\left(1+2\sqrt{28}\right)$

Thus, the Product eccentricity energy of $B_{3,3} = 8\sqrt{28} = 16\sqrt{7}$.

Theorem 3.3:

Let $B_{n,n}^2$ be the square bistar graph where $n \in N, n \geq 1$. Then $E_{PE}(B_{n,n}^2) = (\sqrt{64n+1})+1$

Proof. Let the vertex set of $B_{n,n}^2$ be denoted as $a_1, a_2 \cdots a_n, a, b, b_1, b_2, \cdots, b_n$. Number of vertices of the bistar graph $=2n+2$ and the number of edges of the bistar graph$= 4n+1$

The product eccentricity energy matrix obtained is

$$P_e(B_{n,n}^2) = \begin{bmatrix} 0 & 0 & \cdots & \cdots & 0 & 2 & 2 & 0 & \cdots & 0 & 0 \\ \vdots & . & . & . & \vdots & \vdots & \vdots & . & . & . & \vdots \\ \vdots & . & . & . & \vdots & \vdots & \vdots & . & . & . & \vdots \\ 0 & 0 & \cdots & \cdots & 0 & 2 & 2 & \cdots & \cdots & 0 & 0 \\ 2 & \cdots & \cdots & \cdots & 2 & 0 & 1 & 2 & \cdots & \cdots & 2 \\ 2 & \cdots & \cdots & \cdots & 2 & 1 & 0 & 2 & \cdots & \cdots & 2 \\ 0 & . & . & . & 0 & 2 & 2 & 0 & \cdots & \cdots & 0 \\ \vdots & . & . & . & \vdots & \vdots & \vdots & \vdots & . & . & \vdots \\ \vdots & . & . & . & \vdots & \vdots & \vdots & \vdots & . & . & \vdots \\ 0 & \cdots & \cdots & \cdots & 0 & 2 & 2 & 0 & \cdots & \cdots & 0 \end{bmatrix}$$

Spectrum of $P_e(B_{n,n}) = \begin{pmatrix} 0 & -1 & \frac{1}{2}+\sqrt{1+64n}+1 & \frac{1}{2}+\sqrt{1+64n}-1 \\ 2n-1 & 1 & 1 & 1 \end{pmatrix}$

Eigen values are $0,0,\cdots 0\ ((2n-1)times), -1, \frac{1}{2}+\sqrt{1+64n}+1, \frac{1}{2}+\sqrt{1+64n}-1$

Product Eccentricity energy of the Square Bistar Graph is $(\sqrt{64n+1})+1$

Example 3.4. Product Eccentricity Energy of Squar Bistar Graph $B_{3,3}^2 = 1 + \sqrt{129}$.
The Product Eccentricity Matrix of the Square Bistar Graph $B_{3,3}^2$ is obtained as

$$P_e\left(B_{3,3}^2\right) = \begin{bmatrix} 0 & 0 & 2 & 2 & 0 & 0 \\ 0 & 0 & 2 & 2 & 0 & 0 \\ 2 & 2 & 0 & 1 & 2 & 2 \\ 2 & 2 & 1 & 0 & 2 & 2 \\ 0 & 0 & 2 & 2 & 0 & 0 \\ 0 & 0 & 2 & 2 & 0 & 0 \end{bmatrix}$$

The characteristic polynomial of the above matrix is
$\eta^3(\eta+1)(\eta - \frac{1}{2}\left(1-\sqrt{129}\right)(\eta - \frac{1}{2}(1-\sqrt{129})$
The eigen values of the above matrix is $-1, 0, 0, 0, \frac{1}{2}\left(1+\sqrt{129}\right), \frac{1}{2}\left(1-\sqrt{129}\right)$
Thus, $E_{PE}\left(B_{3,3}^2\right) = 1 + \sqrt{129}$.

Theorem 3.5:
Let $GL(n)$ be a globe graph where $n \in N, n \geq 2$ then $E_{PE}(GL(n)) = 8\sqrt{2n}$.

Proof. Consider the vertex set of the globe graph as $a_1, a_2, a_3, \cdots a_n, a, b$.The number of vertices of the Globe graph $=n+2$and the number of edges of the Globe graph $=2n$
The product eccentricity energy of the globe graph is obtained as

$$P_e\left(B_{n,n}^2\right) = \begin{bmatrix} 0 & 4 & \cdots & 4 & 0 \\ 4 & 0 & \cdots & 0 & 4 \\ \vdots & \vdots & . & \vdots & \vdots \\ 4 & 0 & \cdots & 0 & 4 \\ 0 & 4 & \cdots & 4 & 0 \end{bmatrix}$$

The characteristic polynomial of the globe graph is $\eta^n(\eta + 4\sqrt{2n})(\eta - 4\sqrt{2n})$
Spectrum of the globe graph is given below

$$\begin{pmatrix} 0 & 4\sqrt{2n} & -4\sqrt{2n} \\ n & 1 & 1 \end{pmatrix}$$

Product Eccentricity energy of the Globe Graph is $8\sqrt{2n}$.

Example 3.6. Product Eccentricity Energy of the Globe graph $GL(3) = 8\sqrt{6}$

The product eccentricity matrix of the above graph is given below

$$P_e(GL(3)) = \begin{bmatrix} 0 & 4 & 4 & 4 & 0 \\ 4 & 0 & 0 & 0 & 4 \\ 4 & 0 & 0 & 0 & 4 \\ 4 & 0 & 0 & 0 & 4 \\ 0 & 4 & 4 & 4 & 0 \end{bmatrix}$$

The characteristic polynomial of the globe graph is $-\eta^5 + 96\eta^3$. The eigen values are $-4\sqrt{6}, 4\sqrt{6}, 0, 0, 0$.Thus, the product eccentricity energy of the globe graph $GL(3) = 8\sqrt{6}$

PRODUCT ECCENTRICITY ENERGY OF ANTIPYRETIC DRUGS

Numerous graph-theoretical matrices are used in chemical graph theory and they are crucial for working with graphs numerically and as helpful tools for their algebraic representation. Here, we are interested in a specific family of graphs called molecular graphs, or graphs that show the chemical structure of molecules. They are made by switching out the atoms and bonds of the vertices and edges, respectively. Hydrogen atoms are typically disregarded. An object's density is one of the most important and easily measured physical properties. Among the many uses for which densities are commonly employed are the identification of pure substances as well as the description and estimation of the composition of different combinations. Antipyretics are one of the most frequently used agents in medicine. In this article, we compute the Product Eccentricity Energy of few commonly used antipyretics. Theoretical density and practical density are compared, practical density is obtained using

$\frac{2\,E_{PE}(G)}{\sum_{i=1,i<j}^{n} e(v_i).e(v_j)}$.

Product Eccentricity Energy of Naproxen:

Using Product Eccentricity Matrix where P_{ij} takes $e(v_i).e(v_j)$ when v_i and v_j are adjacent and 0 otherwise we obtain the below $P_e(Naproxen)$.

$$\begin{bmatrix} 0 & 90 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 90 & 0 & 72 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 72 & 0 & 56 & 0 & 0 & 0 & 56 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 56 & 0 & 42 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 42 & 0 & 30 & 0 & 0 & 0 & 30 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 30 & 0 & 30 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 30 & 0 & 0 & 0 & 0 & 0 & 42 & 0 & 0 & 0 & 0 \\ 0 & 0 & 56 & 0 & 0 & 0 & 0 & 0 & 42 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 42 & 0 & 30 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 30 & 0 & 0 & 0 & 30 & 0 & 30 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 30 & 0 & 42 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 42 & 0 & 0 & 0 & 42 & 0 & 56 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 56 & 0 & 72 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 72 & 0 & 90 & 90 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 90 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

The Eigen values obtained from the product eccentricity matrix are

$\pm 149.755, \pm 130.474, \pm 82.4659, \pm 70.1359, \pm 48.6843, \pm 38.7114, \pm 24.3653, 0, 0.$

Using the eigen values obtained the product eccentricity energy calculated is **1089.1832**

$$Density \approx \frac{E_{PE}(G)}{\sum_{i=1,i<j}^{n} e(v_i).e(v_j)} = \frac{(1089.1832)}{900} = 1.210$$

$$Density \approx 1.2$$

Thus, the practical density obtained is approximately equal to the theoretical density.

RESULT

$$Density \approx \frac{E_{PE}(G)}{\sum_{i=1,i<j}^{n} e(v_i).e(v_j)}$$

CONCLUSION

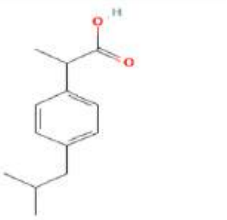
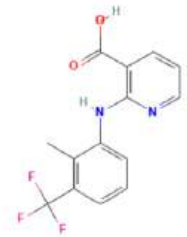
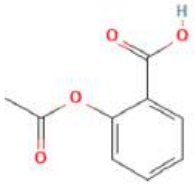
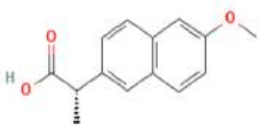
Thus, in this article we have calculated the product eccentricity energy of few standard graphs that are related to bistar graph and computed the practical density of some antipyretic drugs.

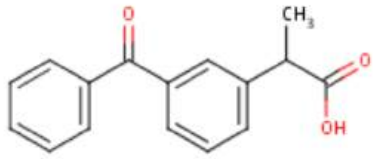
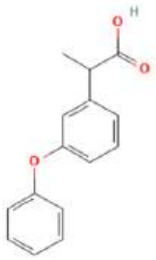
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Table 1.Various Antipyretic Drugs and their Properties

ANTIPYRETIC DRUG	PROPERTIES
1. Ibuprofen $C_{13}H_{18}O_2$ 	**Number of Vertices:** 15 **Number of Edges:** 15 **Product Eccentricity Energy:** 912.1226 **Theoretical Density:** 1.03 **Practical Density:** 1.1531
 *2.* **Flunixin** $C_{15}H_{11}F_3N_2O_2$	**Number of Vertices:** 18 **Number of Edges:** 19 **Product Eccentricity Energy:** 1051.48751 **Theoretical Density:** 1.40 **Practical Density:** 1.221
3. Aspirin $C_9H_8O_4$ 	**Number of Vertices:** 13 **Number of Edges:** 13 **Product Eccentricity Energy:** 357.7304 **Theoretical Density:** 1.40 **Practical Density:** 1.2085
 **4.Naproxen** $C_{14}H_{14}O_3$	**Number of Vertices:** 16 **Number of Edges:** 17 **Product Eccentricity Energy:** 1089.1836 **Theoretical Density:** 1.20 **Practical Density:** 1.210

5.Ketoprofen $C_{16}H_{14}O_3$ 	**Number of Vertices:** 19 **Number of Edges:** 20 **Product Eccentricity Energy:** 1476.799 **Theoretical Density:** 1.198 **Practical Density:** 1.24523
6. Fenoprofen $C_{15}H_{14}O_3$ 	**Number of Vertices:** 18 **Number of Edges:** 19 **Product Eccentricity Energy:** 1405.448 **Theoretical Density:** 0.31 **Practical Density:** 1.23116

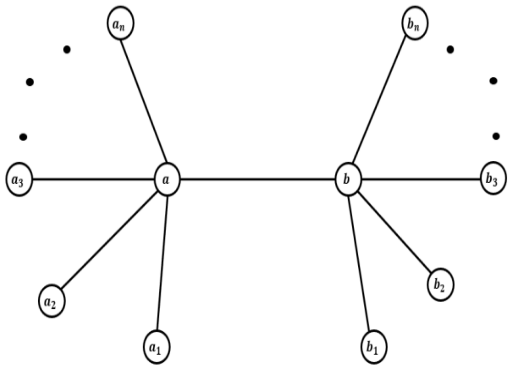


Fig:1

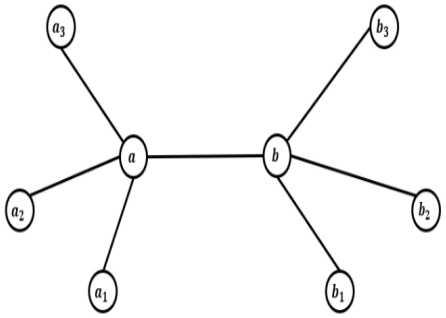


Fig:2

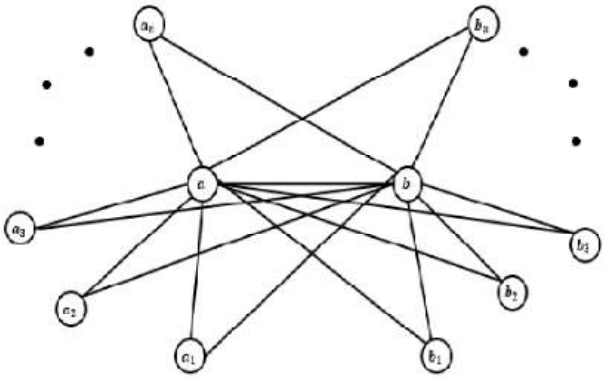


Fig:3

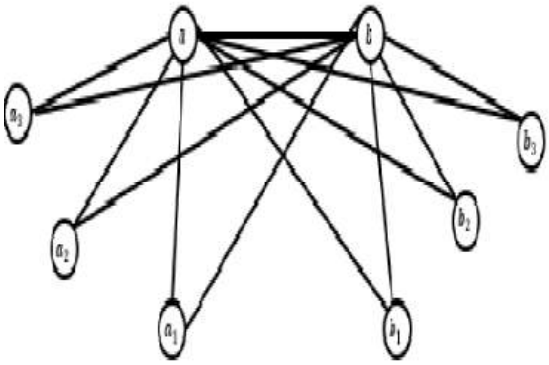


Fig:4

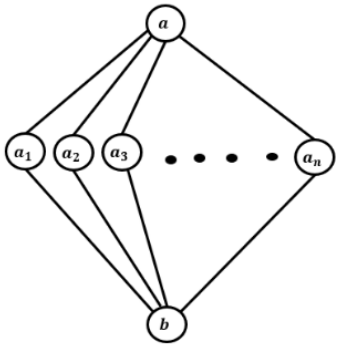


Fig:5

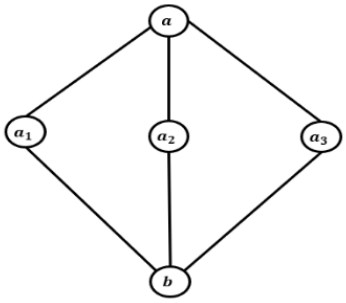


Fig:6

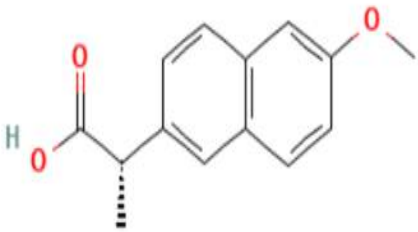


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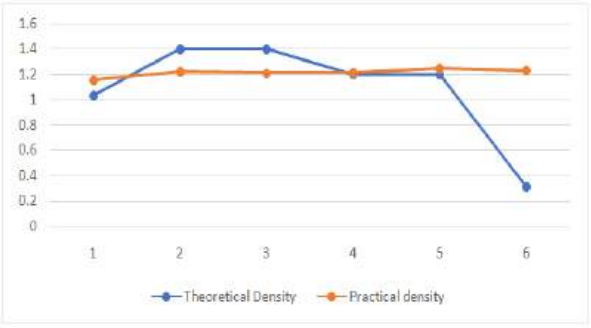


Fig.8 Comparision of the theoretical and practical densities of the Antipyretic Drugs

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RESEARCH ARTICLE

Dandy Walker Malformation Presented with Shunt Infection: A Rare Case Report

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ABSTRACT

Dandy-Walker syndrome (DWS) is a rare congenital malformation of the posterior fossa, characterized by cerebellar hypoplasia, cystic dilation of the fourth ventricle, and hydrocephalus. This case report presents a 5-month-old male infant, born to a consanguineous couple, with macrocephaly and diagnosed with Dandy-Walker phenotype complicated by severe supra-tentorial hydrocephalus. The child underwent a right ventriculoperitoneal (VP) shunt and a retro-cerebellar cystoperitoneal shunt placement. Postoperative recovery was initially stable; however, the child presented again with fever, reduced activity, and recurrent vomiting, raising concerns for shunt-related complications, including infection and obstruction. Despite antimicrobial therapy, persistent symptoms led to the identification of a shunt infection. Laboratory investigations revealed elevated cerebrospinal fluid (CSF) protein levels, mild anemia, and dilated ventricles on neuroimaging. The child was managed with broad-spectrum antibiotics, neurosurgical consultations, and supportive care. This case underscores the complex clinical course of DWS, highlighting the increased susceptibility to shunt infections and the need for vigilant monitoring post-surgery

Keywords: Dandy-Walker Syndrome, Shunt Infection, Hydrocephalus, Ventriculoperitoneal Shunt, Cerebellar Hypoplasia, Shunt Complications

INTRODUCTION

Dandy-Walker malformation (DWM) is a complex congenital anomaly characterized by structural abnormalities of the posterior fossa and cerebellum. This rare disorder has an estimated prevalence ranging between 1 in 10,000 and 30,000 live births. Hydrocephalus, a frequently encountered manifestation, is observed in nearly 80% of affected individuals, with DWM accounting for approximately 4% to 12% of hydrocephalic cases in neonates. The hallmark triad of DWM comprises partial or complete agenesis of the cerebellar vermis, expansion of the posterior fossa accompanied by superior displacement of the tentorium, transverse sinus, and torcular herophili, & cystic dilatation of the fourth ventricle. In addition to these defining features, DWM is often associated with other central nervous system anomalies, including ventriculomegaly, corpus callosum agenesis, holoprosencephaly, and encephalocele, further complicating its clinical presentation [1]. The precise etiology and pathogenesis of DWS remain incompletely elucidated. It is predominantly regarded as a multifactorial genetic disorder, arising from a complex interplay between genetic predisposition and environmental influences. Diagnosis of DWS is typically established through magnetic resonance imaging (MRI) or histopathological examination postnatally. However, in the prenatal setting, ultrasonography serves as the most reliable diagnostic modality. Anomalies indicative of DWS can often be detected during routine second-trimester ultrasound screening, facilitating early identification and potential intervention [2]. At present, no definitive cure exists for Dandy-Walker syndrome. Consequently, management strategies are primarily directed toward mitigating symptoms and addressing associated complications [3]. This report presents an in-depth case study of an infant diagnosed with Dandy-Walker malformation, status post-right ventriculoperitoneal shunt placement, who subsequently developed a shunt infection. The objective of this case study is to elucidate postoperative complications, highlight the clinical challenges encountered, and discuss the strategies employed for successful management.

CASE PRESENTATION

A 5-month-old male infant, born to a consanguineous couple as their first child at full term via LSCS, presented with a history of macrocephaly and was admitted for further evaluation. The child had a birth weight of 2 kg and cried immediately after birth with no perinatal complications. Upon examination, the infant was afebrile, maintaining room air saturation levels, and was hemodynamically stable. His heart rate was 132 bpm, blood pressure 102/44 mmHg, and respiratory rate 29 breaths/min. Chest auscultation revealed equal air entry bilaterally with normal heart sounds and no murmurs, while the abdomen was soft, and normal bowel sounds were noted with no organomegaly. Neurologically, the child was conscious and alert, with pupils bilaterally equal and reactive to light, intact extraocular movements, and a full pulsatile anterior fontanel. Muscle tone was normal, and the child demonstrated full motor power by moving all limbs against gravity. On admission, the infant weighed 6.5 kg, and his head circumference was 49 cm. Laboratory investigations were performed, and a plain MRI of the brain revealed characteristics of the Dandy-Walker phenotype. These included cerebellar hypoplasia, upward counter clockwise rotation of the vermis, cystic dilation of the fourth ventricle, and elevation of the torcula and tentorium. The posterior fossa was enlarged, the tegmento-vermian angle measured 42°, and there was a mild reduction in brainstem volume. Severe dilation of the lateral and third ventricles was also evident, with a bifrontal horn diameter of 78 mm, rounded temporal horns measuring 30 mm on the right and 28 mm on the left, and maximum atrial diameters of 38 mm on the right and 41 mm on the left. The third ventricle diameter was 20 mm, with no transpendymal edema present. Other findings included the separation of the fornix from the splenium and the lowering of the third ventricle floor. Both the corpus callosum and brainstem appeared stretched and thinned, with a reduction in periventricular white matter volume. Flow voids were intact. The child was diagnosed with Dandy-Walker phenotype and severe supratentorial hydrocephalus. After being admitted and kept NPO, intravenous fluids were administered, and surgical intervention was planned. The child underwent a right ventriculoperitoneal shunt (medium-pressure Chhabra shunt with Y connector) and a right retro-cerebellar cysto-peritoneal shunt. Following the surgery, the child was discharged in a stable neurological and hemodynamic state. However, 3 month later, the infant developed a fever and exhibited reduced activity. The child began experiencing episodes of vomiting, for which initial treatment was provided on an outpatient basis. Despite stabilizing briefly, the child was admitted for a prolonged 15-day stay due to ongoing

lethargy and recurrent vomiting. During this hospitalization, a neurosonography was performed, revealing moderate dilation of both the lateral and third ventricles, along with a dilated fourth ventricle. A residual posterior fossa cyst was noted, measuring 88 x 50 x 23 mm. CSF analysis showed a protein concentration of 200 mg/dL, glucose of 40 mg/dL, and 700 cells, of which 10% were polymorphonuclear leukocytes. Consequently, the child was commenced on vancomycin (200 mg in 30 mL over 1 hour, administered twice daily) and ceftriaxone (350 mg, twice daily) for a seven-day course before being transferred to our facility for advanced care. A 9-month-old male child, presents with the following anthropometric details: head circumference of 46.5 cm (75th to 90th percentile), height of 63 cm (<3rd percentile), and weight of 7 kg (<3rd percentile). The child was brought to the hospital by his mother with complaints of fever for one month and diminished activity, along with vomiting for the past 15 days. The child has a known history of Dandy-Walker malformation and underwent a right ventricular-peritoneal (VP) shunt placement. Since the procedure, the child's condition has been characterized by declining activity and vomiting, prompting an evaluation for suspected shunt-related complications such as shunt meningitis or blockage. The child was asymptomatic post-surgery, however, he began developing fever with an insidious onset, progressively worsening over the course of a month. The fever is intermittent and low-grade, typically aggravating at night but alleviated by medication. The fever is not associated with any rash or diaper rash. Dull activity and irritability were noted, with the child refusing food and showing a marked decrease in activity. Vomiting, which was projectile and non-bilious, contained milk and mucus and was alleviated by medication. There were no complaints of loose stools, respiratory distress, or changes in urinary output. The child did not report abdominal pain, seizures, or ear or eye discharge. There is no family history of similar conditions, and no other comorbidities were reported. Upon examination, the child appeared alert and febrile, with a visual large head circumference (46.5 cm), normal vital signs, and normal tone, power, and reflexes.

His blood glucose was 120 mg/dL, and a right VP shunt was in situ. The child's developmental quotient was noted to be 91%.Laboratory investigations, including a complete blood count, renal function tests, and liver function tests, were conducted as outlined in Table 1. Notably, the hemoglobin level was found to be low at 10.1 g/dL, accompanied by a mean corpuscular hemoglobin (MCH) of 21.4 pg. The fever profile yielded negative results for Widal and dengue. A sterile body fluid culture, including CSF, was sent for analysis, but no bacterial growth was detected in the culture. A neurosonography was performed, revealing dilation of the entire ventricular system. On Day 1 of hospitalization Intravenous vancomycin was administered at 60 mg/kg per day (105 mg in 20 cc, four times a day), and ceftriaxone at 100 mg/kg per day (350 mg in 20 cc, twice daily). Syrup levetiracetam was started at 20 mg/kg (0.7 ml, twice daily), and domperidone was administered at 0.2 mg/kg (1.4 ml, twice daily). Injection paracetamol was given at 10 mg/kg per day (7 ml, four times daily). Further treatment was provided as outlined in the treatment table 2. On day 2, a neurological opinion was sought. The physician noted spontaneous movements, positive reservoir filling, and a depressed anterior fontanelle. A CT brain scan and CSF workup were advised. By day 3, the child was fever-free, with improved activity and subsiding vomiting. The head circumference was measured at 47.5 cm. On day 5, the pediatrician referred the child to a neurosurgeon due to persistent increase in head circumference (46.5 cm to 47.5 cm) and CSF protein level of 134 mg/dL with a glucose levels of 64%, the pediatrician referred the child to a neurosurgeon. The CSF cell count revealed 3 cells/ cu mm, with 35% polymorphonuclear cells and 65% lymphocytes. A CT scan showed significant dilation of the entire ventricular system. Neurosurgical consultation recommended close monitoring for persistent vomiting, seizures, or a drop in Glasgow Coma Scale (GCS) score. Over the course of the next days, the child remained fever-free with improved activity. By Day 10, the diagnosis of Dandy-Walker syndrome with hydrocephalus and right VP shunt infection, complicated by mild anemia, was confirmed. On general examination, the child was active, afebrile, with a heart rate of 112 bpm, respiratory rate of 32 breaths/min, and a head circumference of 47.4 cm. The anterior fontanelle was flat. On Day 12, the child developed a rash, but there was no irritability, vomiting, or seizures. Dermatology consultation revealed a single well-defined erythematous plaque with raised borders over the left forearm and diffuse hyper pigmented patches with scaling over the pubic area. 1% clotrimazole cream was prescribed. By Days 13–15, the child remained active, afebrile, with a heart rate of 120 bpm and a respiratory rate of 28 breaths/min. Cardiovascular and respiratory examinations were normal. Abdominal examination was soft and non-tender. The child was discharged in stable condition with a prescription for syrup levetiracetam, syrup tonoferon, and instructions for complementary feeding.

DISCUSSION

Dandy–Walker syndrome (DWS) is a relatively uncommon congenital anomaly, with an incidence estimated at approximately one in every 25,000 live births. Epidemiological data indicate a higher prevalence of this condition among females compared to males [4]**.** Shunt-related infections represent a prevalent etiology of central nervous system (CNS) infections and constitute a critical complication associated with ventriculoperitoneal shunt (VPS) implantation. The incidence of VPS infections ranges between 5% and 22%. In the aftermath of such infections, patients often necessitate multiple surgical procedures, face the risk of profound neurological impairments, and experience an overall deterioration in clinical prognosis. Research by Yengo-Kahn AM et al. encompassed 210 patients aged 16 years. Among these, 19 individuals were diagnosed with Dandy–Walker syndrome, of whom 8 developed shunt infections while 11 did not. It was observed that 19.5% of all patients who experienced shunt infections also had Dandy–Walker syndrome, whereas only 6.5% of patients without shunt infections were affected by the same condition. This disparity suggests a statistically significant association between Dandy–Walker syndrome and an increased susceptibility to shunt infections ($p = 0.013$). Moreover, the prevalence of Dandy–Walker syndrome was considerably higher in patients with shunt infections (19.51%) compared to those without (6.51%). Although large-scale studies are absent in the current literature, it has been postulated that immunodeficiency associated with Dandy–Walker syndrome may contribute to this heightened risk. Among the infectious agents identified in patients with shunt infections, *Staphylococcus epidermidis* was the most commonly isolated pathogen [5].
Emerging evidence indicates that DWM arises from developmental anomalies affecting the roof of the rhomb encephalon, resulting in varying degrees of vermian hypoplasia and cystic dilation. This intricate malformation is believed to stem from two distinct pathophysiological mechanisms: the arrest of vermian development and the failure of fenestration of the fourth ventricle foramina, which leads to the persistence of an enlarged Blake's pouch and subsequent compression of the cerebellar vermis. Additionally, rare genetic mutations have been implicated in the etiology of DWM, involving genes such as *FOXC1* (located at 6p25.3), *ZIC1* and *ZIC4* (at 3q24), as well as *FGF17*, *LAMC1*, and *NID1*, highlighting the complex genetic underpinnings of this disorder [6].

The etiology of DWS remains incompletely understood; however, overlapping deletions in the 3q24q25.1 chromosomal region have been identified in a limited subset of patients. Within this deleted segment, heterozygous deficiencies of the *ZIC1* and *ZIC4* genes have been detected and are postulated to play a pivotal role in the pathogenesis of DWS, as evidenced by findings from mouse model studies [7]. In a study conducted by Yengo-Kahn AM et al., revealed that the most frequently reported symptom was nausea, vomiting, or poor feeding, observed in 37.7% of cases, closely followed by irritability in 37.1% of patients. On physical examination, a bulging fontanelle was noted in 44.3% of individuals, while an increase in head circumference was the most prevalent finding, present in 70.9% of cases. Notably, none of the patients exhibited new or worsening focal neurological deficits at presentation, and oculomotor abnormalities and episodes of apnea were relatively rare, occurring in only 4.6% and less than 5% of the cohort, respectively [8].In this case report, the patient presented with a one-month history of persistent fever accompanied by reduced activity levels, along with episodes of vomiting persisting for the past 15 days.Dandy–Walker malformation has been linked to neuropsychiatric disorders, including schizophrenia. A case report published by Tréhout M et al. documented a DWM-like condition in a patient with treatment-resistant schizophrenia, suggesting a potential association between structural cerebellar anomalies and the pathophysiology of certain psychiatric conditions[9]. Ultrasound serves as the cornerstone imaging technique for evaluating the fetal brain, enabling precise assessment of parameters such as head circumference, bilateral thalami, lateral ventricles, choroid plexus architecture, cavum septum pellucidum, cerebellum, cisterna magna dimensions, nuchal fold, and the spinal structure. In addition to these evaluations, ultrasound frequently aids in detecting CNSanomalies that are often linked with Dandy–Walker malformation. The routine measurement of cisterna magna during prenatal neurosonography can prompt suspicions of congenital posterior fossa malformations. Nevertheless, after the 20th week of gestation, magnetic resonance imaging (MRI) demonstrates superior diagnostic capability compared to ultrasound in identifying CNS abnormalities, owing to its enhanced resolution and detailed visualization of intracranial structures [4]. Several therapeutic approaches have been proposed for the management of Dandy–

Walker syndrome-associated hydrocephalus (DWSH). These include the placement of a ventriculoperitoneal shunt (VPS) and a cystoperitoneal shunt (CPS), both aimed at diverting cerebrospinal fluid to alleviate intracranial pressure. Additionally, more advanced techniques such as dual-compartment or "complex" shunting systems have been utilized to address both ventricular and cystic components simultaneously. Endoscopic third ventriculostomy (ETV), with or without adjunctive choroid plexus cauterization (CPC), has also emerged as an effective minimally invasive alternative, particularly in cases where traditional shunting may pose higher risks or complications. Procedural complications associated with shunt-based interventions were classified into several categories, with treatment failure attributed to specific underlying causes. These included shunt obstruction, which impedes cerebrospinal fluid flow, and infections that compromise shunt function. Mechanical issues such as catheter fractures, misplacement of the shunt system, and the need for additional proximal catheters were also identified as contributing factors. Furthermore, complications related to cerebrospinal fluid dynamics, such as over-drainage or under-drainage, were documented The study conducted a comparative analysis of shunt-based and ETV based primary treatments for Dandy–Walker syndrome-associated hydrocephalus. Findings indicated that both procedures demonstrate comparable safety profiles in terms of complication rates and the need for subsequent revisions. Despite this equivalence, ETV is frequently favored due to its potential to mitigate the risk of long-term shunt-related complications, offering a more durable solution in suitable candidates. Nonetheless, shunt-based interventions remain indispensable, particularly in high-risk infants with complex anatomical or clinical conditions, where ETV may be less effective or contraindicated [8].

CONCLUSION

Shunt-related infections, as demonstrated in this instance, represent serious complications that may result in enduring neurological impairments. Prompt recognition of clinical manifestations such as pyrexia, emesis, and heightened irritability is essential for early therapeutic intervention. This case underscores the increased susceptibility to shunt infections in individuals with DWS, potentially attributable to inherent immunological deficiencies. While ETV serves as a viable alternative in select cases, the necessity of shunt implantation remains paramount in managing intricate presentations of profound hydrocephalus. Additionally, this case accentuates the significance of prolonged surveillance to detect recurrent hydrocephalus, shunt dysfunction, or infectious complications. Optimal management necessitated a multidisciplinary approach, highlighting the critical roles of timely diagnosis, precise neurosurgical procedures, and pre-emptive strategies for complication control. Ultimately, holistic perioperative management, meticulous postoperative observation, and swift responses to emerging issues are pivotal in enhancing prognostic outcomes for DWS patients reliant on shunt systems.

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Table 1: Laboratory Analysis

Parameters	Result	Reference
Hemoglobin	10.1 g/dL	11.1-14.1
White blood cells	14.34 Thousand cells/cumm	4-10
Red blood cells	4.72 mln/cmm	5-7
Platelets	346 Thous/uL	200-550
Neutrophils Lymphocytes	48.5 % 36.3 %	40-80 20-40
Mean concentration hemoglobin	21.4 pg	31-37
RDW	16.5 %	11.6-14
Mean cell volume	70.6 fl	100-120
Hematocrit	33.3 vol %	40-50
Blood urea	19mg/dL	15-40
Sr. Creatinine	0.16mg/dL	0.70-1.3
Sodium Potassium Chlorine	140 4.1 97 mEq/L	136-145 3.6-5.1 98-107
Calcium Phosphorous Uric acid	9.6 4.76 2.26 mg/dl	8.8-10.6 2.8-4.5 3.5-7.2
Total serum Bilirubin	0.27 mg%	0.2-1.1
Aspartate Aminotransferase	26 U/L	5-35
Alanine Aminotransferase	9 U/L	7-40
Alkaline phosphatase	195 Units/L	28-111
Albumin	4.10 g/dL	6-8

Table 2: Drug Chart

Medication Prescribed	Dose	Frequency	Route	Duration
Vancomycin	@60mg/kg/day 105 mg in 20cc NS	QID	IV	21 Days
Ceftriaxone	@100mg/kg/day 350mg in 20cc NS	BD	IV	21 days
Levetiracetam	@20mg/kg/day (1ml= 100mg) 0.7ml	BD	PO	14 days
Paracetamol	@10mg/kg/day 7ml ↓ @15mg/kg/day	QID SOS	PO	2 days 6 days

	(5ml = 125mg) 4.2ml			
Domperidone	@0.2mg/kg/day 1.4ml	BD SOS	PO	1 Day 1 Day



Figure 1: Frontal View of Macrocephaly in a 9 Month Old with DWS

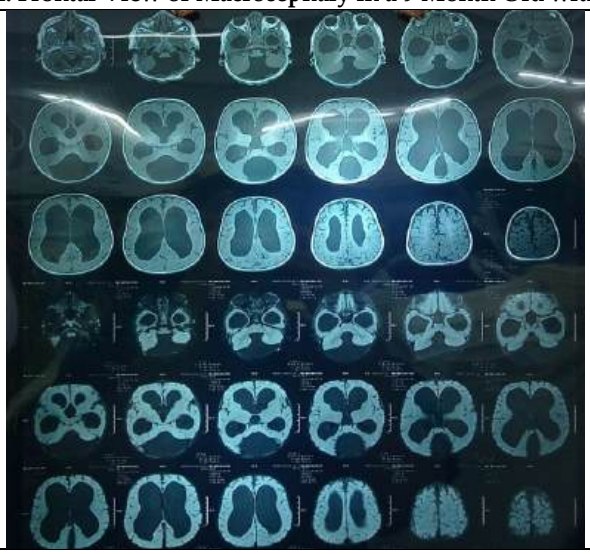


Figure 2: MRI scan of the patient demonstrating Dandy walker malformation and Hydrocephalus

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RESEARCH ARTICLE

Climate Change and Ecological Equation through the Lens of Butterfly: A Study of Flight Behavior

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ABSTRACT

This research paper examines Barbara Kingsolver's *Flight Behaviour* through the lens of climate change and ecological disruption, focusing on the symbolic role of the monarch butterfly in illustrating the effects of environmental shifts. The text portrays the altered migration patterns of monarch butterflies, a consequence of climate change, as a powerful metaphor for broader ecological instability. By analysing the relationship between the butterfly's disrupted migration and the novel's human characters, this paper explores themes of displacement, adaptation, and the interconnectedness of human and non-human life. The research highlights how Kingsolver uses the butterfly to reflect both the fragility of ecosystems and the urgent need for a collective response to climate change. Additionally, the paper investigates the role of science and knowledge in addressing environmental crises, the intersection of social inequality with ecological degradation, and the importance of integrating scientific and local perspectives. In a nutshell, the study argues that *Flight Behavior* not only raises awareness about the impact of climate change on ecosystems but also calls for a holistic approach to environmental action, emphasizing the collective responsibility of humanity to safeguard the future of the planet.

Keywords: Climate Change, Ecological Disruption, Monarch Butterfly, Barbara Kingsolver, Flight Behavior, Environmental Awareness, Migration Patterns

INTRODUCTION

Climate change has become one of the most urgent challenges of the 21st century, with far-reaching implications for the environment, society, and the global economy. The accelerating impacts of climate change—rising global

temperatures, extreme weather events, sea level rise, and biodiversity loss—are evidence of an increasingly unstable ecological balance. At the heart of this challenge lies the concept of the *ecological equation*, a term used to describe the complex and interconnected relationships between the earth's ecosystems, human activities, and the natural resources we rely upon. This research paper seeks to explore the dynamics of climate change through the lens of the ecological equation, examining how human-driven factors such as carbon emissions, deforestation, and industrialization disrupt the delicate balance of ecosystems. Climate change is one of the most pressing global issues of our time, and literature has become an important tool for exploring and raising awareness about its far-reaching consequences. One such literary work is Barbara Kingsolver's *Flight Behavior*, a novel that intricately intertwines themes of climate change, ecology, and the human experience. In this paper, the focus will be on how *Flight Behavior* uses the butterfly, specifically the monarch butterfly, as a central symbol to explore the ecological impact of climate change. The butterfly in the novel becomes an entry point for understanding the interconnectedness of the natural world and how shifting environmental conditions disrupt the delicate balance of ecosystems. As we face an uncertain future, it is critical to develop a comprehensive understanding of the ecological equation to guide global efforts toward environmental resilience, sustainable development, and climate justice. Through this investigation, the paper hopes to contribute to ongoing discussions about the urgent need for a collective global response to the climate crisis.
The literature surrounding Flight Behaviour reveals the deep interconnections between climate change, butterfly migration, and human experience. Kingsolver's portrayal of altered butterfly flight behaviour serves as a powerful metaphor for the broader ecological disruptions caused by climate change. The novel prompts reflection on how human beings perceive and respond to environmental shifts, while also urging greater conservation efforts. The studies and research referenced in the review underscore the complexity of butterfly migration and flight behaviour in the face of a changing climate, highlighting the critical need for continued ecological research and action to preserve vulnerable species.

RESEARCH FOCUS

The primary aim of this research is to analyze how Flight Behavior reflects the ecological and climate change narrative through the symbolic use of butterflies, their migration patterns, and the implications these hold for both natural ecosystems and human societies. The central research questions could be:

- How does Kingsolver use the butterfly (specifically the monarch) to symbolize the broader ecological effects of climate change?
- In what ways does the novel highlight the disruption of natural cycles and ecological balance?
- How does the human experience, as portrayed in *Flight Behavior*, mirror the larger ecological and environmental crises signified by the butterflies' changing migration patterns?

Ecological and Climate Change Themes in *Flight Behavior*

In Barbara Kingsolver's *Flight Behavior*, the author weaves together a compelling narrative that explores the intersection of ecological systems and the very real consequences of climate change. The novel is set against the backdrop of a changing natural world, where the effects of global warming disrupt local ecosystems and alter the lives of the characters. The themes of ecological imbalance and climate change are not only central to the story's plot but also serve as a lens through which the broader societal implications of environmental degradation are examined.
Flight Behavior follows the life of Dellarobia Turnbow, a rural woman who, through her encounter with a mysterious migration of monarch butterflies, becomes aware of the deeper environmental crises unfolding around her. The arrival of the butterflies, which normally migrate in specific patterns, is disrupted due to changes in temperature and weather patterns caused by global warming. This disruption reflects the broader ecological themes present throughout the novel, where the natural world is portrayed as fragile and vulnerable to human impact. Kingsolver's novel is set in rural Appalachia, where the protagonist, Dellarobia Turnbow, comes across an astonishing sight: thousands of monarch butterflies swarming in the mountain woods. This unprecedented event signifies an ecological anomaly caused by climate change, as the butterflies have altered their migration patterns due to warmer temperatures. The migration of the monarchs, an event usually happening further south in Mexico, is disrupted by

changing climatic conditions, making it a symbol for broader ecological instability. In examining the ecological and climate change themes in *Flight Behavior*, this research paper will explore the novel's portrayal of human-environment interactions and the consequences of ecological disruption. By analyzing the characters' evolving understanding of climate change and the symbolic use of the monarch butterfly migration, the paper aims to illustrate how Kingsolver uses fiction to highlight the urgency of environmental action. Through its vivid depiction of the impacts of climate change on both a personal and global scale, *Flight Behavior* offers a thought-provoking commentary on the need for sustainable practices and collective responsibility in addressing the ecological challenges of our time.

The Butterfly as a Symbol of Ecological Disruption

Monarch butterflies are often used in literature and science to symbolize the fragility and resilience of ecosystems. In *Flight Behavior*, Kingsolver uses the butterfly's disrupted migration as a powerful metaphor for ecological systems that are increasingly being destabilized by climate change. In *Flight Behavior*, Barbara Kingsolver uses the monarch butterfly's disrupted migration as a powerful symbol to explore the theme of ecological disruption. The butterflies' dramatic shift in their traditional migratory path, which is caused by the effects of climate change, serves as a metaphor for the fragility of natural systems and the consequences of human-induced environmental changes. This symbolic use of the butterfly not only underscores the immediate impacts of climate change on wildlife but also reflects the broader, systemic disruptions in the delicate balance of ecosystems. The monarch butterfly, known for its incredible long-distance migration, becomes a central figure in the novel as it draws attention to the changing climate patterns that interfere with natural processes. Traditionally, monarch butterflies migrate from Canada and the northern United States to the warmer regions of Mexico. However, in *Flight Behavior*, the butterflies are found in a small Appalachian valley in Tennessee, far from their usual migratory path. This inexplicable shift in behavior symbolizes the larger environmental changes occurring globally, such as rising temperatures and altered weather patterns, which disrupt the established cycles of nature. The butterflies' arrival is initially perceived as a wonder, a spectacle of beauty. However, as the novel progresses, it becomes clear that their presence is not a natural phenomenon but a result of an environmental crisis. This shift in the butterflies' migration serves as a wake-up call for the protagonist, Dellarobia Turnbow, and the surrounding community, forcing them to confront the larger, less visible disruptions occurring in the natural world.

The butterflies' altered behavior parallels the internal transformations of the characters as they begin to realize the severity of climate change and the challenges posed by ecological collapse. In addition to symbolizing environmental disruption, the monarch butterflies also represent the intersection of personal and global concerns. Dellarobia's emotional and intellectual journey mirrors the butterfly's flight: both are caught between the past and future, between denial and acceptance of the overwhelming changes occurring around them. The symbolism of the butterfly, as something fragile yet capable of great journeys, highlights the urgency of addressing ecological disruptions before irreversible damage is done. This paper will examine the symbolic significance of the monarch butterfly in *Flight Behavior* as a reflection of ecological disruption, drawing connections between the butterfly's altered migration and the larger environmental crises caused by climate change. By analyzing the narrative and its characters' responses to the butterflies' presence, this study will explore how Kingsolver uses the symbolism of the butterfly to evoke both the beauty and the tragedy of ecological imbalance, urging readers to acknowledge the broader implications of environmental degradation. Ultimately, the butterfly in *Flight Behavior* serves as a potent reminder of the interconnectedness of all living things and the urgent need to restore ecological harmony before it is too late. The monarchs' unseasonal arrival in the Appalachian mountains illustrates the impact of temperature shifts on migratory patterns and ecosystems. Monarchs, as cold-blooded creatures, depend on specific climatic conditions to guide their migration. The disruption of their path underscores the irreversible changes happening in nature due to human-driven climate change. The butterflies' migration northward can also be seen as a metaphor for the human experience of displacement caused by environmental factors. As natural habitats become inhospitable, both human and non-human species are forced to adapt, relocate, or face extinction.

The Butterfly as a Reflection of Human Lives

As Dellarobia's story unfolds, her relationship with the butterflies deepens, and she begins to see them as a metaphor for her own struggles in life. Her personal transformation parallels the environmental transformation, as the butterflies' arrival becomes a catalyst for her own awakening to the broader social and environmental issues that affect her community.

- **Personal Awakening**: Dellarobia's encounter with the butterflies is a turning point that opens her eyes to the urgency of addressing climate change. She begins to understand that her personal life is interconnected with the global environmental crisis, echoing the butterfly's journey from a distant land to her community. This connection between the human and non-human reflects how climate change is not a distant issue but one that affects us all, regardless of our socio-economic status or location.
- **Human Ignorance and Denial**: At the start of the novel, many people in Dellarobia's community dismiss the butterflies' arrival as an anomaly or a sign of divine intervention. This reflects widespread denial and ignorance about climate change. As the novel progresses, Dellarobia moves from skepticism to recognition, mirroring the journey of many individuals and communities in grappling with the realities of climate change.

The Role of Science and Knowledge in Understanding Climate Change

Kingsolver also places a strong emphasis on the role of science in interpreting and understanding environmental phenomena. The scientist, Dr. Byron, who accompanies Dellarobia in her discovery of the butterflies, represents the scientific community's efforts to understand the effects of climate change on ecosystems. The understanding and response to climate change are heavily reliant on the development and dissemination of scientific knowledge. Over the past several decades, scientific advancements have not only provided us with empirical evidence of the global climate crisis but have also offered frameworks for understanding its causes, effects, and potential solutions. Climate change, as a global phenomenon, requires interdisciplinary scientific efforts ranging from atmospheric science to ecology, economics, and social sciences, in order to fully grasp its complexities and to inform policy and action. This research paper examines the critical role that science and knowledge play in understanding climate change, emphasizing the importance of scientific research, public education, and the role of science communication in shaping collective responses. One of the primary ways science contributes to our understanding of climate change is through the collection and analysis of data. Climate models, observational data, and simulations allow scientists to predict future climate scenarios, providing critical information for policymakers, governments, and industries to develop mitigation and adaptation strategies. The establishment of global institutions such as the Intergovernmental Panel on Climate Change (IPCC) has played a pivotal role in synthesizing scientific data and disseminating it in accessible formats to inform global climate negotiations and policy decisions. Through the IPCC's periodic assessment reports, the scientific community provides evidence-based projections about the impacts of climate change on ecosystems, biodiversity, human health, and the global economy. Additionally, scientific knowledge helps identify and analyze the causes of climate change, particularly the role of greenhouse gases, deforestation, and industrial practices. Understanding the human activities contributing to climate change is essential for creating policies that target reductions in emissions and the transition to sustainable practices. Scientific inquiry into renewable energy sources, carbon sequestration, and green technologies also offers solutions to combat climate change, making the advancement of science and technology essential in curbing the crisis. However, the role of science is not limited to technical knowledge; it also plays a vital role in addressing the social and political dimensions of climate change. Public understanding of climate science is critical to fostering collective action, yet misinformation and climate denial continue to challenge the efforts of scientists and environmentalists. Science communication, through both traditional media and newer platforms, helps bridge the gap between scientific expertise and public understanding. Clear, accessible, and accurate communication about climate change is crucial for empowering individuals, communities, and leaders to make informed decisions about how to act in the face of the climate crisis.

- **Scientific Observation and Climate Change**: Dr. Byron's research on the butterflies' migration and habitat shifts illustrates the ways in which scientific inquiry is essential to understanding and responding to ecological

disruptions. The detailed study of the butterflies' changing migration patterns helps to ground the novel's ecological message in scientific reality.

- **Integration of Local Knowledge and Science**: While Dr. Byron embodies the scientific approach, Dellarobia's intuitive understanding of the butterflies' significance highlights the importance of integrating local, experiential knowledge with scientific analysis. This blend of traditional wisdom and modern science is essential for understanding and addressing the complexities of climate change.

Climate Change, Rural America, and Ecological Equity

Kingsolver also addresses how climate change disproportionately impacts rural, working-class communities. In the novel, Dellarobia and her community are struggling with economic hardship, and the arrival of the butterflies becomes an opportunity to raise awareness about the intersection of social inequality and ecological degradation. Ecological equity is an emerging concept that explores the intersection of environmental sustainability and social justice, focusing on the fair distribution of ecological benefits and burdens across societies and generations. As the effects of environmental degradation, climate change, and resource depletion disproportionately impact marginalized and vulnerable communities, the concept of ecological equity becomes essential in understanding how both human and environmental needs must be balanced in pursuit of a just and sustainable future. The principle of sustainable development highlights the need to meet present needs without compromising the ability of future generations to meet their own needs. Intergenerational equity, a concept central to sustainable development, focuses on ensuring that ecological resources are preserved for the future, creating a fair relationship between current and future generations. Scholars like Hans Jonas and John Rawls have contributed to this theory, discussing the ethical obligations we have to protect environmental goods for the benefit of future generations. Intergenerational equity challenges the exploitation of natural resources for short-term gains and argues for policies that promote long-term environmental sustainability. Environmental justice theory examines how environmental degradation and the disproportionate exposure to environmental hazards impact marginalized communities based on race, class, and socioeconomic status. Rooted in the civil rights movement, environmental justice advocates for the fair distribution of environmental harms and benefits, ensuring that vulnerable populations are not unfairly burdened by environmental risks. The theory challenges the historical patterns of environmental exploitation that often affect low-income and minority communities, advocating for equitable access to clean air, water, and safe living conditions. Pioneers such as Robert Bullard and David Pellow have significantly contributed to this field, emphasizing that environmental policies should take into account the social and economic inequalities that shape ecological vulnerability. Ecological modernization theory focuses on the potential for economic development and environmental sustainability to coexist through technological innovation, policy reform, and market-driven solutions. While ecological modernization does not directly address social inequalities, it is relevant to the concept of ecological equity because it suggests that ecological challenges can be overcome through strategic investments in green technologies and sustainable practices. This theory, advanced by scholars like Joseph Huber and Martin Jänicke, offers an optimistic perspective on the role of technology and global cooperation in achieving ecological equity.

- **Environmental Justice**: The novel subtly critiques how the environmental crisis affects the most vulnerable communities first. Climate change exacerbates existing social inequalities, and the people in rural Appalachia—who often rely on industries like coal mining and agriculture—are particularly affected by both environmental degradation and economic shifts.
- **Rural vs. Urban Divide**: The novel underscores the tension between rural and urban perspectives on climate change, with the rural community in *Flight Behavior* initially skeptical about the scientific warnings and the broader political implications of climate change. The rural setting provides an opportunity to discuss how ecological shifts challenge traditional ways of life and force communities to confront difficult truths.

The Butterfly's Migration and the Future of the Planet

Ultimately, the butterfly's migration, interrupted by climate change, serves as a reminder of the planet's fragility and the interconnectedness of all living systems. As the butterflies navigate through changing climates, they also represent the future of all species, including humans, in a world increasingly shaped by human actions. Monarch

butterflies are known for their incredible long-distance migration, an event that has been occurring for generations. Their predictable seasonal movements—from Canada and the United States to the warm, specific areas of Mexico—have been a symbol of the earth's natural rhythms and ecological stability. In *Flight Behavior*, however, the butterflies' arrival in a rural Appalachian valley in Tennessee—far from their usual migratory path—signals the disruption of natural systems. This unnatural behavior is caused by rising temperatures and shifting climate patterns, underscoring the way that climate change alters not just human lives but the very migration and existence of species. The butterflies' altered migration, while initially interpreted as a mystical phenomenon, gradually becomes a symbol of environmental collapse. As the community members grapple with the implications of the butterflies' arrival, the narrative highlights how ecosystems are being forced to adapt or fail due to the changing climate. This disruption serves as a warning about the future of the planet and the vulnerable species that depend on stable, predictable environmental conditions. In this way, the butterfly migration in *Flight Behavior* acts as a microcosm for larger environmental challenges and the need for urgent action to preserve biodiversity.

The Disruption of Natural Cycles and Its Implications for the Planet

The butterflies' migration in *Flight Behavior* reflects how climate change is altering the delicate ecological cycles that sustain life on earth. The warming temperatures, resulting from human activities such as deforestation and the burning of fossil fuels, have thrown off seasonal patterns, affecting both flora and fauna. This shift in environmental conditions disrupts the intricate relationships between species, forcing them to adapt in ways that may be unsustainable in the long term. In the novel, the monarch butterflies' presence in the valley leads to intense local scrutiny and debate. As the community members, particularly the protagonist Dellarobia Turnbow, begin to understand the implications of the butterflies' altered path, they confront the reality of climate change and its potential to destabilize not only the environment but also their own livelihoods. This disruption of a familiar natural phenomenon serves as a stark reminder of how the planet's ecosystems are increasingly vulnerable to the consequences of human actions. The butterflies' migration thus symbolizes the fragility of life on earth and the urgent need for action to address environmental issues like climate change, resource depletion, and habitat destruction.

The Role of the Monarch Butterfly as a Harbinger of Change

In *Flight Behavior*, the monarch butterflies act as a harbinger of ecological change, both in their physical disruption of the migration route and in the broader implications they carry. The butterflies' presence challenges the community to recognize the environmental shifts happening around them, prompting a confrontation with the larger issues of climate change and ecological imbalance. For Dellarobia, the butterflies are a catalyst for personal transformation, pushing her to re-evaluate her understanding of the world and her place within it. The butterflies symbolize a crossroads for the planet—much like the pivotal moment humanity faces in the fight against climate change. Just as the butterflies are at a critical juncture in their migration, the earth is at a critical point in its climate trajectory. The migration's disruption calls attention to the urgency of environmental action and the importance of addressing climate change in a meaningful way before irreversible damage is done. The fate of the monarch butterfly is inextricably linked to the future of all species on the planet. This serves as a call for collective action and underscores the importance of addressing climate change in a holistic, globally coordinated way. Just as the monarchs cannot migrate alone, humanity must work together to address the environmental challenges that affect us all.

CONCLUSION

Barbara Kingsolver's *Flight Behavior* uses the migration of monarch butterflies as a powerful metaphor for the disruption caused by climate change. Through the lens of the butterfly, the novel explores themes of ecological instability, human displacement, and the urgent need for scientific and social intervention. The butterfly's altered migration symbolizes the larger ecological equation that humanity must address: the balance between human activities and the natural world is delicate, and as the novel suggests, the future of the planet depends on how we choose to act in response to climate change. This paper can further explore how Kingsolver's narrative bridges

scientific, ecological, and social perspectives on climate change, highlighting the complexity of the issue and the importance of both individual and collective responsibility. Through this lens, the butterfly's journey becomes not only a symbol of nature's beauty and fragility but also a reminder of the profound changes taking place in our world.Through the symbol of the monarch butterfly and its disrupted migration, *Flight Behaviour* provides a poignant commentary on the future of the planet in the face of climate change. The novel illustrates how ecological imbalances, as seen through the butterflies' migration, are not isolated incidents but are part of a larger, global issue affecting both human and non-human life. The butterfly's journey—once a symbol of natural harmony—is now a metaphor for ecological collapse and the loss of biodiversity that threatens the health of the planet. This research paper emphasises how Kingsolver uses the butterfly's migration to explore the broader environmental themes in the novel, stressing the importance of recognizing and responding to the ecological crises that shape the future of the planet. By understanding these disruptions, *Flight Behaviour* urges readers to consider the long-term consequences of inaction and the need for collective responsibility in securing a sustainable future for all living species.

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RESEARCH ARTICLE

Effectiveness of Om Chanting on Stress Level among Nursing Students in Selected Nursing Colleges in Anand District

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ABSTRACT

Stress is a physical and psychological state in which the individual is forced to make adjustments. Due to family expectations, rivalry for scores and career choices student nurses have been found to be affected by academic, clinical, and financial stressors. Chanting the Om mantra on a regular basis can help with depression, anxiety, cardiovascular difficulties, stress, and a variety of other issues. Furthermore, nursing students might lessen their stress levels by repeating the Om mantra on a regular basis. Objective of the study was to evaluate the effect of Om chanting on decreasing stress level among nursing students. Method: True experimental research design was used to conduct the study.A total of seventy participants were gathered, and 35 were assigned at random to each of the experimental and control groups. The academic stress scale and sociodemographic data were part of the data gathering method. After receiving the intervention for five minutes each morning for 30 days in consecutive days, the experimental group's post-interventional stress level was measured. According to the pre-test data, a significant proportion of the experimental group's student nurses suffered from extreme stress. A change was noted in the post-test, nevertheless, as most student nurses in the experimental group showed only low signs of stress. Additionally, the pre-test data revealed that the control group was extremely stressed. Every nursing student in the control group showed signs of severe stress on the post-test. The mean post test result of experimental group was 25.54, while the non-interventional groups was 66.74. When comparing the experimental group to the control group, there was a substantial decrease in stress levels, as indicated by the mean difference between the two groups of 39.629 which was significant. The Mann-Whitney value of 2.000, p =.001). The null hypothesis was rejected and it was inferred that OM chanting was effectively in

reducing the mean stress level score Reciting the Om mantra as a form of alternative health care is recommended for nursing students as a way to reduce stress and to energize their bodies, minds, and spirits.

Keywords: Stress, Meditation, Yoga, Psychology, Mindfulness, Young adults

INTRODUCTION

Stress is an unavoidable part of life that affects everyone on a daily basis [1][2]. The American Institute of Stress reveals that approximately 33% of individuals report experiencing severe stress. Furthermore, a staggering 77% of individual undergo stress that has a direct impact on their physical health. Additionally, 73% of individuals indicate that their mental health is adversely affected by stress, and 48 % people have problem of insomnia due to stress. Courses for professionals in health have been said to be extremely demanding and straining, necessitating extensive preparation and the capacity to cope with high-stress conditions [3][4]. Furthermore, stress can be a contributing factor to or exacerbate various mental and physical challenges commonly experienced by students, including headaches, fatigue, feelings of sadness, anxiety, and difficulties in managing tasks [5]. As per the World Health Organization (WHO), stress has been designated as the prevailing health epidemic of the 21st century [6]. Nursing is a noble profession, and students are stationed in clinical areas to provide services. It is critical to maintain a positive mental attitude when dealing with sick patients. Nurses work on the front lines in all health-care settings, and it takes hours and days of intensive training to become a skilled nurse, which begins on the first day of nursing school or college [7]. Medical students specializing in nursing face intensified strain during their training than students in other health disciplines [8]. Research conducted worldwide indicates that the occurrence of stress among students pursuing health professions falls within the range of 14.3% to 56% [9]. A New York University publication states that for 55% of students, academic stress is their main source of stress. Six out of ten college students claim to have experienced anxiety to the point that they have at least occasionally been unable to finish their coursework [10]. A descriptive study was done to find out stressed feelings, anxious thoughts, and depressive mood level in trainee nurses of BMCB Nursing College, Gujarat (2020).120 students in all were chosen using a practical sampling technique. A self-administered questionnaire that included the Beck Depression Inventory, State Anxiety Scale, and Perceived Stress Scale was used to collect the data. Each sample has a time limit of 20 minutes.

The results suggest that nursing students have a significant level of stress. Anxiety is moderate, and depression is present in a minimum number of nursing students [11]. In a study by Indira A et al to evaluate the extent of stress experienced by nursing students revealed that 15 students (25 %) had very mild stress, 22 students (36.7 %) had moderate stress, and 23 students (38.3 %) had severe stress. Statistically significant correlation is evident in stress levels and socio demographic characteristics including educational background of the parents, the monthly family earning, family structure, and consciousness of nursing [12]. This highlighted the significance of stress-relieving strategies in nursing schools, because trainee nurses encounter elevated levels of stress, it is necessary to reduce the stress among them by employing various types of coping mechanisms. Various research projects published over the past ten years suggest that practicing mindfulness practices can help to alleviate apprehension and depression, as well as promote calmness, all of which are beneficial to psychological and physical well-being [12].Om meditation can help people with low self-esteem if they practice it on a regular basis. The word 'Om' carries a cosmic positive vibe that aids in the creation of positive vibrations and a holy sensation. Om meditation is advantageous over other meditation techniques since it is simple to practice, takes less time, and does not require the assistance of an expert or teacher. The most essential benefit of all is that it assists you in getting rid of thoughts that hinder your thinking process[12].Scientific investigations on Om indicate that the cognitive repetition of Om leads to heightened physiological alertness and increased receptivity to sensory stimuli[13]. The literature by Dr. Anita Sharma & Reetudhwaj Singh on Chanting Slogans as an Effective Coping Strategy for Adolescents with Educational Stress emphasize that mantra chanting promotes a calm view on life. A tranquil mind is the most effective form of medical

coverage. The whole positive cycle begins with a well-rested mind. Meditation, in psychoanalytical terms, aids in the overcoming of neurotic tendencies and brings calm and happiness to the mind. The OM and Gayatri mantras stimulate brain cells, resulting in their activation and, as a result, improved concentration [14]. Based on the data, the researcher believes that stress among nursing students is a widespread issue, and that it is critical to provide them with appropriate guidance. Nursing students face a variety of challenges as they are required to use theoretical knowledge and develop critical thinking abilities in a professional setting. Research featured in the International Journal of Yoga indicates that engaging in Om chanting meditations could potentially deactivate the right amygdala, a brain region associated with negative emotions. Om chanting meditations may assist to alleviate negative thoughts, worry, and stress. It is critical at this moment to evaluate the amount of psychological pressure among Student nurses and address the issues. Because there has been few research dedicated to investigating the benefits of Om chanting in lowering stress among nursing learners. Consequently, the aim of this research was to evaluate the Effectuality of Om chanting in alleviating stress among nursing students.

MATERIALS AND METHODS

The methodology used in this investigation was quantitative. In this study, a True experimental research design was selected. The study focused on nursing students as the target population, and samples were recruited using a simple random sampling technique. The minimum sample size calculated was 68 so 70 participants were finally selected for the study. The entire study population was 70 (35 in each experimental and control group). Prior to intervention, stress was assessed using the standardized academic stress scale. Following a stress assessment, five minutes of Om chanting were given to experimental group for 30 consecutive days. No Om chanting was given to the control group. After the implementation of Om chanting, the stress levels in the treatment group and the non-intervention group were assessed using standardized academic stress scale. All participants in the study provided informed consent prior to their involvement in the research with the permission of the Institution's ethics committee.

Inclusion criteria

Individuals who are interested to take part in the research. Learners enrolled in the 1st and 2nd year of the B.Sc. Nursing program, irrespective of gender, who are present during the data collection period are eligible to take part in the study. Students experiencing moderate to severe stress level can also participate in the study.

Exclusion Criteria

Learners who are unwilling to take part in the research or are unavailable during the data collection period. Students who have any serious ailments, such as muscular disorders, heart conditions, asthma, color blindness, or sensory motor disabilities. Students who are scheduled to take an exam in the following two weeks were excluded from the study. The data was evaluated and interpreted in accordance with the study's objectives. For analysis, descriptive and inferential statistics were utilized. Frequency and percentage were used in descriptive statistics. The Wilcoxon test was used in inferential statistics to test the hypothesis at the 0.05 level of significance.

RESULTS

The data in table1 depicts that most of the participants in the experimental and control groups, 45.7% and 40%, respectively were in the 19-year-old age group, while most participants in the interventional group 77.1%, and the non-interventional group, 85.7%, were females, and 91.4% students in the treatment group and 71.4% students in the non-interventional group were Hindu. The majority of individuals in both the interventional group 31% and the non-interventional 27% stay with their families. In both the groups all the students 100% were single. Students from nuclear families make up 54.3% of the interventional group and 68.6% of the non-interventional group. The interventional and non-interventional groups both had 100% participants who received financial assistance from their parents. The majority of students in both treatment group 57.1% and control group 24 (68.6%) enjoy listening to music. Table 2 shows stress levels of nursing students in the interventional group assessed before and after the

intervention. Pre-test showed 97.1% severe stress, 2.9% moderate stress, and none mild stress. Post-test showed no stress, 80 % mild stress, and 20 % moderate stress. After applying the Om chanting, no nursing students experienced significant stress. Table 3 shows the distribution of nursing students in the control group based on the level of stress. It was discovered that 97.1% of the 35 students in the pre-test had severe stress, whereas 2.9% had moderate stress level. In the post-test, all of the nursing students were experiencing significant stress Table 4 depicts that Wilcoxon test value 5.162 with p value 0.00 suggests that the experimental group of nursing students has a lower stress level. Table 5 data represents the level of stress in nursing students was different in interventional and non-interventional group. The mean difference of interventional and non-interventional group was 39.629 and obtained Man-Whitney value was 2.000 with p value .001, suggests that the amount of stress was substantially lowered in interventional group in comparison with non-interventional group.

DISCUSSION

OM chanting, often referred to as "Aum" or "Omkar," is a sacred and ancient practice originating from various Eastern spiritual traditions, including Hinduism, Buddhism, and Jainism. This powerful syllable is considered to be the universe's first sound and is believed to encompass the essence of creation, preservation, and transformation. In recent years, OM chanting has gained attention not solely due to its spiritual importance but also for its potential therapeutic advantages. This discussion delves into the existing research on OM chanting and its effects on mental, emotional, and physical well-being. OM chanting has been associated with reduced stress and anxiety levels. The rhythmic repetition of the sound is believed to induce a soothing influence on the mind., promoting relaxation and decreasing the production of stress hormones. Research has suggested that regular practice of OM chanting may contribute to overall stress management. The rhythmic and meditative nature of OM chanting may help improve concentration and focus. The practice requires sustained attention to the sound and vibration, potentially enhancing cognitive abilities over time. This aspect has drawn interest from educators and practitioners seeking ways to enhance learning and attention span. A student may experience numerous difficulties and tensions. Compared to their peers and coworkers enrolled in other programmes, student nurses are more likely to feel increased stress. The study acknowledges the elevated stress experienced by nursing students, which can impact their learning and overall well-being. Some stress is acceptable, but when it interferes with a student's education or personal life, it becomes a problem. According to research; nursing is a high-stress vocation in which nursing students experience difficult situations that frequently affects both their learning process and their health problems [15].

Before the intervention in the experimental group, 34 nursing students (97.1%) had severe stress, 1 (2.9%) had moderate stress, and none had mild stress and in the control group , it was found that out of the 35 students 34 (97.1%) experienced severe stress, and only one (2.9%) had moderate stress. This can be as a result of the student nurses' ignorance of stress management techniques. However after implementing the Om chanting in experimental group it was identified that among nursing students, 28 (80%) reported mild stress, 7 (20%) reported moderate stress, and the majority reported no stress at all. Grade competitiveness, a lack of time commitment, and problems with time management are just a few of the academic expectations that can cause stress. The requirement to adapt to new learning settings due to the need for continuous self-regulation and the development of superior cognitive abilities, as well as the complexity of the material that needs to be learned and the time and effort that go along with it. Adapting socially, specifically adjusting to campus life and being separated from friends and family is another category that causes stress. Last but not least, there are financial constraints and technological challenges. These results are consistent with prior research carried out by Nurs AP, Singh D, Chaturvedi M indicating that trainee nurses often face experiencing heightened stress level [16]. The study's recognition of this stress level emphasizes the importance of effective stress reduction strategies for nursing students to maintain their well-being and enhance their learning experiences. Similar results were observed in the research carried outby Das BN et al., where in student nurses shows elevated stress, highlighting the need for stress management programs and mentorship [17]. The implementation of OM Mantra Repetition and AnulomVilom Pranayama led to a reduction in stress levels among medical and nursing students. Those who actively participated in these practices exhibited noteworthy

enhancements in their physiological indicators [18]. Chanting mantras encourages a serene outlook on life. A refreshed mind is the best form of health insurance. A well-rested mind is the starting point of the entire positive cycle. According to psychoanalysis, meditation helps people overcome their neurotic tendencies and promotes mental peace and contentment. The OM and Gayatri mantras activate brain cells by stimulating them, which improves concentration [19]. Both yoga and meditation are beneficial for both physical and mental wellness. Om mantra chanting, which is basic and easy to do, also falls under the category of meditation. Research shows that Chanting the Om mantra increases the creation of some critical hormones, protein enzymes, and compounds that reduce stress [19] Currently, a lot of research describes the use of relaxation techniques including yoga, meditation, spiritual healing, reiki treatment, relaxation techniques, pet therapy, and others to relieve stress. The current findings revealed that the experimental group's nursing students are less stressed than the control group after implementing Om chanting. Stress levels differed among nursing students in both the interventional and non-interventional groups. Upon comparing the experimental group to the control group, a significant reduction in stress levels was observed, as indicated by the difference in mean between the two groups of 39.629 and the resultant Man-Whitney value of 2.000 with a p value of.001. These outcomes were equivalent to research conducted by Sharma A, Singh R to determine the beneficial effects of mantra chanting on reducing academic stress in teenagers and the study's findings indicated that reciting the Om and gayatri mantras can significantly reduce stress in adolescents[14]. Similar results were seen in a study conducted by Singh A that there were significant variations in the self-efficacy and wellbeing measures taken before and after the intervention. It was determined that goal meditation is beneficial in raising students' levels of self-efficacy and wellbeing [20]. OM chanting, with its centuries-old roots in spiritual and philosophical traditions, presents a unique avenue for exploring its therapeutic potential. While existing research has started to shed light on its effects on stress reduction, emotional well-being, and spiritual connection, further interdisciplinary studies that integrate psychology, neuroscience, and spiritual studies are needed. Such research could provide a more comprehensive understanding of OM chanting's influence on human health and well-being, both from a secular and spiritual perspective.

CONCLUSION

Om meditation can be introduced to nurses and students in clinical settings, as it's simple, time-saving, and requires no expert guidance. The study findings will help nurses become more aware of the value of chanting Om and how it might help them cope with stress. By educating nurses and students about non-pharmacological techniques, the study lessens the need for pharmacological management to treat stress-related health problems. To help medical professionals comprehend its advantages and enhance the psychological and physical wellness of mental patients, nurse management needs to set up an Om chanting continuing education program.

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Table 1: Distribution of nursing students of both experimental and control group according to Socio-demographic variables N=70

Sr.No	Socio demographic Variables	Experimental Group n=35		Control Group n=35	
		F	%	F	%
1	**Mean age (year)**	19±0.9	19±0.8		
2	**Gender** a. Female b. Male	 27 8	 77.1 22.9	 30 5	 85.7 14.3
3	**Religion** a. Hindu b. Christian c. Islam	 32 3 0	 91.4 8.6 0	 25 8 2	 71.4 22.9 5.7

4	**Place of Living**				
	a. Hostel	3	8.6	8	22.9
	b. With family	31	88.6	27	77.1
	c. Separate with friends	1	2.9	0	0
5	**Marital status**				
	a. Married	0	0	0	0
	b. Single	35	100.0	35	100.0
	c. Separated	0	0	0	0
	d. Windowed	0	0	0	0
6	**Type of family**				
	a. Nuclear	16	45.7	24	68.6
	b. Joint	19	54.3	11	31.4
	c. Extended	0	0	0	0
7	**Economical support**				
	a. Parents	35	100	35	100.0
	b. Husband	0	0	0	0
	c. Wife	0	0	0	0
	d. Educational loan	0	0	0	0
	e. Others	0	0	0	0
8	**Regular hobbies**				
	a. Reading	7	20.0	3	8.6
	b. Listening to music	20	57.1	24	68.6
	c. Gardening	0	0	1	2.9
	d. Painting	1	2.9	2	5.7
	e. Others	7	20.0	5	14.3

Table 2: Distribution of nursing students according to the level of stress in experimental group. N=70

Level of stress	Pre Test		Post Test	
	Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
Mild	0	0.00	28	80.0
Moderate	1	2.9	7	20.0
Severe	34	97.1	0	0.00

Table 3:Distribution of nursing students according to the level of stress in control group. N=70

Level of stress	Pre Test		Post Test	
	Frequency (f)	Percentage (%)	Frequency (f)	Percentage (%)
Mild	0	0.00	0	0.00
Moderate	1	2.90	0	0.00
Severe	34	97.1	35	100.0

Table 4: Effectiveness of Om chanting in reducing level of stress in experimental and control group N=70

Group		Mean	Mean difference	Standard Deviation	Wilcoxon	P Value
Experimental Group	Pre test	64.17	39.63	5.399	5.162	.000
	Post test	24.54		5.204		
Control group	Pre test	63.80	2.94	6.393	1.953	.051
	Post test	66.74		6.104		

Table 5: Comparison of level of stress between experimental and control group N=70

	Mean	Standard Deviation	Man Whitney Test Value	P Value
Difference between the Group	39.629	7.531	2.000	.000
	5.914	5.457		

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RESEARCH ARTICLE

Shinkansen Method of Pre-Casting Full-Span Box Girder (FSBG) for High- Speed Railway in India

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ABSTRACT

Worldwide, high-speed rail and road construction, as well as LRT and MRT projects, typically incorporate Full Span Box beams. High-speed rail lines are commonly built in isolated areas. Prefabricated full-span bridges (FSBGs) are some of the fastest ways to construct viaducts and bridges. The entire span is moved from FSBG's casting yard to the bridge site using a specially made multi-axle wheeled cart. Pre stressed concrete bridges can be built much more quickly, with lower labor costs, better quality, and at a lower cost thanks to high-speed bridge pre casting. Individual concrete components that were manufactured and installed one after the other have been used to construct a number of high-speed railway bridges. For two-track bridges, single-member pre stressed concrete box girders are a great option. Shinkansen technology is prefabricated using full-span post-tensioned concrete beams in the Indian high-speed rail project.

Keywords: LRT, MRT, Prefabricated Full-Span Bridges (Fsbgs), Precasting, Prestressed.

INTRODUCTION

Bridge spans of thirty to forty meters and a total girder mass of nine hundred to one hundred tons are typical for Indian high-speed rail projects. As part of the PSC Borders process, the complete bridge span is poured in the casting yard and transported to the bridge site on a specially made wheeled cart with many axles. PSC Borders uses a specially built bridge gantry to raise and transfer the whole pier span into its final place at the bridge site. Precasting allows for fast construction and consistent, high-quality casting operations in factory-like settings, as well as year-round erection in almost all weather conditions. Segment beams are not recommended for full spans since they initiate seven times faster. The largest PSC beams in the Indian construction industry are 40 meters long and weigh

roughly 970 MT. 42 MT of steel and 390 Cum of concrete are used to cast 40 m of the order either all in one piece or without building joints. This project focuses on the construction of full-scale prefabricated facilities for high-speed railway cast yards for PSC box girders. In addition, the efficiency and interplay of the various specialized tools required to pour, hoist, transport, and position whole PSC box beams in the yard are explained.

The Project

The Mumbai – Ahmedabad High Speed Rail (MAHSR) Project, often known as the Bullet Train Project, is the first High Speed Rail (HSR) network to be constructed in India. The MAHSR Project line connects Ahmedabad, in Gujarat State, with Mumbai, in Maharashtra State, passing via the Union Territory of Dadra and Nagar Haveli. The 508 km long Mumbai-Ahmedabad High Speed Rail Corridor is split between the states of Maharashtra (156 km), Gujarat (348 km), and Dadra & Nagar Haveli (4 km)of the total 352 km, 325 km are being executed by L&T. The stretch is divided into 8 bundles from C1 to C8.

Project Features

Twenty-three casting yards are being built along the alignment to cast girders. Depending on the needs, each casting yard is situated close to the alignment and has a size ranging from 16 to 93 acres. A variety of facilities are developed in each casting yard, including batching plants, aggregate stacking areas, cement silos, labor camps, precast girder handling, rebar tying, rebar cage handling at jigs, shutter panel fixing and alignment, casting beds with hydraulically operated prefabricated molds, shutter panel concreting sequence, hutter panel de-moulding sequence, and so forth.
Post-tensioned Full Span Box Girder and any associated tasks falling under the purview of the technical specifications section. Thirty and forty meters are the most common girder beam spans; however, when there are constraints, smaller sections are divided. Using massive equipment such as lifting platforms, bridge carriers, control systems, and container carriers, these prefabricated beams are launched. Beams for launches are constructed and stacked at these launch yards to ensure a consistent supply. The container support conveys the box girder from the stack yard to the bridge gantry, where it is raised and placed on the pier deck bearing.

Major Equipment's Used in Casting Yard

Straddle Carrier

Straddle carrier is heavy haulage equipment that is used to lift, transport, and load the precast FSBG girders and FSBG girder reinforcement cage, shown in

FSBG Rebar Jig

The purpose of the FSBG Rebar Jig is to facilitate the construction of rebar cages. The Rebar Jig's design ensures that the necessary cover is maintained while the form and reinforcement are tied correctly. The rebar jig's connections can all be easily removed and moved because they are all bolted together.

FSBG Rebar Cage

In the rebar jig, the FSBG Rebar is built. The rebar cage has a 40-meter span and weighs between 42 and 45 MT (approximately). Fe500D TMT high strength deformed steel bars are utilized as reinforcement in pre-casting operations. The cage also includes various inserts and the PT duct profiling. The rebar jig fixes and sets the bursting reinforcements.

Pre-Cast Full Span Girder Moulds.

The ground support beam is elevated on the concrete foundation pedestals. There is room to place seismic stopper recesses, wedges, etc. in the soffit shutter. The soffit shutter has spaces on both ends for wedges to be installed in order to guarantee a level surface for mounting bearings.

The outer frame's

job is to hold up the FSLM girder's webs and overhanging section. For demoulding purposes, hydraulic jacks (10MT capacity) are offered.

Movable Inner Forms

The bottom support beams, which are braced together, and each support beam is supported by 48mm dia. Inner shutter hauling must be done with an electrically powered rack and pinion system. During hauling, the spine beam shall be rolled over the wheels mounted on the supports. Once the spine beam is aligned to the position, the hydraulic jacks mounted in the spine beam shall be activated to align the inner shutter. After ensuing the alignment of inner shutters, the load bearing turn buckles are engaged to care of required concrete pressure. The hydraulic jacks shall be disengaged. Similarly, during demoulding, the hydraulic jacks (10MT cap.) are engaged. The turnbuckles are removed and placed on rack in the spine beam. Now, hydraulic jacks will be activated, and the shutters will be de-moulded to the required envelope. The vertical jacks (40 MT cap.) fixed to the support beams shall be activated to lower the entire spine beam along with top shutter panels. Once the demoulded to the required shape, the entire inner forms shall be pulled out using the drive assembly and parked in parking area.

HDPE Duct Placing

For varying FSBG element lengths, full length HDPE duct can be obtained. The pre-stressing ducts and HDPE tubing are positioned and fixed in the correct location using spacer bars in accordance with the design requirements, plans, and specifications. Welding or other strong fastening is required to keep the ducts welded to the spacer bars during the concreting process. In the Rebar Jig, PT Duct profiles are inspected and tested. All PT Duct Coupling (Coupler or Heat Shrink) will now be finished in the Rebar Jig since it offers simpler access and guarantees a high standard of quality. PT Stranding will now be finished before casting in order to ensure the safety of the PT Ducts. Installing fixtures must follow approved blueprints at all times.

FSLM Rebar Cage Transportation

A cage lifter must raise the reinforcement cage and place it within the casting mould after it has passed a successful reinforcing check, making sure it is held without distorting.

(**Fig. 4).**The cage must be lifted using a "strong back" (a stiff truss) and then placed in the mould using a straddle-carrier. However, we are employing two hydraulic cranes for the initial casting of the FSBG girder.

Survey Check

Survey towers must be placed properly in order to achieve full span box girder geometry control; complete station and auto level will be employed for this. Outside the casting area are survey towers whose purpose is to prevent straddle carriers from moving. Setting the girder center line is a prerequisite for beginning work on the entire span molding. It is the surveyor's responsibility to maintain the soffit position and level in accordance with the drawing's pre-calculated parameters. It is required to confirm and, if needed, modify the outside form level in compliance with the drawing criteria. Selecting the bulkhead's location and ensuring its verticality are essential. Following the reinforcement's installation, the exact duct location must be ensured and the duct profile must be maintained in compliance with specifications.

Camber Control &Measurement

Camber control is to be implemented in accordance with the Employer's Requirements (Technical Specification). Survey plates can be put into the girders to determine camber, or the IRS Bridge Manual Annexure 11/14 has measurement instructions. During the various stages of girder casting while post-tensioning, after the building or installation of accessories, upon delivery of the track contractor, during the static inspection (or at the completion), at any level the Engineer deems appropriate, the calculated camber will be compared to the actual camber measured on-site for each girder. Any significant difference between the theoretical and real camber values must be reported to the Engineer in Charge so that the proper course of action can be followed.

Case Study- Casting of FSBG span

Sequence of Activities

The number of storage platforms is decided by the delivery curing time, and the productivity of the pre-casting facility is matched to that of the erection lines. There might be more platforms with more standard spans and emergency platforms, and the size of the storage facility might grow to the point where stacking is required. Cage prefabrication in full-span reinforcing bar jigs is necessary due to time constraints and the availability of heavy lifters at the pre-casting factory. Bar jigs with reinforcement improve the organization's adaptability. In order to enhance cage handling and shorten the casting bed's cure time, the girders are usually constructed for post tensioning. Watertight plastic ducts are built and tested, the end bulkheads are fastened to the reinforcing bar jig in accordance with beam geometry, the tendon anchorages are fastened to the bulkheads, the remainder of the cage is assembled, and all embedded items are fastened to the cage. Strands are placed into the ducts throughout the casting and curing processes in order to lighten the cage during transfer into the casting bed and to divert activity from the critical passage. Before lifting, a stiffening truss, or strong back, is fastened to the cage to prevent warping. If a reinforcing bar jig produces a cage every four days, the casting line requires four jigs. Reinforcing bar jigs cost more expenditure, but separate cycle times for casting beds and reinforcing bar jigs increase girder production flexibility and reduce interference among carpenters, ironworkers and prestressing teams. Additional jigs can be mounted as necessary. After 12- to 18 hours of curing, partial post tensioning is used to make the girder self-supporting for transfer to the storage platform; post tensioning transfer often requires longer curing. Parallel casting lines are separated by runways for steel cage delivery and beam removal. The inner form is slid across the casting bed once the cage is delivered to shut the mould. To establish a maintenance area, the runways of the inner portal shutter can be extended at one end of the casting line. The post tensioning technique is used to stress the longitudinal and transverse tendons. The bottom slab has webs for post tensioning during storage, as well as anchored strands and parabolic ducts. Hydraulic jacks are used for initial post tensioning and pre stress transfer at one end of the casting line. The number of reinforcing bar jigs in a casting line is determined by the productivity of the casting beds and jigs. Depending on span dimensions and cross section type, a casting line can create one girder every day in a two- or three-day cycle. If a casting bed yields a girder every three days, then three casting beds are needed.

Concrete Placement – Bottom Soffit, Web, Top Deck/Slab

The approved concrete mix (M-50 Grade) is batched from the two on-site batching machines and transported by 6.0 m^3 transit mixers to the casting position. Two hours is the minimum retention time for the concrete mix. The full span-girder length and detail are used to estimate the actual quantity of concrete. The temperature of the concrete is maintained at 32 degrees Celsius while it is being placed. The casting of concrete will cease when the temperature rises over 32 degrees Celsius. To maintain the temperature of the concrete mix when the outside air temperature rises over 28 degrees Celsius, the following measures are taken: For mixing concrete, cooled water is used. Sprinkled water is applied to the aggregate, and temperature adjustments are made at batch level to ensure that the C/W ratio and concrete. To ensure that the C/W ratio and concrete temperature are not influenced, water is sprayed over the aggregate moisture content, and temperature adjustments are made at the batch level. The temperature differential in concrete is measured. A concrete slump of 170mm is excellent. In a smooth, continuous casting operation, the concrete casting will start at one segment and proceed to the other part. 54.0 m^3/hr is the constant pace at which the concrete is cast. This means that each car will take about 12.5 minutes. To place all concrete precisely where it is needed, tremie pipes, concrete boom pumps, and concrete hoppers are utilized. Layers of concrete are applied continuously, with a maximum thickness of 300 to 500 mm. Four tremie chutes of varying lengths are used to pour concrete into the webs, ensuring that it is deposited accurately and without segregation. Through a window hole, concrete is poured into the Upper Inner Mould Soffit. Four brand-new form vibrators have been put on the bulkhead. Through a window hole, concrete is poured into the Upper Inner Mould Soffit. Four brand-new form vibrators have been put on the bulkhead. Grease use is not permitted in the PT block out area. Using high pressure water blasting (3,000 psi), the building joints are prepared. The PT Block out uses Sika Rugger Soul - MH (Paint on application) to provide a good construction joint surface. Professional construction joint surfaces are created on the Top Deck by using Sika Rugger Soul - C (Spray application).Grease use is not permitted in the PT block out area. Using high pressure water blasting (3,000 psi), the building joints are prepared. The PT Block out uses Sika Rugger Soul - MH

(Paint on application) to provide a good construction joint surface. Professional construction joint surfaces are created on the Top Deck by using Sika Rugger Soul - C (Spray application).

Pour Sequence

Layer .1. By Pump 1 Start of Bottom Soffit & Web Walls.

In the first layer, the diaphragm soffit is filled to a depth of approximately 500mm (50% depth), and this concrete will reach around 4.0m through the 1.50m diaphragm and into the transition soffit zone. Because the depth of the transition soffit is set to 300mm, it will be filled in the first step.

Layer .2. By Pump 1.

In the second layer, the diaphragm soffit is filled to a depth of roughly 583mm (100% depth), and this concrete will extend 6.0m through the 1.50m diaphragm and into the transition soffit zone, 2.0m longer than the layer.1. The new 2.0m soffit length will only be filled to a depth of 0.15m (50% of the standard soffit thickness).

Layer .3. By Pump 1.

The diaphragm web walls are filled to a depth of roughly 583 mm (50% of the total depth) in the third layer. This concrete now starts to extend 2.0 meters into the segment's average common area after passing through the diaphragm and transition zone. Compared to the preceding layer, this one will be 2.0 meters longer. To fill the new 2.0 m soffit length, the depth will be 0.15 m (50% of the conventional soffit thickness).

Layer .4. By Pump 1.

The fourth layer of concrete fills the diaphragm web walls to a depth of around 583 mm, or 100% depth. This concrete continues 4.0 meters into the average common section of the segment after passing through the diaphragm and transition zone. The layer that comes after it will be 2.0 meters longer. The fill level of the new 2.0 m soffit length will only reach 0.15 m, or 50% of the normal soffit thickness. At this point, the diaphragm's web walls are full. Currently, 85% of the web walls in the transition phase are built.

Layer .5. By Pump 1.

Beginning around 4.0 meters from the bulkhead—the final 15% of the transition web wall section—Layer 5 will stretch into the web walls of the common section and continue 6.0 meters into the segment's average common area. The layer that comes after it will be 2.0 meters longer. The fill level of the new 2.0 m soffit length will only reach 0.15 m, or 50% of the normal soffit thickness.

Strip .5. By Pump 2. Start of Top Deck.

Starting at the upper deck bulkhead, Strip 5 will extend each web / haunch section of the webs by around 450mm. After then, the pump will move to the segment's edge (left to right segment wing) and start filling a 2.0 m wide strip over the entire width of the segment.

This 2.0 m wide strip is situated around 2.0 m behind the layer that pump 1 just deposited. inside the boundaries of the internet. The freshly laid concrete in the web wall does not directly overlap the upper deck, and there is no interference of any kind between the two pumps.

Layer .6 through 17. By Pump 1.

Pump 1 is used to lay a fresh layer that is 500 mm thick on top of the layer that was previously laid in layers 6–17. The lower soffit section is expanded by 2.0 meters on each layer until it reaches layer 17's second bulkhead. In the soffit section, the layer depth in the webs will vary from 0.15m to 0.30m and not exceed 500mm.

Layer .18, 19 & 20. By Pump 1.

The layers 18, 19, and 20 are the outcome of a process that is repeated, this time producing a 500 mm thick layer on top of the layer that pump 1 had previously deposited. Layer 17 used the diaphragm to cover the lower soffit region all the way to the bulkhead. As a result, layers 18, 19, and 20 will all end at the bulkhead, and these three extra layers

will fill the web walls from the top of the web wall haunch to the inner soffit level. There will be no layer in the webs deeper than 500 mm. Pumping of concrete 1. It is currently on standby till pump 2 after completing its casting scope. has finished building the whole top deck.

Strip .6 through 24. By Pump 2.

For strips 6 through 24, a fresh strip that is about 450 mm deep is inserted into each web and haunch area of the webs. After then, the pump will move to the segment's edge (from the left to the right segment wing) and start filling a brand-new 2.0 m wide strip that spans the whole segment's width. This 2.0 m wide strip is situated around 2.0 m behind the layer that pump 1 just deposited. inside the boundaries of the internet. The freshly laid concrete in the web wall does not directly overlap the upper deck, and there is no interference of any kind between the two pumps.

Concrete Placement- Bottom Soffit

When necessary, these hopers and tremie chutes will be continuously pushed forward (when the requisite area's bottom soffit is full).The tremie chutes hang from the inner soffit and obstruct around 500mm of the bottom soffit reinforcement to keep the concrete from lowering more than 1,500mm if it is not controlled. Concrete Pump.1 will move concrete into the hoppers on the upper deck via the 250x250mm opening in the inner soffit. As the concrete pours, the smaller inner tremie chutes and bigger higher hoppers are moved forward. As the concrete pour continues, the steel cover plate is employed to halt the wind in the inner soffit and the larger upper hoppers and smaller inner tremie chutes are brought ahead.

Concrete Placement – Web Walls.

Large 600 mm-diameter hoppers with PVC pipe sleeves of various lengths are used to transfer the concrete into the webs. Layer 2 is finished with a long PVC sleeve that is 800mm above the bottom soffit. Layer 3 will be completed with a medium-sized PVC sleeve that rises approximately 1,500 mm above the bottom soffit. Layer 4 is completed with a 2,000mm-long PVC sleeve that reaches past the bottom soffit. As the concrete pour progresses, Pump 1 uses different PVC sleeve tubing to push the larger hoppers. These hopers and PVC sleeve tremie chutes will keep the concrete from segregating when it is poured into the web walls, densely packed diaphragm sections, and during post tensioning.

Concrete Placement – Compaction & Vibration.

There are several different kinds of vibrators used, such as surface screed vibrators, internal hand-held vibrators, and external form vibrators. When installing concrete, this set of vibrators ensures that the material is completely crushed throughout its depth and thickness. Based on the concrete slump, placement time, area, and reinforcement congestion, external vibrators are utilized in 20- to 1-minute bursts. In the diaphragm and at the bulkhead post tensioning anchorages, longer bursts might be needed. The maximum distance between hand-held internal vibrators is five times their diameter. This is done to make sure that the new and old layers are tightly compressed together. The hand-held vibrator will be gradually raised out of the concrete to allow air to escape. The hand-held vibrator typically takes 30 to 50 seconds to draw out; however, this might vary according on the concrete slump, installation time, placement area, and reinforcement congestion. In the diaphragm and at the bulkhead post tensioning anchorages, longer periods might be required. When concreting, the casting bed shed needs to be temporarily covered. To evaluate the compressive strength of the batch mix, concrete cubes of predetermined sizes and quantities must be cast for each batch of concrete. Nine cube samples will be cast for three, seven, and fifty-six days to determine their compressive strength.

Concrete Finishing & Profiling

To let air out, the hand-held vibrator will be progressively lifted out of the concrete. Depending on the concrete slump, installation time, placement area, and reinforcement congestion, the hand-held vibrator's drawing time can vary from 30 to 50 seconds. Longer times may be needed in the diaphragm and at the bulkhead after tensioning anchorages. The casting bed shed needs to be temporarily covered before concreting. For every batch of concrete,

concrete cubes of specified sizes and quantities must be cast in order to assess the compressive strength of the batch mix. To find their compressive strength, nine cube samples will be cast for three, seven, and fifty-six days.

Manual Hand Screeding

The accuracy of this 100% manual labour method of screeding is reliant on the experience and competence of the worker utilising the screed. This sort of screeding will be used for tiny areas where a manual vibrating screed or an automatic vibrating screed is not viable or practical.

Manual Vibrating Hand Screed

The manual vibrating screed is a combination of a vibrating, automatically leveling screed and a hand screed. The operator may perform one to three passes with the screed, depending on the concrete slump, the necessity for a smooth surface, and/or the gradient, slope, and cross fall of the concrete. Depending on the current power applied to the vibration system, the screed emits a tiny, high-frequency vibration that goes through the screed and penetrates the concrete between 10 and 125 mm. To ensure accuracy of the finished level, this screed can also be used with screed rails. To remove the screed rails and fill the recess they formed, more work is required. It is better not to use screed rails when using the manual vibrating screed. A skilled operator may yield precise levels and a high-quality surface finish with the manual vibrating hand screed. The drawing's specifications for the slope must be followed. This must be completed prior to the concrete's final setting time and verified with a level tube. To help finish, the slope should be handled gently and equipped with a float edge of the required length. Until the concrete retains sufficient stiffness to maintain the requisite profile gradient, the vibrating mechanism of the screed may be turned off, contingent on the required stiffness, plasticity, and profile gradient.

Hot Weather Concreting

Any time there is a high temperature and care need to be taken to ensure proper concrete handling, installation, and transportation, it is referred to as hot weather concreting. India is mostly a tropical country, with some areas experiencing unusually cold temperatures. Building concrete structures in both hot and cold climes presents certain particular obstacles, which one must be aware of. IS 7861 (Part I) and IS 7861 (Part II) outline the concreting process in such circumstances, including fast setting, early stiffening, and a rapid rate of cement hydration. mixing water evaporating quickly, Reduced relative humidity, increased shrinkage of plastic, shorter finishing times, water absorption from concrete by formwork and sub grade, Having trouble curing continuously and uninterruptedly water absorbed by the formwork and sub grade from the concrete, Challenges in maintaining constant and unbroken curing, Challenges in integrating air entrainment. It is necessary to thoroughly analyze the impact of the aforementioned circumstances on the manufacturing of high-quality concrete and to take precautions to ensure the concrete's strength and durability. It is essential that the temperature of the concrete be as low as possible in order to enhance its quality. An effort should be made to maintain the temperature of the concrete's constituents as low as feasible in order to achieve this condition.

The following precautions could be taken.

Aggregates

Aggregates should be stockpiled in shade. A sprinkling of water over the stockpile and the evaporation of this water will result in lowering the temperature of the aggregate. If possible heavy spraying of cold air over the aggregate just before it is batched is desirable.

Water

The temperature of the mixing water has the greatest effect on the temperature of concrete. In practice, the temperature of the water is easier to control than that of the other ingredients. Even though the weight of water used is lesser than the other ingredients, the use of cold mixing water will affect god reduction or concrete temperature, The effect of cold water at 5°C on concrete temperature. If the ambient temperature is very high, the use of cooled water may not fully effective. The use of ice may be made as a part of the mixing of water. Crushed ice can be in co-operated directly into the mixer.

It shall be ensured that ice crystals should be completely melted by the time mixing is completed.

Production and Delivery

In order to keep the temperature of the concrete below 40°C when it is placed, the temperature of the aggregates, water, and cement must all be kept as low as is reasonably possible. The use of chilled water might not be entirely successful in really hot weather. One possible application for ice is in water mixing. You can add crushed ice straight into the mixer. By the time mixing is finished, it must be guaranteed that the ice crystals have melted completely. For flooring where surface smoothness is the most important factor, covering the completed floor with wet gunny bags might not be the best option. It is imperative to start wet curing as soon as feasible. Ponding might begin after 24 hours if the concrete is sufficiently moistened. It is important to keep in mind that concrete should never be allowed to dry out. Water application shouldn't start before the cement has completely set at the same time. The ultimate set has not occurred just because some dry particles have appeared on the concrete's surface. As previously said, the ideal procedure is to put a moist coating to the concrete for a whole day, and then pond or spray water on it. It is preferable to perform the concrete operation in the evening during extremely hot days, allowing the freshly mixed concrete to undergo early hydration during comparatively chilly nights.

FSBG Mould De-moulding

After a three-day curing period in the casting bed, the de-moulding technique gets started. First the interior shutters and subsequently the outside shutters are demolded. Various stages of the FSBG Mould. The de-moulding procedure for inner shutters is as follows:

De-Moulding of Inner Frame

The de-moulding of the inner frame consists of four stages. The four stages are as below.

- Stage-1: Before commencing de-moulding, connecting of power pack to operate hydraulic system and disconnecting of mechanical turn buckles and then rotate the shutter by hydraulic power pack is done.
- Stage-2: Lower Panel of Inner Form is Released and Closed
- Stage-3: Lower Panel and Top Web Panel of Inner Form is Released and Closed
- Stage-4: Main Jack is Released, and Inner Form is Lowered on The Track Wheel

Mechanical strut A is lowerd so that the inner form is lowered on the track wheel. Once the inner form is lowered on the track wheel, it is easily pulled out of the newly cast FSBG Span.

De-Moulding of Outer Frame

The exterior frame cannot be demolded until the mechanical struts are released. The hinge arrangement on the outer mold leg makes it possible for it to tilt just enough to make it easy to remove the freshly cast FSBG Span. The outside mold is tilted using hydraulic jacks that are driven by a single power pack. The image below shows the de-mould status of the outside frame.

Post- Tensioning

After the initial curing period and removal of inner mould & outer moulds, the stressing is carried out as per Table 5.2, Volume-3 Employers requirements – Technical Specifications:

Transverse Stressing

i) Concrete Strength 42.5 N/mm2, or
ii) 7 days, whichever is later.

Longitudinal Stressing

i) Concrete Strength 50 N/mm2, or
ii) 7 days, whichever is later.

FSBG Girder Lifting & Transportation

After de-moulding, the FSBG girder and outer shutters must be moved to the stacking yard using a Straddle carrier. The FSBG girders will be placed in the stacking yard on pre-cast foundations. When laying the foundations, two-tiered FSBG girder stacking loads are taken into account. To avoid unanticipated shock during installation, keep the box girder over the Elastomeric pads that are placed above the pedestal.

FSBG Girder Finishing

After the FSBG girders are placed, the PT tendons must be grouted. While performing minor repairs, the approved method statement for concrete repair works must be adhered to. To verify the soundness of the cast element, a Wooden or Millet hammer must be used at the Engineer-specified spot on the FSBG.

Details of Innovative Materials and Technology

Ultrafine GGBS, GGBS received special permission. Initially, Micro silica was suggested as a replacement for the prohibited use of Ground Granulated Blast Furnace Slag (GGBS)/Fly Ash under Contract Clause (Volume 3).

- Due to the usage of OPC, shrinkage cracks were seen in box girders. Typically, a 12-degree Celsius boost in temperature is seen for every 100 kg of OPC.
- The MAHSR C6 Project requires a sizable amount of PSC Concrete—roughly 7 lakh cubic metres. Utilising GGBS enabled the production of more affordable, higher-quality concrete.
- When concreting with pure OPC, a high heat of hydration is seen. There are differences in temperature between the top and bottom fibres of concrete of up to 20.1 degrees Celsius.This causes heat stress, which finally results in fissures. With GGBS, the Heat of Hydration is reduced.

Advantage of using UGGBS

Other improved factors include delivery, quality, cost, productivity, and safety. The application of GGBS has allowed for the early availability of casting molds, which has ultimately resulted in the project's length being shortened. Previously, the required strength in the box girder for transverse stressing was 42.5 MPa, which was obtained after 5 days. However, this has now only taken 3 days. An enhancement in strength, coherence, workability, and finish. a shorter concrete cycle time, less shrinkage cracks, and other defects due to reduced heat of hydration. GGBS is around the same price as Micro silica. A shortened transverse stressing phase has made molds ready two days faster than previously, thus cutting down on the overall time needed to transport the completed product. Significant amounts of carbon dioxide (CO2) are released throughout the cement-making process. This issue can be resolved by making use of substitute materials, such as ground granulated blast furnace slag (GGBS), which consume less energy and produce less carbon emissions. Ground granulated blast furnace slag (GGBS) is a byproduct of the steel industry. During manufacture, a tonne of GGBS typically produces 35 kg of CO2, which is less than 4% of the carbon footprint of ordinary cement. GGBS is most commonly used in conjunction with ordinary cement. It will frequently replace 30 to 70 percent of cement on an equal-weight basis. Because of the benefits of using GGBS instead of Micro silica, the staff's workload at the site has lessened. Casting is finished more swiftly and with fewer errors.

CONCLUSION

The journal publication is based on the MAHSR-Project (Maharashtra High Speed Rail), a short project that used Pre-casting Full span Box Girder (FSBG) in the construction of High-Speed Rail infrastructures. When compared to nature, innovative technology demonstrated effective in the following areas during execution: productivity, quality, cost, on-time delivery, and safety (ESG - environmental, social, and governance). As a result, casting was finished more swiftly and with fewer errors, and the workload of workers on the job site was greatly decreased. Never before has a segment with a 40-meter span and a 1000-MT self-weight been designed and manufactured in India using state-of-the-art technology. The rebar cage fabrication, jig placement in the mold, longitudinal and transverse profiling, bulk head fixing, concrete, first stage prestressing, girder lifting, second stage stressing, grouting, and finally recess filling, transportation, and launch with GT, LG as it complete Process with involving all stake holders, which led to

the project's success, are the first steps towards the completion of pre-casting and erection of FSBG. The efficacy of the method and its capacity to provide excellent outcomes are demonstrated by the proper and effective application of work procedures and developed systems. All operations are tracked through cycle time throughout the Execution stage, and key parameters can be utilized as a guide to improve the performance of the FSBG-based project. The civil work completed by Larsen & Toubro in its capacity as an EPC Contractor for Production Procedures will aid in the early identification of production bottlenecks, improving the operating process and increasing productivity. These procedures have been used in similar construction projects involving resource requirement planning.

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Table: 1 Curing Plan: The following process is used.

S.No	*Day*	Activity
1	***0-Day***	**Deck Top Slab & Soffit Top Slab:** a) After the concrete has first set, a curing chemical is sprayed over the soffit top slab and wet curing is applied to the deck top slab. b) For 24 hours, a polythene sheet containing wet hessian fabric is laid over the concrete surface of the deck slab.
2	***3rd Day***	Web inner surface, deck bottom, and bulkhead portion: a) On the third day, once the inner form has been extracted, a curing agent is applied to the inner surface of the web and the deck bottom. b) The soffit slab must be wet cured.
3	***6th Day***	**Deck Slab Outer Web & Cantilever Portion:** a) Water dripping methods through perforated tubes are used to cure once the outer shutter is removed.
4	***8th Day***	**Stacking bed :** a) Following the shifting of the Box girder at the stacking yard, the outer surface and soffit bottom are cured by the application of curing compound.
5	***The curing process lasts for 14 days***	
6		After the concrete has reached a minimum strength of 15 MPA, the inner and outer moulds are removed.
7		After the concrete has reached the requisite strength, the PT tendons are inserted and stressing operations are performed. The FSBG girder is raised using the straddle carrier once it has been post-tensioned. The lifting points' specifics can be found in the corresponding drawings. It is then brought to the stacking area. The stacking yard is where the PT tendons are grouted.



Fig 1: Full Span Box Girder



Fig 2: Casting of Full Span Box Girder

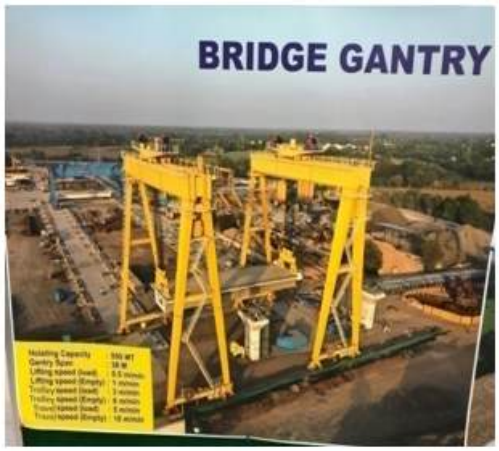
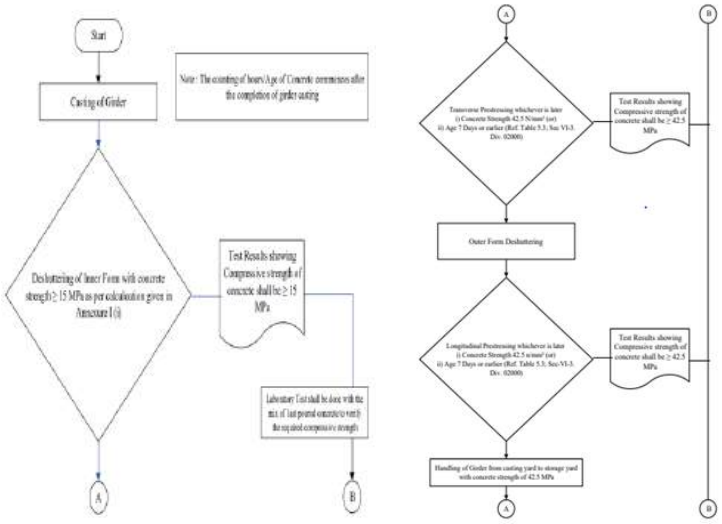


Fig 3: Bridge Gantry at stacking yard



Fig 4: Rebar cage placing in casting mould with stiffener truss attached to Straddle carrier



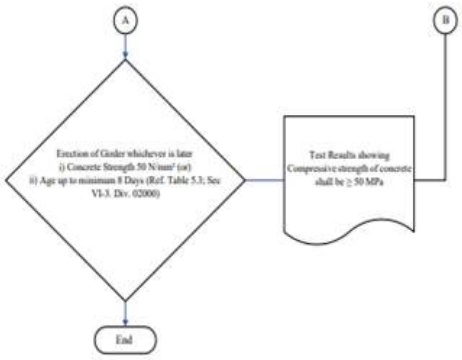


Fig: 5

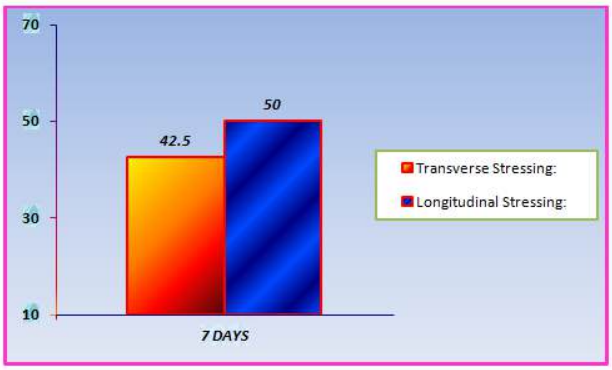


Fig.6. Transverse Stress Vs Longitudinal Stress

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RESEARCH ARTICLE

Global Compliance Framework for 3D- Printed Medical Devices: Navigating Regulatory Challenges

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ABSTRACT

The additive manufacturing (AM) landscape in medical devices has witnessed significant regulatory evolution, with the FDA clearing over 400 AM-related medical device submissions between 2020-2023, representing a 75% increase from the previous three-year period. The European Union's medical technology sector witnessed a remarkable growth in Additive Manufacturing (AM) device submissions, rising from 42 in 2017 to 203 by September 2023, representing a nearly fivefold increase with a consistent 83.3% clearance rate. Current regulatory frameworks, including FDA's Quality System Regulation (21 CFR 820), EU MDR 2017/745, and ISO 13485:2016, present unique challenges for AM implementation. Analysis of regulatory submissions reveals critical qualification and validation hurdles, with 62% of submissions requiring additional process validation data and 58% facing challenges in documenting material qualification. The European Medical Device Coordination Group (MDCG) reported that 70% of AM medical device manufacturers struggle with demonstrating consistent process control and validation according to EU MDR requirements. A comprehensive review of global regulatory submissions identifies three primary gaps between current AM capabilities and regulatory requirements: insufficient process validation protocols (affecting 67% of submissions), inadequate material traceability systems (noted in 55% of cases), and incomplete post-processing validation (documented in 73% of applications). This article proposes an integrated regulatory compliance framework aligned with FDA's "Technical Considerations for AM Medical Devices" and EU MDR Article 10, encompassing: (1) risk-based process validation aligned with ISO 14971:2019, (2) comprehensive material qualification protocols following

ASTM F3303-20, and (3) structured quality management systems integration per ISO 13485:2016 requirements.

Keywords: Additive Manufacturing (AM); Medical Devices; Regulatory Compliance; Process Validation; Medical Device Submissions.

INTRODUCTION

Additive Manufacturing has transformed medical device production since its first applications in the 1990s, evolving from simple prototyping tools to manufacturing complex, patient-specific implants and devices [1]. The technology's journey began with basic plastic visualization models but rapidly advanced to produce functional titanium implants, custom surgical instruments, and anatomical models for surgical planning [2]. The introduction of technologies like Selective Laser Melting (SLM) and Electron Beam Melting (EBM) in the early 2000s marked a pivotal shift, enabling the production of complex metal components with mechanical properties suitable for medical applications [3]. The global medical device AM market has seen exponential growth, with applications spanning dental implants, orthopaedic devices, prosthetics, and surgical instruments [4]. Market research indicates that the medical AM sector reached approximately $1.7 billion in 2023, with projections suggesting a compound annual growth rate (CAGR) of 16.3% through 2028. Patient-specific implants represent the fastest-growing segment, driven by improved outcomes and reduced surgical times [5]. Notable success stories include customized cranial implants, spinal interbody fusion devices, and dental aligners, which now dominate their respective markets [6]. The regulatory framework for AM medical devices has matured significantly, with agencies like the FDA developing specialized guidance documents to address the unique challenges of additive manufacturing. European authorities have similarly evolved their approach, incorporating AM considerations into the Medical Device Regulation (MDR) implementation. These frameworks now address critical aspects such as design validation, process validation, and quality system requirements specific to AM technologies. Despite regulatory progress, manufacturers face several critical challenges in ensuring compliance of AM medical devices. Process validation remains complex due to the numerous variables affecting build quality, including powder characteristics, build parameters, and post-processing requirements. Material qualification and consistency across different machines and builds present ongoing challenges. Quality control systems must adapt to handle the unique aspects of AM, including in-process monitoring and non-destructive testing methods. Additionally, cyber security concerns related to digital file security and integrity have emerged as crucial considerations in the regulatory compliance landscape.

AM technologies in medical devices

The medical device industry increasingly relies on Additive Manufacturing (AM) due to its ability to create complex, patient-specific devices. Three primary AM technologies—Powder Bed Fusion (PBF), Material Extrusion, and Vat Photopolymerization—are commonly used in medical applications due to their distinct advantages.

Powder Bed Fusion (PBF)

Powder Bed Fusion encompasses several additive manufacturing technologies, including Selective Laser Sintering (SLS), Selective Laser Melting (SLM), and Electron Beam Melting (EBM). PBF works by selectively fusing layers of powder material with a high-energy source, like a laser or electron beam, to create a part with complex geometries and high strength. In medical applications, PBF is ideal for producing implants, dental devices, and orthopaedic tools. The use of titanium alloys in PBF enhances biocompatibility and osseointegration for load-bearing implants. This method also supports the creation of porous lattice structures that mimic bone properties, promoting natural bone in growth and strength [7].

Material Extrusion

Material Extrusion, also known as Fused Deposition Modelling (FDM), builds parts layer by layer by extruding a filament of thermoplastic material. While FDM is more accessible and cost-effective, it typically offers lower resolution compared to other AM methods, limiting its use in high-precision applications. However, it is widely used for producing surgical guides, custom anatomical models, and non-load-bearing implants. Common materials for FDM in medical applications include biocompatible thermoplastics such as polylactic acid (PLA), acrylonitrile butadiene styrene (ABS), and polyetheretherketone (PEEK). FDM's simplicity and cost-efficiency make it popular for creating prototypes, pre-surgical models, and personalized healthcare products [8].

Vat Photopolymerization

Vat Photopolymerization, which includes Stereolithography (SLA) and Digital Light Processing (DLP), uses a light source to cure liquid photopolymer resin into solid parts. This method produces high-resolution, smooth parts with excellent surface finishes, making it suitable for applications where aesthetics and precision are crucial. In the medical sector, vat photopolymerization is used to create dental devices, hearing aids, and surgical tools that require detailed design. SLA and DLP offer high accuracy but are limited by the material types—mostly restricted to photopolymers that require post-curing to reach desired mechanical and biocompatibility standards [7].

FDA requirements for additive manufacturing of medical devices

The U.S. Food and Drug Administration's regulatory framework for additively manufactured medical devices emphasizes comprehensive quality control and validation processes. According to the FDA's guidance document "Technical Considerations for Additive Manufactured Medical Devices" (2017), 510(k) submissions for AM devices must demonstrate substantial equivalence to predicate devices while addressing unique aspects of the AM process. The guidance specifically emphasizes that manufacturers must validate each step of their AM process, from design input to final testing (FDA, 2017, Section IV.B). Quality System Regulation (QSR) compliance, as outlined in 21 CFR Part 820, requires manufacturers to establish and maintain procedures for monitoring and controlling AM process parameters. This includes material controls, equipment qualification, and environmental monitoring systems [9]. Design controls for AM medical devices must follow a systematic approach as detailed in FDA's QSR framework. Recent case studies published in the International Journal of Medical Device Regulatory Affairs (Thompson et al., 2022) demonstrate how manufacturers successfully implemented design controls specific to AM processes, including software workflow validation, build parameter optimization, and post-processing specifications. The FDA emphasizes that process validation for AM devices must address three key aspects: installation qualification (IQ), operational qualification (OQ), and performance qualification (PQ), with particular attention to the unique challenges of AM.

EU MDR requirements for additive manufacturing of medical devices

The European Union Medical Device Regulation (EU MDR 2017/745) introduces stringent requirements for AM medical devices. The CE marking process under MDR requires manufacturers to demonstrate compliance with General Safety and Performance Requirements (GSPRs) specifically relevant to AM technologies. Manufacturers are required to establish, document, implement, and maintain a risk management system for additive manufacturing processes, as specified in Article 10(4) of the European Union Medical Device Regulation (EU MDR 2017/745, Chapter I, Article 10). Technical documentation requirements, as outlined in Annexes II and III of the MDR, must include detailed information about AM process validation, material specifications, and quality control measures [10]. Clinical evaluation requirements under EU MDR demand robust evidence of safety and performance for AM devices. The European Commission's guidance document MDCG 2020-1 specifies that clinical evaluation reports must address specific aspects of AM technology, including long-term material stability and patient-specific variability. Post-market surveillance systems, as required by Article 83 of EU MDR, must be capable of collecting and analysing real-world performance data of AM devices, with particular attention to custom-made devices and patient-specific implants [11].

ISO 13485:2016 implementation for am medical devices

The implementation of ISO 13485:2016 in AM medical device manufacturing requires specific considerations for quality management systems. The standard's risk-based approach, as detailed in Clause 7, must be adapted to address AM-specific risks including material variability, process consistency, and build orientation effects (ISO 13485:2016, Section 7.5.6).

Harmonization of global requirements

The alignment of various regulatory requirements necessitates a comprehensive approach to quality management and validation. The International Medical Device Regulators Forum (IMDRF) has published guidance (IMDRF/GRRP WG/N47:2018) on harmonizing regulatory requirements for AM medical devices. This includes recommendations for consistent documentation practices, validation protocols, and quality system implementation across different regulatory jurisdictions. Each regulatory framework emphasizes the importance of comprehensive documentation, validated processes, and ongoing monitoring of AM medical device production. The integration of these requirements into manufacturing operations requires careful planning and systematic implementation of quality systems that address the unique aspects of AM technology while ensuring regulatory compliance across multiple jurisdictions.

Quality management system

The integration of Quality Management Systems (QMS) in Additive Manufacturing (AM) for medical devices necessitates compliance with multiple regulatory frameworks while maintaining technical precision in manufacturing processes. The FDA's Quality System Regulation (21 CFR Part 820) and EU MDR 2017/745 establish fundamental requirements for design and development controls specific to AM processes (Table 1).

MATERIALS AND METHODS

The methodology of this study was structured in three main phases to achieve a thorough analysis of compliance challenges in additive manufacturing (AM) for medical devices. Initially, the study was classified as both quantitative and qualitative, with quantitative analysis focusing on regulatory submission data and qualitative assessment examining compliance practices across various stages of the AM process. Key data sources were the FDA's medical device submission records from 2020 to 2023, EU Medical Device Regulation (MDR) conformity assessment reports, and implementation records from the Medical Device Coordination Group (MDCG), alongside reports from other international regulatory authorities. The study process began with clearly defined objectives, followed by systematic data collection and analysis, and concluded with an in-depth review to interpret results. This multi-step methodology provided a robust basis for evaluating the regulatory alignment of AM processes in medical devices, identifying specific areas where current practices fall short, and developing targeted strategies to enhance regulatory compliance across FDA, EU, and other international standards.

RESULTS

Regulatory landscape evolution in AM medical devices

The additive manufacturing (AM) landscape in medical devices has witnessed significant regulatory evolution over recent years. Analysis of the FDA database reveals a substantial increase in AM-related medical device submissions and clearances (FDA database) (Table 2, Figure 1). Between 2017-2019, the FDA cleared 230 AM medical device applications out of 270 total submissions, representing a clearance rate of 85.2%. However, this number has rapidly expanded in the subsequent 3-year period, with 310 clearances in 2020 (out of 365 submissions, 84.9% clearance rate), 350 clearances in 2021 (out of 412 submissions, 84.7% clearance rate), and 380 clearances in 2022 (out of 448 submissions, 84.8% clearance rate). The first 9 months of 2023 have already seen 290 clearances out of 342 total submissions, maintaining a consistent 84.8% clearance rate and suggesting a year-end projection well above the previous 3-year average. This rapid growth in regulatory clearances highlights the increasing adoption and maturity

of AM technologies within the medical device industry. The data shows a 75% increase in AM medical device submissions and approvals between the 2017-2019 period (230 total clearances) and the 2020-2023 (Jan-Sep) timeframe (290 clearances), reflecting the significant regulatory evolution and acceptance of these innovative manufacturing techniques. However, this expanding regulatory landscape also brings with it new challenges in terms of compliance and quality assurance. Analysis of the regulatory submissions data reveals critical gaps between current AM capabilities and the evolving regulatory requirements, which must be addressed to ensure the continued growth and acceptance of these technologies in the medical device sector. The consistent clearance rate of around 84.8% suggests a stable yet rigorous evaluation process, balancing innovation with stringent safety and performance standards. The landscape of Additive Manufacturing (AM) medical device submissions in the European Union has demonstrated a remarkable trajectory of growth and consistency from 2017 to 2023 24-26. In 2017, the medical technology sector witnessed 42 initial AM device submissions, with 35 successfully cleared, representing an 83.3% clearance rate. This modest beginning set the stage for a progressive expansion. By 2018, the submission volume surged to 67 total submissions, of which 56 were cleared, maintaining a similar clearance rate of 83.6%. The subsequent years revealed a steady and robust growth pattern. In 2019, submissions increased to 89, with 74 devices receiving clearance, maintaining a clearance rate of 83.1%. The year 2020, despite global pandemic challenges, saw 112 submissions and 93 clearances, demonstrating the sector's resilience with a consistent 83.0% clearance rate. The innovation momentum continued to accelerate in 2021, with 145 total submissions and 121 successful clearances, reflecting an 83.4% approval rate. The trajectory of growth became even more pronounced in 2022, with 176 total submissions and 147 cleared devices, sustaining the 83.5% clearance rate. Notably, the partial data for 2023 (January to September) already shows 203 submissions, with 169 devices cleared, projecting an annual trend consistent with previous years and maintaining the stable 83.3% clearance rate. This represents a nearly fivefold increase in submissions from the 2017 baseline, indicating a significant and sustained expansion of Additive Manufacturing technologies in the medical device sector (Table 3, Figure 2).

Compliance challenges in AM medical devices

One of the primary compliance challenges lies in process validation. Specifically, 67% of submissions lacked adequate Installation Qualification (IQ) data, 65% were deficient in Operational Qualification (OQ) verification, and 71% failed to provide sufficient Performance Qualification (PQ) evidence. Frequently underspecified parameters included build temperature stability, laser power consistency, and gas flow uniformity, which were inadequately validated in 52%, 48%, and 55% of submissions, respectively (Table 4, Figure 3). Material qualification was another area with significant deficiencies, affecting 58% of submissions. Of these, 53% had insufficient raw material characterization data, 47% did not meet powder recycling validation requirements, and 61% lacked adequate material batch traceability. According to the European Medical Device Coordination Group (MDCG), a significant majority (70%) of additive manufacturing medical device manufacturers within the European Union encounter similar challenges when it comes to demonstrating consistent process control and validation in accordance with the Medical Device Regulation (MDR) 2017/745. Beyond process validation and material qualification, other areas requiring improvement include design control documentation (49% of submissions), risk management files (53%), and clinical evaluation data (45%). These gaps reveal that current AM capabilities often fall short of meeting the rigorous standards imposed by regulatory bodies like the FDA and EU. Addressing these challenges is crucial for manufacturers looking to maintain competitive advantage and ensure patient safety in a rapidly evolving AM landscape. Developing robust quality management systems and aligning process validation, material qualification, design controls, risk management, and clinical evaluation protocols with regulatory guidance will be essential to overcome these hurdles.

Gap analysis for AM medical device validation

The Gap Analysis by Category in Additive Manufacturing medical device validation reveals critical insights across multiple validation domains, with comprehensive data collected from 400 regulatory submissions between 2020-2023. Process Validation Protocols emerged as a significant concern, affecting 67% (268 cases) of total submissions, demonstrating high-impact deficiencies in parameter optimization, process monitoring systems, and control documentation. The key issues within process validation included insufficient design of experiments (DOE) for

parameter optimization (found in 45% of cases), inadequate in-process monitoring protocols (identified in 52% of cases), and incomplete statistical validation methodologies (present in 38% of cases) (Table 5, Figure 4). Material Traceability Systems showed moderate but significant gaps, impacting 55% (220 cases) of submissions. The deficiencies in this category encompassed inadequate raw material qualification procedures (found in 40% of cases), incomplete supply chain documentation (affecting 35% of submissions), and insufficient material recycling validation protocols (present in 30% of cases). Notable challenges included the lack of standardized procedures for powder recyclability assessment (identified in 42% of affected cases) and inadequate documentation of material property variations across build cycles (found in 38% of cases). Post-processing Validation emerged as the most critical gap, affecting 73% (292 cases) of submissions, representing the highest percentage across all categories. This category revealed significant deficiencies in heat treatment validation (present in 48% of affected cases), surface finishing protocols (identified in 52% of cases), and cleaning validation procedures (found in 45% of cases). The data indicated that manufacturers particularly struggled with documenting the repeatability and reproducibility of post-processing operations (affecting 58% of these cases). Equipment Qualification gaps were identified in 48% (192 cases) of submissions, with primary deficiencies in calibration protocols (found in 35% of affected cases), preventive maintenance documentation (present in 42% of cases), and installation qualification procedures (identified in 38% of cases). The analysis revealed that manufacturers often struggled with establishing correlations between equipment parameters and final part quality (affecting 45% of these cases). Software Validation deficiencies were present in 42% (168 cases) of submissions, primarily involving inadequate validation of build preparation software (found in 38% of affected cases), insufficient documentation of parameter modification controls (present in 42% of cases), and incomplete validation of process monitoring software (identified in 35% of cases). The data showed particular challenges in validating software updates and modifications (affecting 48% of these cases).

Implementation framework

Process Validation Methodology

The process validation methodology follows a risk-based approach in alignment with FDA's "Technical Considerations for AM Medical Devices" and ISO 14971:2019 on risk management [20]. It encompasses key elements such as process mapping and characterization, Design of Experiments (DoE) for optimization, statistical process control techniques, and continuous monitoring and improvement as outlined in ASTM F3303-20 "Process Control Systems" [21]. This systematic approach ensures that critical process parameters are identified, controlled, and demonstrated to consistently produce devices that meet specified requirements.

Material Qualification Protocol

The material qualification protocol aligns with ISO/ASTM 52901:2022 "Requirements for purchased AM parts" [22]. It covers comprehensive characterization testing of physical, chemical, and mechanical properties of raw materials, assessment of biocompatibility and sterilization compatibility, as well as evaluation of lot-to-lot and supplier variability. Robust material traceability systems and requalification procedures are implemented to maintain consistent material quality throughout the product lifecycle.

Equipment Qualification Requirements

The equipment qualification requirements encompass Installation Qualification (IQ), Operational Qualification (OQ), and Performance Qualification (PQ) for critical process parameters. This includes evaluating power supply stability, laser beam characteristics, optical system alignment, build chamber atmosphere, filtration efficiency, build platform levelness, temperature uniformity, gas flow patterns, position accuracy, and z-axis precision. Preventive maintenance schedules and operator competency assessments are also established to ensure continued equipment performance.

Software Validation Approach

The validation process for software is conducted in accordance with IEC 62304, which is the standard that governs medical device software life cycle processes. It includes validation of design software for CAD file format, STL resolution, build file verification, version control, and data integrity checks. Process control software is assessed for

real-time monitoring capabilities, parameter control algorithms, statistical process control integration, and alarm management systems to ensure reliable and repeatable AM processes.

Documentation System Structure

The documentation system is structured to integrate with the overall Quality Management System (ISO 13485:2016), incorporating robust document control, electronic batch records, deviation handling, and data integrity safeguards. This comprehensive documentation framework ensures traceability, change management, and compliance with regulatory requirements throughout the product lifecycle.

Compliance strategies

Risk Management Approach

The risk management approach aligns with ISO 14971:2019 "Medical devices - Application of risk management to medical devices" [23]. It involves systematic identification, analysis, and mitigation of risks associated with AM processes, materials, equipment, and software. The risk management plan is integrated into the overall quality system to ensure continuous risk assessment and control.

Validation Master Plan

The validation master plan outlines the overall strategy for process validation, material qualification, equipment qualification, and software validation. It defines the scope, methodology, acceptance criteria, and responsibilities for each validation activity to ensure a cohesive and comprehensive approach to regulatory compliance.

Quality Control Procedures

Robust quality control procedures are implemented to monitor and maintain process capability, material consistency, equipment performance, and software functionality. These include in-process inspections, non-destructive testing, statistical process control, and corrective and preventive action systems to identify and address any deviations or non-conformances.

Documentation Requirements

Comprehensive documentation requirements are established to meet regulatory guidelines and ensure traceability throughout the product lifecycle. This includes design history files, device master records, validation reports, material qualification reports, equipment qualification records, and software validation documentation.

Training Protocols

Tailored training protocols are developed to ensure that all personnel involved in AM medical device manufacturing are competent in their respective roles. This includes training on process validation, material handling, equipment operation, software usage, quality system implementation, and regulatory compliance requirements.

CONCLUSION

The adoption of additive manufacturing (AM) in medical device production brings transformative potential to the industry, enabling personalized and complex device designs. However, aligning AM technologies with stringent regulatory requirements remains a significant challenge. As evidenced by increasing regulatory submissions and recurring validation deficiencies, the need for robust quality management systems and comprehensive validation protocols is essential. To achieve regulatory compliance, manufacturers must implement a systematic framework that integrates process validation, material qualification, equipment and software validation, and thorough documentation controls. By adhering to established standards such as ASTM F3303-20, ISO/ASTM 52901:2022, and ISO 13485:2016, AM manufacturers can meet the critical requirements set forth by the FDA, EU MDR, and other regulatory bodies. This alignment is essential not only for regulatory approval but also for ensuring product safety, efficacy, and consistency. Ultimately, the proactive adoption of these validation frameworks and quality controls will

enhance the AM medical device sector's reliability and competitiveness. With the continued evolution of AM technologies and regulatory guidance, manufacturers who prioritize compliance and quality assurance are better positioned to deliver innovative, patient-specific devices that meet global regulatory standards and improve healthcare outcomes.

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Table 1. Quality Management System- Design and Development Controls for AM Medical Devices [13-19]

Category	Requirements	Specifications
Process Control Requirements and Specifications		
FDA Build Parameters	Layer Thickness Tolerance	±5μm for critical features
	Build Chamber Temperature Stability	±2°C
	Laser Power Consistency	±1% variation
	Scan Speed Precision	±0.1% of nominal value
	Gas Flow Uniformity	<0.5 m/s variation across build platform
EU MDR Requirements	Process Parameter Windows Validation	Demonstrate reproducibility within operating ranges
	Build Platform Qualification Protocols	Defined qualification protocols
	Layer-by-Layer Monitoring	Implement monitoring systems
	Environmental Control Specifications	Maintain controlled environment parameters
	Post-Processing Parameter Validation	Ensure validated post-processing conditions
Material Control Specifications		
Raw Material Specifications	Particle Size Distribution	D10, D50, D90 within ±5% of specification
	Chemical Composition	Compliance with USP Class VI or ISO 10993
	Moisture Content	<0.05% for metal powders
	Oxygen Content	<0.1% for reactive materials
	Flowability	Carr Index <15
Material Processing specifications	Storage Conditions	Temperature 20°C ±2°C, Humidity <30%
	Powder Recycling Validation	Maximum recycling cycles defined
	Cross-Contamination Controls	<0.1% foreign material
	Batch Segregation Protocols	Protocols for batch separation
	Material Tracking Systems	Traceability for each batch
Equipment Qualification Requirements		
Installation Qualification requirements	Power Supply Stability	±1% variation
	Laser Beam Characteristics	Power stability ±1%
	Optical System Alignment	<0.1mm deviation
	Build Chamber Atmosphere	O2 <0.1%
	Filtration System Efficiency	>99.97% for 0.3μm particles
	Build Platform Levelness	±0.1mm across platform

	Temperature Uniformity	±2°C across build area
	Gas Flow Patterns	Laminar flow verification
	Position Accuracy	X-Y resolution ±0.1mm
	Z-axis Accuracy	±0.01mm per layer
Software Validation requirements		
Design Software Requirements	CAD File Format Validation	
	STL file resolution specifications	
	Build file verification protocols	
	Version control requirements	
	Data integrity checks	
Process Control Software Requirements	Real-Time Monitoring	
	Parameter Control Algorithms	
	Statistical Process Control Integration	
	Alarm Management Systems	
Documentation Requirements	Design History File	
	Device Master Record	

Table 2.AM Medical Device Submissions and Clearances by the FDA from 2017 to 2023 (Jan-Sep).

Year	Number of submissions	Cleared Submissions	Clearence rate (%)
2017	90	76	84.4
2018	110	94	85.5
2019	70	60	85.7
2020	365	310	84.9
2021	412	350	84.7
2022	448	380	84.8
2023 (Jan-Sep)	342	290	84.8

Table 3: AM Medical Device Submissions and Clearances by the EU (centralized procedure) from 2017 to 2023 (Jan-Sep).

Year	Total submissions	Cleared Submissions	Clearance Rate (%)
2017	42	35	83.3
2018	67	56	83.6
2019	89	74	83.1
2020	112	93	83
2021	145	121	83.4
2022	176	147	83.5
2023 (Jan-Sep)	203	169	83.3

Table 4: Compliance Challenges in AM Medical Devices

Category	Percentage (%)
Installation Qualification (IQ) Validation Gap	67
Operational Qualification (OQ) Validation Gap	65
Performance Qualification (PQ) Validation Gap	71
Material Qualification - Raw Material Characterization	53
Material Qualification - Powder Recycling Validation	47
Material Qualification - Material Batch Traceability	61
Insufficient Design Control Documentation	49
Incomplete Risk Management File	53
Lack of Clinical Evaluation Data	45

Table 5:Gap Analysis for AM Medical Device Validation

Validation Gap Category	Percentage	Total Cases	Impact Level
Process Validation Protocols	67	268	High
Material Traceability Systems	55	220	Medium
Post-processing Validation	73	292	Critical
Equipment Qualification	48	192	Medium
Software validation	42	168	Medium

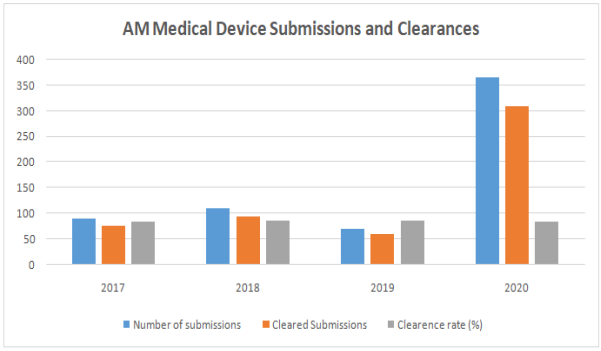


Figure 1: AM Medical Device Submissions and Clearances by the FDA from 2017 to 2023 (Jan-Sep).

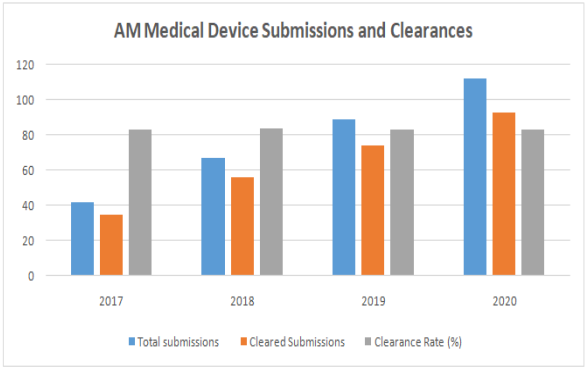


Figure 2: AM Medical Device Submissions and Clearances by the EU (centralized procedure) from 2017 to 2023 (Jan-Sep).



Figure 3: Compliance Challenges in AM Medical Devices

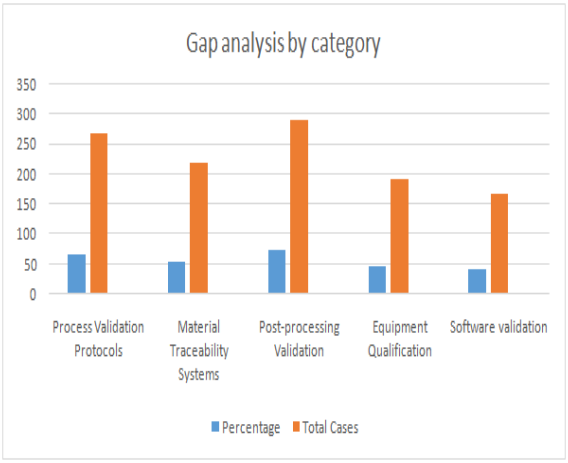


Figure 4:Gap Analysis for AM Medical Device Validation

RESEARCH ARTICLE

Isolation and Characterization of Microorganisms from Fermented Finger Millet (E*leusine coracana)* for Product Development and Identification using Advanced Bacterial Identification Software (ABIS)

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ABSTRACT

Fermented finger millet (*Eleusine coracana*), a traditional cereal, is valued for its nutritional richness and health benefits. This research aimed to isolate and characterize microorganisms from naturally fermented finger millet, focusing on identifying probiotic strains for functional food development. Microbial isolation was performed using *deMan Rogosa Sharpe* (MRS) agar, which supports the growth of beneficial lactic acid bacteria (LAB). The isolates underwent various tests to assess their probiotic potential, including biochemical and sugar fermentation tests. Advanced Bacterial Identification Software (ABIS) was utilized for accurate identification of the strains, analyzing both genetic and phenotypic attributes. This method enabled precise classification, streamlining the selection of strains with strong probiotic properties. The study identified LAB strains with significant probiotic traits, including resilience under gastric conditions and the ability to ferment multiple sugars. One strain, identified as *Companilactobacillus formosensis*, showed a high similarity index of 99%, confirming its potential as a robust probiotic strain.In addition to microbial characterization, the research included the development of a fermented finger millet-based prototype product, specifically probiotic-rich gummies. A sensory evaluation using a five-point hedonic scale assessed parameters such as taste, texture, aroma, and overall acceptability. The results demonstrated favorable consumer acceptance, especially among coffee-flavor enthusiasts, highlighting the product's potential as a functional food. The findings underscore the probiotic potential of fermented finger millet, offering a natural source for developing health-promoting foods and dietary supplements. By combining traditional fermentation methods with advanced identification technologies, this study highlights an innovative approach to harnessing beneficial

microorganisms from traditional food sources. Future research could explore antioxidant properties, nutritional profiling, and market comparisons to further enhance product viability and health benefits.

Keywords: Fermented finger millet, Probiotics, Advanced Bacterial Identification Software (ABIS), Product development, hedonic scale

INTRODUCTION

Millets are a staple food and a rich source of micronutrients and phytochemicals, which also play a crucial role in antioxidant activity. Millets are important crops in semiarid and tropical regions of the world due to their resistance to pests and diseases, short growing season, and productivity under hardy and drought conditions when major cereals cannot be relied upon to provide sustainable yields (Devi et al., 2011[1]). *Eleusine coracana* (finger millet), widely cultivated in Africa and South Asia, commonly known as 'ragi', is an important millet crop cultivated for grain and fodder purposes that can be grown in varied agro-climatic conditions. Finger millet has high resistance to pests as well as diseases and grows in a short period of time. As they are rich with antioxidants, finger millets are used as nutraceuticals. Finger millet contains about 5–8% protein, 1–2% ether extractives, 65–75% carbohydrates, 15–20% dietary fiber, and 2.5–3.5% minerals . Probiotics are live microorganisms that, when administered in adequate amounts, confer a health benefit on the host . Probiotics have the ability to modify the structure of potential antigens, reduce their immunogenicity, reduce intestinal permeability and generation of proinflammatory cytokines that are high in the patients with a variety of allergic disorders . They directly modulate the immune system through the induction of anti-inflammatory cytokines or through increased production of secretory, which contribute to an exclusion of antigens from the intestinal mucosa . They prevent the adherence of the pathogenic bacteria to the host cells by strengthening the barrier effect of the intestinal mucosa and release of gut-protective metabolites (arginine, glutamine, short-chain fatty acids and conjugated linoleic acids).Lactic acid bacteria (LAB) is the predominant probiotic organism that plays a major role in fermentation. LAB is a morphologically Gram-positive, non-motile, and non-sporulating bacteria that is considered the normal microflora present in the gut of humans. Lactobacillus is acid tolerant, and has a mechanism to inhibit the growth of various pathogenic bacteria (Gram-positive and Gram-negative) and fungi through the production of lactic acid .Lactobacillus has a crucial role in improving digestive reactions, thereby eradicating digestive problems. Lactobacillus probiotics are known for several mechanisms to adhere to intestinal epithelial cells. This property is an important criterion for the colonization of Lactobacillus in the gastrointestinal tract . Fermentation is an ancient and culturally significant food preservation method in indigenous communities in Africa and developing countries. It enhances the nutritional value, digestibility, sensory characteristics, and functional qualities of raw products. Fermented foods and beverages are a major dietary component, with lactic acid bacteria (LAB) acting as probiotics, which can inhibit pathogens .Isolation of probiotic strains from fermented finger millet can be done using suitable media . They can be usually isolated using MRS (deMan, Rogosa, Sharpe) media.Biochemical tests are used for microbial identification based on differences in their biochemical activities exhibited by different types of bacteria. Bergey's Manual of Systematic Bacteriology helps us to identify bacterial species. The study identified isolates using morphological, phenotypic, and biochemical methods, examined cultures for Gram-staining, endospore tests, motility, and catalase tests, and determined carbohydrate fermentation profiles. Using advanced software ABIS, with help of above test results we can identify the most probable bacterial strain present in fermented finger millet.

MATERIALS AND METHODS

1kg of finger millet is collected from an Oushadhi department store in Thrissur. It was made into fine powder using a mixer grinder and the sample was stored in a poly zipper bag for further analysis.

- **Isolation of Lactic Acid Bacteria :** The fermented finger millet sample is serially diluted in Saline solution (0.85% NaCl in 100 ml distilled water) up to 10^6 dilutions.MRS agar was prepared for isolation by suspending 70g of MRS powder in 1000 ml of distilled water. The medium was boiled with constant stirring for 1 minute for uniform distribution of the medium. Sterilization is done(autoclave) at 121°C for 15 minutes, cool the medium before pouring. After solidifying the Fermented sample is inoculated and streaked on sterile plates and incubated at 37°C for 48h.
- **Gram Staining:** An inoculation loop is used to transfer a drop of suspended culture to the microscope slide. Culture is spread with an inoculation loop into a thin film. The slide is dried by heat fixed. Crystal violet stain, primary stain is added over the fixed culture. After 30 to 60 seconds, rinse the slide with a gentle stream of water to remove the excess crystal violet stain. The mordant, gram's iodine is added for 60 seconds and the slide is rinsed with running water. The decolorizer is added for 3 - 5 seconds and rinsed with water. The counterstain, safranin is added on the smear and after 40 to 60 seconds it is washed off with water and excess water is blotted with blotting paper.
- **Motility Test:** Take one cavity slide and clean the well with dry tissue paper. Apply small amount of petroleum jelly around the four corners of the cover glass. Gently shake the bacteria containing culture broth until it is evenly suspended. Then, using the wire inoculating loop, take a loopful of culture. Place the loopful of culture in the center of the cover glass. Hold the cavity slide in an inverted position, well down, over the cover glass; then press it down lightly. The petroleum jelly, which is applied around the corners of the cover glass will adhere to the cavity slide. Now turn the slide over. Place the slide on the microscope stage, cover slide on the top. Start examining the hanging drop with the low-power objective. It is more effective to observe from one edge of the drop, which will appear as a dark line. To get more clear focus, use high-dry and oil immersion objectives.
- **Endospore Staining**: Endospore staining is the staining process used to identify the presence of endospores in a bacterial sample,. Clean a slide. Put a drop of distilled water using an inoculation loop.Smear the bacteria in the drop of water. Allow it to air dry. Heat-fix the slide with gentle heat. Place the slide over a beaker or conical flask of steaming water. Flood the slide with malachite green dye and steam the slide for 3-5 minutes..Rinse the slide with water. Counter stain with safranin for 1 minute. Rinse the slide with water and tap dry. Blot gently. Dry the bottom of the slide before placing it on the stage of the microscope and view with the oil immersion lens.

BIOCHEMICAL TEST

- **Catalase Test:** This test helps in the detection of enzyme catalase in organisms. Into a clean slide, hydrogen peroxide is added into the bacteria.
- **Oxidase Test:** This test helps in the identification of enzyme oxidase in organisms. A strip of filter paper is soaked with a little freshly prepared 1% reagent. A tiny amount of culture is rubbed on the filter paper. After around 60 seconds, the results are observed.
- **Starch Hydrolysis**: Starch media is prepared and aseptically made a single line streak of the bacterial colony. Inverted the petri plate and kept in the incubator for 24 - 48 hours. After incubation the agar plates are covered with iodine solution. The result is observed.
- **Triple Sugar Iron Test** : TSI agar slants are prepared and with a straight inoculation needle, the isolated colonies are picked up. Inoculate the slant by first stabbing down to the bottom. Withdraw the needle and streak on the surface. The cap should be loosely kept and incubated at 37°C for 18 to 24 h. The result is observed.
- **Carbohydrate Fermentation Test :** The Carbohydrate fermentation of lactic acid bacteria was conducted in MRS broth and bromocresol purple. We used bromocresol green as the pH indicator in the Carbohydrate broth base. Dyes such as phenol red, bromothymol blue can also be used as pH indicators. 10 g of sugars Maltose, lactose, fructose, Galactose, Sucrose, glucose, and Mannitol were used. The media was autoclaved at 121°C for 15 minutes, before adding the sugars. The colony was inoculated from overnight incubated MRS medium and incubated at 37°C for 24-48h. The gas production can be detected by placing Durham's tube in an inverted

position before autoclaving the media (Efrizal et al., 2021[6]). The positive result can be identified by the color change of bromocresol green from green to yellow in acidic PH. (Funnekotter et al., 2023[7])

IMViC Test

IMViC Test, stands for Indole Methyl Red Voges-Proskauer Citrate Test, is done for the detection of bacterial species present in the sample. (Shoaib *et al.,* 2020[5])

- **Indole Test** :- Sub cultured microbes inoculated in the sterile peptone broth specialized for the Indole Test. Peptone broth constitutes 0.30g of Peptone and 0.15g of Sodium chloride in 30 ml of distilled water. After 24 - 48 hours of incubation, a few drops of Kovac's reagent were added to the medium. Result is observed
- **Methyl Red - Voges-Proskauer Test** :- The high medium utilized for MR - VP test is MR - VP broth in a composition of 0.85g in 50 ml of distilled water. Microbes which are subcultured were inoculated in MR - VP broth and incubated for 24 - 48 hours at 37°C.
- **MR Test** -After incubation, 8 - 10 drops of Methyl Red indicator were added to the medium. Kept the sample for 1 hour and no color change occured. This indicates the absence of glucose fermentation.
- **VP Test :** For VP test, 12 drops of Barritt's A reagent and 4 drops of Barritt's B reagent were added to the medium. Kept for 1 hour and yellow color stands for the absence of glucose fermentation.
- **Citrate Test :** Citrate Test is undergone in Simmon's Citrate Agar medium, in a composition of 0.72g agar in 30 ml distilled water. Bromothymol blue, a pH indicator (6.9 - 7.6), was added to the agar and kept for solidification. Subcultured organism inoculated in sterile agar and incubated for 24 - 48 hours. Green color appeared which shows the absence of citrate.

Product Development

A prototype of probiotic-rich fermented millet-based gummies was developed by using fermented millet (after 24h fermentation), jaggery instead of sugar, and china grass as solidifying agents as ingredients. Corn starch and gelatin are also preferred as solidifying agents. Coffee powder was used for flavoring purposes, other flavors also can also be used. The Gummies were frozen for 3-4 hours. The food characteristics such as taste, texture, and appearance were checked by using A five point Hedonic rating scale.

PREPARATION OF PRODUCT

1. Fermentation of ragi in water for a minimum of 4 hrs.
2. Into the saucepan add water and china grass. Only add the required amount of water as adding more will affect the solidifying action of china grass. Flame should be the minimum
3. After around 5 minutes or less the china grass has been dissolved in the water. Transfer it to a bowl.
4. Let the melted china grass to cool for around 5 minutes
5. Prepare a mixture of coffee powder and jaggery and dissolve it using a small amount of water.
6. Add the coffee-jaggery solution and fermented ragi into the bowl of melted china grass and mix it very well.
7. Transfer the mixture to the mould of choice and keep it in the refrigerator for 3 - 4 hrs.

RESULTS AND DISCUSSION

The isolated colonies are grown on the MRS media after 48 hrs. It has been seen that the formed colonies are mucoid, opaque, flat, entir**e,** Gram positive, rod shaped non-motile, non-sporulating bacilli Various biochemical tests have been done for the identification of the bacteria. In the catalase test performed there was no bubble formation which indicated that the organism is catalase negative. That means the organism is an anaerobe, or may be a facultative anaerobe that only ferments and does not respire using oxygen as a terminal electron acceptor.In the oxidase test, the results show a negative reaction by the absence of coloration. That means this organism does not produce oxidase. Organisms that are oxidase-negative may be anaerobic, aerobic, or facultative; the oxidase negative result just means that these organisms do not have the cytochrome c oxidase that oxidizes the test reagent. They may respire using other oxidases in electron transport. The result in the starch hydrolysis is seen as there is no starch that is hydrolyzed

as there is no clear zone. Hence it is a negative result. The negative results indicate that the organism is not able to produce DNase. The observed result of the Triple Sugar Iron test after 24 hr is that there is acid butt and acid slant (yellow butt, yellow slant): lactose and/or sucrose has been fermented. And there is no gas production which indicates the fermentation of lactose, and/or sucrose. In the IMViC Test, the Indole test for the detection of degradation of tryptophan, MR- VP test for the detection of glucose fermentation and the Citrate test for the Citrate present in the bacterial sample were observed by negative results. A negative result from an indole test indicates that the organism lacks tryptophanase. A negative result for both the Methyl Red (MR) and Voges-Proskauer (VP) tests indicates that a bacterial colony is unable to produce acid properly from glucose fermentation. This could be due to several reasons, including the organism not producing significant amounts of acidic or neutral end-products from glucose fermentation. A negative citrate test result for an organism means that there is no visible growth or only a trace amount of growth. Sugar fermentation is a metabolic process that occurs in an anaerobic condition to produce alcohol and acid. Sugar fermentation test enabled us to understand the carbohydrates fermentation ability of the isolated lactobacillus. The lactobacillus strain fermented all the tested sugars but not mannitol without any gas production by converting the green color of bromocresol green to yellow. The obtained result in ABIS tool is that the isolated strain of lactobacillus shows a similarity of 99% and a probability of 56.3% with *Companilactobacillus formosensis.* Characteristics of the product were obtained through scale analysis from 18 people. Appearance and texture have high scores. Coffee liking individuals liked the flavor and smell of the product whereas individuals who disliked coffee gave low scores. Through the overall survey it is understood that the product provides energy and refreshments to individuals especially coffee lovers. The product may be mostly liked by children.

CONCLUSION

The bacillus have been isolated in MRS medium. Identification and characterization were conducted by morphological analysis as well as biochemical methods.The isolated colonies were identified by ABIS online laboratory tool showing 99% of similarity with 56.3% probability on *Companilactobacillus formosensis.* Millet is a gluten-free grain that is widely consumed in various parts of the world, particularly in Asia and Africa. Lactic acid bacteria, such as *Companilactobacillus formosensis*, are commonly used in the fermentation of grains and other food products. In the context of millet, these bacteria can be utilized in fermentation processes to produce traditional fermented foods or beverages, such as: Fermented Millet Porridge: Lactic acid bacteria can be added to millet porridge to initiate fermentation, which can enhance the flavor, texture, and nutritional profile of the porridge. Millet-Based Fermented Beverages: Fermented millet beverages are popular in some cultures. Lactic acid bacteria can ferment the sugars present in millet, producing lactic acid and other compounds that contribute to the characteristic flavor and aroma of the beverage. Millet Bread: Lactic acid bacteria can also be used in the fermentation of millet-based bread or other baked goods. Fermentation not only enhances the flavor and texture of the bread but also improves its shelf life. Millet-based Fermented Condiments: Fermentation of millet can also be used to produce fermented condiments or sauces, which are commonly used to flavor various dishes. In addition to imparting flavor and enhancing nutritional value, fermentation with lactic acid bacteria can also contribute to food preservation by creating an acidic environment that inhibits the growth of harmful microorganisms. It's worth noting that specific fermentation processes and recipes may vary depending on cultural traditions and preferences. If you're interested in incorporating *Companilactobacillus formosensis* into millet-based fermentation processes, it's essential to ensure proper hygiene and fermentation conditions to achieve desired outcomes in terms of flavor, safety, and nutritional quality.

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Table 1 : Taxonomy of Finger millet

● *Kingdom*	*Plantae – Plants*
● *Sub kingdom*	*Tracheobionta - Vascular plants*
● *Super division*	*Spermatophyta - Seed plants*
● *Division*	*Magnoliophyta - Flowering plants*
● *Class*	*Liliopsida - Monocotyledons*
● *Sub class*	*Commelinidae*
● *Order*	*Cyperales*
● *Family*	*Poaceae - grass family*
● *Genus*	*Eleusine*
● *Species*	*Eleusinecoracana*

Table 2 : Biochemical Tests

Sl No.	Biochemical Test	Results
1.	*Catalase*	No bubble formation
2.	*Oxidase*	No colouration
3.	*Starch Hydrolysis*	No clear zone
4.	*Triple Sugar Iron*	Yellow color, No gas production

5.	*IMViC* *i) Indole*	Negative
	ii)Methyl Red	Negative
	iii)Voges-Proskauer	Negative
	iv) Citrate	Negative

Table 3 : sugar Fermentation

Sl No.	Carbohydrate used	Carbohydrate fermentation	Gas production
1.	*Mannitol*	-	No gas production
2.	*Lactose*	+	No gas production
3.	*Glucose*	+	No gas production
4.	*Galactose*	+	No gas production
5.	*Sucrose*	+	No gas production
6.	*Fructose*	+	No gas production
7.	*Maltose*	+	No gas production

Table 4: Hedonic rating scale. Scale: 1-dislike extremely; 2-dislike slightly; 3-neither like nor dislike; 4-like slightly; 5-like extremely

Tester	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	T16	T17	T18
Appearance	5	4	5	4	4	4	3	3	3	4	4	4	2	4	4	5	3	3
Taste	4	4	4	4	4	2	3	3	3	3	2	2	3	3	2	2	4	4
Smell	3	3	5	5	4	3	4	4	3	3	3	4	2	4	3	2	3	3
Texture	3	3	4	5	4	4	4	4	3	3	1	3	4	3	4	3	4	4
Acceptability	3	3	5	5	4	2	4	4	3	2	4	2	2	2	2	2	2	2

Table 5: Hedonic scale average score

Characteristics	Total score	Average score
Appearance	71	3.9
Taste	59	3.2
Smell	66	3.6
Texture	70	3.8
Acceptability	53	2.9



Fig. 1. Finger millet



Fig. 2. Isolated LAB colonies

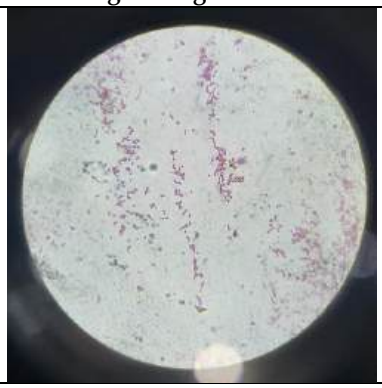


Fig. 3. Endospore Staining

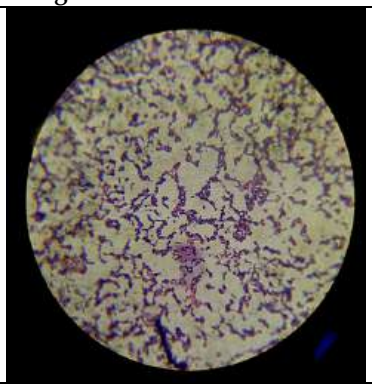


Fig. 4.Gram Staining



Fig. 5. Starch Hydrolysis



Fig. 6. Triple Sugar Iron Test

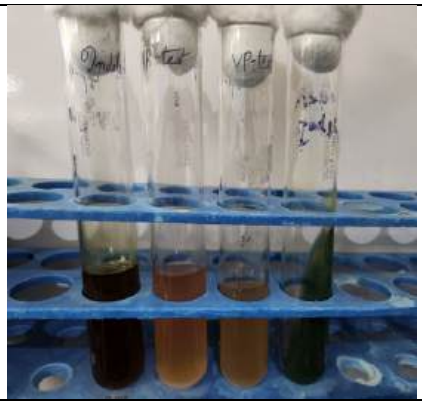


Fig. 7. IMViC Test



Fig. 8. Sugar Fermentation Test



Fig. 9. Strain identification by ABIS online laboratory tool

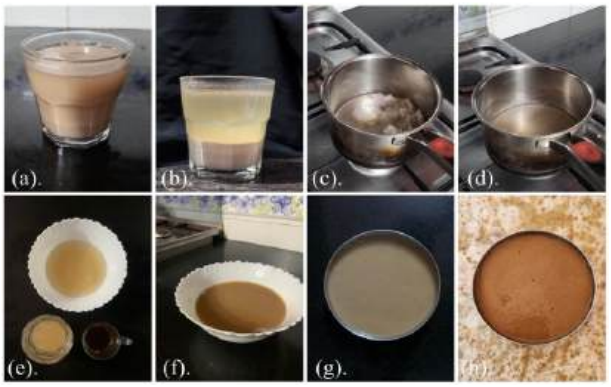


Fig 10. The steps of product development: (a) Before fermentation. (b) After fermentation. (c) Melting china grass using water. (e) Melted china grass along with fermented ragi and coffee -jaggery mixture. (f) The final product mixture. (g) Transferred into the steel mould. (h) After chilling it for 5 hours.



Fig 11.Probiotic Ragi Gummies.

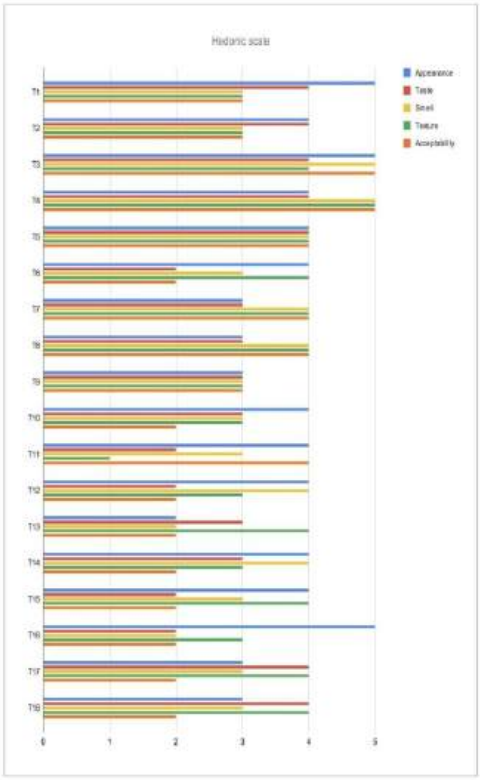


Fig 12: Graphical representation of hedonic scale

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RESEARCH ARTICLE

Designing of Modified Switching System in Steel Pipe Production Industry Based on Statistical Neutrosophic Sets using Poisson Distribution

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ABSTRACT

In recent years, everything in the globe is jam-packed with indeterminacy, the Neutrosophic becomes appear and create its place into research as an advancement/new avenue in the various fields. Generally Classical statistics is used based on the deterministic nature of information and based on its structure and its scale. In some circumstances, the quality characteristics may not be certain enough leading to vagueness or impreciseness situation. Accordingly, (FST)Fuzzy Set Theory takes its place to model the uncertainty in the manufacturing industries during the end of the last century. Due to exponential growth of data, an extension of Fuzzy, known as Neutrosophic Logic(NL) is in progression to overcome these uncertainties. Thus, NL taken its role in Quality Control (QC) through Acceptance Sampling Plans(ASPs) and Systems. The construction of plans and systems based on neutrosophic sets were already studied in the literature. This article furnishes the concept and designing of Modified Quick Switching System (QSS) based on Neutrosophic Poisson Distribution. The Modified QSS is designated as QSS-r (n; C_N, C_T) where r=2,3 and its characteristics functions of ASPs such as Probability of acceptance (P_a), Average Outgoing Quality (AOQ), Average Total Inspection (ATI) have also been analyzed using Neutrosophic Poisson as a baseline distribution and highlighted advantages with numerical illustrations.

Keywords: Modified QSS-r, OC, AOQ, ATI, SSP, FST, NL, Neutrosophic Poisson Distribution.

INTRODUCTION

In any manufacturing industry, it is mandatary to check the conformity of the produced items with the standard quality specifications. while undergoing the 100% inspection, the cost may be too high in inspecting or testing all the produced items for the quality standards. Accordingly, the acceptance sampling plans procedures is applied to decide the quality of the produced items in inspecting set of sample items. In this modernized and technocratic scenario some of the real case problems, the classical acceptance sampling plans are not applicable due to the indeterministic environment to assess the degree of association. FST is an efficient and popular approach to model the uncertainty and has also been successfully used in ASPs. In FST, the uncertainty modelling is built on the term Membership Function ($\mu(x)$) by using a continuous variable (x) inside [0,1] interval in a space of (X). To overcome the indeterministic environment more effectively, NL one of the fuzzyextensions have been developed with three terms for membership(truthiness), non-membership(falsity) and indeterminacy. Neutrosophic Statistics is an extension of the Classical Statistics and deals with the set values data rather than crisp ones. Neutrosophic Statistics is considered as extension of Classical Statistics. In Classical Statistics, the data is very well known and formed by the crisp numbers whereas in case of Neutrosophic Statistics, the data contains some indeterminacy. The data may be ambiguous, vague, imprecise, incomplete and even unknown in Neutrosophic Statistics, alternate to crisp numbers applied in Classical Statistics, one can apply the sets in Neutrosophic Statistics. NL provides better results in modelling the uncertainty depending on human factor. During the inspection cycle, the operator may be undecided in classifying the semi-defective item as defective or non-defective because of some reasons such as technical restrictions. The traditional FST assign the items to one of the two possible sets: defective or non-defective. This behaviour creates diverseness between real life and calculated results. In such cases, FST do not fit into it. The mentioned triple-term structure of NSs supports to model these kinds of uncertainties more adequately. In recent years, some studies have been carried out in the literature in the area of acceptance sampling using NSs with reference to SSP and DSPs. The chief formulations of Acceptance Sampling plans for Single Sampling were derived based on Neutrosophic Statistics. QSS proposed by Dodge in 1967 (mixture of ASPs with swapping rules is widely applicable and providing high level of protection and reduction in time and cost inspection) based on NSs is designed with the procedures, OC curves and tables based on NSs with numerical examples. The modifications in QSS proposed by Romboski in 1969 and designated the two modified systems as QSS-2(n; C_N, C_T) and QSS-3(n; C_N, C_T). Modified QSS is an advantageous system than QSS-1 due to the reasons that it gives an OC curve which is more discriminating than the OC curve of normal and tightened plans and ease in switching rules. The sample size of the Modified QSS is found to be lesser than QSS. To overcome the vagueness present in the data, the concept of Neutrosophic Statistics is applied in the paper to design Modified QSS based on Neutrosophic sets to reduce the sample size rather than existing plans and systems in the literature by using Poisson distribution as a baseline distribution.

REVIEW OF LITERATUE

QSS

QSS were originally proposed by Dodge (1967) and later investigated by Romboski (1969) and Govindaraju (1991). Based on Romboski's studies, Taylor (1992) designed QSS with the combination of Reduced and Tightened Sampling plans by comparing with MILSTD 105E and compared the advantages of QSS(RT).

Fuzzy QSS

Uma and Nandhinidevi (2018) studied the determination of QSS using both fuzzy Binomial distribution and fuzzy Poisson distribution with OC curves of sample size tightening and acceptance number tightening. Nandhinidevi and Uma (2018) analysed fuzzy logic importance on QSS by attributes using the Poisson distribution. Uma, Nandhinidevi and Manjula (2020) studied the impact of fuzzy logic on Quick Switching Single Double sampling plan with the acceptance number tightening criteria.

Neutrosophic Acceptance Sampling Plans and Systems:

Aslam (2019) initiated to study in both attribute and variable Acceptance sampling plans and proposed a new attribute sampling plan by employing the Neutrosophic Interval method and theNeutrosophic Binomial distribution is utilized for computing the lot acceptance, rejection andindeterminate probabilities at various specified sample size and acceptance number parameters. Isik and kaya (2020a) developed the attribute single ASPs for Poisson distribution based on single-valued Neutrosophic sets and Isik and kaya (2020b) also study the double Acceptance Sampling Plans based on single-valued Neutrosophic sets using Binomial distribution. An inclusive representation of single and double Acceptance Sampling plans based on single-valued Neutrosophic sets using Binomial distribution and Poisson distribution is recommended by covering the two studies. Isik and kaya (2022d) formulated the characteristics functions of Acceptance Sampling plans – Average Outgoing Quality, Average Total Inspection, Average Sample Number by incorporating the three terms- truth, false and indeterminacy. Uma and Nandhitha (2022) reviewed the significance of Neutrosophic set on Acceptance Sampling plans (attribute and variable) in their study.Isik and kaya (2023) designed and analysed the single and double Acceptance Sampling Plans using the Binomial and Poisson distributions based on Interval Valued Neutrosophic sets. The Acceptance Sampling plans based on Interval Valued Neutrosophic sets can increase the real case applicability of the problems encountered. Uma and Nandhitha (2023) have constructed and evaluated the Quick Switching System using Neutrosophic Poisson Distribution with OC curve and necessary tables are framed for various parameters. Uma and Nandhitha (2023) investigated the Quick Switching system using FSs and NSs and compared its efficiency.

NEUTROSOPHIC SETS

Type-1 fuzzy sets or classical fuzzy sets considers only the membership and only have $\mu(x) \in [0,1]$ in the membership function. Since non-membership is states as $1-\mu(x)$, type-1 fuzzy sets are only usable in complete information case. Intuitionistic sets (ISs) have functions for both membershipand non-membership. While $\mu(x) \in [0,1]$ is membership function and $\vartheta(x) \in [0,1]$ is non-membership function, the condition $0 \leq \mu(x) + \vartheta(x) \leq 1$ is satisfied (Atanassov, 2003). If the sum of membership and non-membership values is less than 1, it means incomplete information (Wang *et al.*,2005). NSs are the generalized form of ISs. It handles membership (truthiness), non-memership (falsity) and indeterminacy cases independent from each other. This independency makes possible to use inconsistent data in modelling (Smarandache, 2005). (t, i, f) = (truthiness, indeterminacy, falsity)

$$\leq t + i + f \leq 3, \quad t, i, f \in [0,1] \tag{1}$$

Truthiness, indeterminacy and falsity values can be real numbers or interval-valued numbers. If these are interval-valued numbers, the set is named as interval Neutrosophic set and it is represented with three intervals. Summation of the biggest upper limits of these three intervals must between 0 and 3 (Wang et al., 2005). Representation of interval NSs is shown in Eq. (1):

$$x = \langle [Tx_L Tx_U], [Fx_L Fx_U], [Ix_L Ix_U] \rangle$$

$$T_x, I_x, F_x \in [0,1]$$

$$\leq sup_{T_x} + sup\, F_x + sup\, I_x \leq 3$$

MODIFIED QUICK SWITCHING SYSTEM QSS-r(n; C_N, C_T), r=2 And 3

Romboski (1969) designates the OC function of modified systems as follows:

QSS-2: $P_a(p)$ = $$\frac{P_N P_T^2 + P_T(1-P_N)(1+P_T)}{P_T^2 + (1-P_N)(1+P_T)} \tag{2}$$

QSS-3: $P_a(p)$ = $$\frac{P_N P_T^3 + P_T(1-P_N)(1+P_T+P_T^2)}{P_T^3 + (1-P_N)(1+P_T+P_T^2)} \tag{3}$$

Where P_N and P_T are the probability of accepting the lot using normal and tightened SSP using NL respectively. The conditions for application of these systems are same as that of QSS-1(n; C_N, C_T).

OPERATING PROCEDURE

Step 1: Under Normal Inspection, take a random sample of size 'n' from the lot and count the number of non-conforming units(d)

i) If $d \leq C_N$, accept the lot and repeat Step 1 for the next lot.

ii) If $d > C_T$, reject the lot and go to Step 2.

Step 2: Under Tightened Inspection, take a random sample of size' n' from the next lot and count the number of non-conforming units(d)

i) If $d \leq C_N$, accept the lot and continue inspection using Step 2 until 'r' lots in succession are accepted. When 'r' lots in succession are accepted go to Step 1.

ii) If $d > C_T$, reject the lot and repeat Step 2 for the next lot.

MODIFIED QSS BASED ON NEUTROSOPHIC SETS FOR POISSON DISTRIBUTION

In this section, QSS with reference to SSP having certain plan parameters and Neutrosophic defection status is offered with Poisson distribution as a baseline distribution. Difference from classical acceptance sampling plans is considering the indeterminacy case as a defection status.

A: A Neutrosophic set for item defect such that A ={t,i,f}={(P(S),P(I),P(F)}
P(S): Non-defective probability
P(I): Indeterminacy probability
P(F): Defective probability

B: A Neutrosophic set for test result such that B ={t,i,f}={(P_a, P_i, P_r)}
Pa: Acceptance probability
Pi: Indeterminacy probability for the normal plan
Pr: Rejection probability for the normal plan
n: Sample size
N: Lot size
c: Number of maximum allowable defective item
I: Number of maximum allowable indeterminate item
d: Defective item count in a sample
i: Indeterminate item count in a sample

PERFORMANCE MEASURES

Formulation of single sampling plan based on Poisson distribution has two frequency values as defect frequency λ_F = n.P(F) and indeterminacy frequency λ_I= n. P(I). If the neutrosophic set A has inconsistency, the probability values should be normalized by dividing each of them with total probability to make
t + I + f = 1. This normalization is offered by (Smarandache, 2014).

For single sampling plan, the Neutrosophic probability of acceptance is represented as 'P_a', the rejection probability is represented as 'P_r' and the indeterminacy probability is represented as 'P_i'.

$$P_a = \sum_{d=0}^{C_N} \frac{\lambda_F^d}{d!}\left[\sum_{i=o}^{min\ (I,n-d)} \frac{\lambda_I^i}{i!} e^{-(\lambda_I+\lambda_F)}\right] \quad (4)$$

$$P_r = \sum_{d=c_{N+}1}^{C_N} \frac{\lambda_F^d}{d!}\left[\sum_{i=o}^{n-d} \frac{\lambda_I^i}{i!} e^{-(\lambda_I+\lambda_F)}\right] \quad (5)$$

$$P_i = \sum_{i=I+1}^{n} \frac{\lambda_I^i}{i!}\left[\sum_{d=o}^{\min\ (N,n-i)} \frac{\lambda_F^d}{d!} e^{-(\lambda_I+\lambda_F)}\right] \quad (6)$$

$P_{aN} + P_{rN} + P_{iN} = 1$ …….. total probability

Therefore, the probability of acceptance P_a (p), probability of rejection P_r(p), probability of indeterminacy P_i(p)for QSS-2 and QSS-3 is calculated based on Eq. (2) and (3)Operating Characteristic (OC) is formed as a surface

depending on P(F), P(I) and P_a. Figures below shows OC surface for QSS-2 and QSS-3 using Neutrosphic Poisson distribution having parameters n=30, C_N=2, C_T=1, I=2 for the probability pairs satisfying P(F) €[0.01,0.1] and P(I) € [0.01,0.1] .The obtained curves are found to be steeper than single sampling plan using Neutrosophic Poisson distribution and QSS using Neutrosophic Poisson distribution.

AOQ is calculated similar to ASPs but includes λ_F instead of λ. The AOQ is calculated as follows:

$$AOQ = P_a * P(F) = P_a * \frac{\lambda_F}{n} \quad (7)$$

During the calculation of ATI, one of the two different strategies can be followed. If the business requires high sensitivity in output quality, all the items are tested in case of indeterminacy. For this approach $ATI_{pessimistic}$ is calculated is shown in Eq. (17). If the business does not force to test all the items in case of indeterminacy, $ATI_{optimistic}$ is calculated as shown in Eq.(18).

$$ATI_{pessimistic} = n + (P_r + P_i)(N-n) \quad (8)$$

$$ATI_{optimistic} = n + (P_r)(N-n) \quad (9)$$

ILLUSTRATION

In this section, the proposed system is explained based on some numerical examples. In given data samples, the items have three defective states: defective, non-defective and indeterminate. For example, the inspected item can have a measure which is too close to the specification limit while the measurement is not sensitive enough depending on the technical restrictions.

If the classical ASPs are applied,

the risk avoider operators (labelling the indeterminate items as defective ones) can increase the cost for inspection process and risk-taking operator (labelling the indeterminate items as non-defective ones), which cause problems with the supplier or other departments. In both scenarios, there will be contrast between paper calculations and acceptance probability experienced in real cases. For this reason, NSs is applied by considering the three possible outcomes – acceptance, rejection and indeterminacy. To illustrate the application capability of the proposed system, an example scenario can be such that: A company supplies Stainless Steel pipes (SS pipes) to a supplier and applies ASPs for these SS pipes. SS pipes can have different types of defects such as surface defect, weld defect, dimensional defect and material defect. In this case, some pipes may have surface defect only in the middle portion of the pipe, while others may have it in the outer ring of the pipe. The operator may become undecided in some cases. The agreement is made between the company and supplier depending on a quality level. The supplier categorize an item non-defectiveness probability, an item indeterminacy probability and an item defectiveness probability for the incoming lots. The company can control the quality of the incoming SS pipes by applying special purpose Sampling System such as Modified QSS-2 & 3 ASPs based on NSs. A set of system parameters and mass quality characteristic combinations have been tested to analyze the outputs of proposed system better. The obtained results have been tabulated below

COMPARATIVE STUDY

In this section, the proposed system Modified QSS based on Neutrosophic sets is compared with the existing sampling systems under ClassicalPoisson distribution with respect to acceptance probability, rejection probability and indeterminacy probability. The selection of parameters involves same values for both sampling systems.The probability values are presented in Table 4 with sample size n=50 , acceptance numbers **C_N = 2 , C_T = 1 ,** indeterminacy I = 2. From table 3, it may be noted that the existing sampling plan under the classical statistics present the determined values for the specified parameters whereas the fuzzy logic present the value in the interval. But the Neutrosophic logic provides the value for acceptance probability, rejection probability and indeterminacy probability. In table 4, when n=50, C_N=2, C_T=1,I=2 is applied for the lot inspection, there is 24% chance that an experimenter faces indeterminacy regarding the lot sentencing. By comparing three, we infer that the classical statistics and fuzzy logic has only the decision of acceptance or rejection, also does not give information regarding the indeterminacy. Therefore, the neutrosophic statistics is considered to be more effective, and flexible under the

uncertainty and indeterminacy scenario. According to the results, the summation of Pa, Pr, Pi for all the data sets is observed as equal to 1. This is an expected result because the probabilities were normalized at the beginning. Table 1 and 2 shows solutions for both consistent(P(S)+P(F)+P(I)=1) and inconsistent information (P(S)+P(F)+P(I)$\neq$1) cases. In table 1, if P(S), c and/or I increases, P_a increases but the relative greatness of P(S) over P(F) and P(I) has positive effect on P_a. N has no effect on Pa, Pr, Pi and AOQ while the plan parameters are not changing. However, AOQ is highly affected by the plan parameters n, c and I.Increase of N has apparent additive effect on ATI. ATI is also affected from the relative greatness of P(S) over P(F) and P(I). When the probability values P(S), P(F) and P(I) are changed, the difference between ATI_{opt} and ATI_{pes} is changed but the arithmetic average of ATI_{opt} and ATI_{pes} shifts at a small range. However, change of N shifts both ATI_{opt} and ATI_{pes} to bigger values.

CONCLUSION

In this article, construction and designing of modified quick switching system - QSS_{NP} (n;C_N,C_T;I) with reference to single sampling plan using Neutrosophic Poisson distribution for various Neutrosophic quality characteristics such as OC curve, AOQ and ATI are studied. The mentioned Modified QSS_{NP} are usfeul for situations where inspected items can have measures too close to specification limit while the measurement is not sensitive enough due to some constraints. They even represent the real life better by eliminating the negative effects of risk avoider operators on inspection cycle. As a future study, the paper can be extended to determine standard sampling plans including indeterminacy term.

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Table 1: Parameters of the Numerical examples for QSS-2 and QSS-3 using NPD

	Parameters							
No	**n**	**n**	**c_N**	**c_T**	**I**	**P(S)**	**P(F)**	**P(I)**
1	600	30	3	2	2	0.95	0.05	0.05
2	600	30	2	1	2	0.95	0.04	0.02
3	600	30	2	1	2	0.83	0.03	0.04
4	1200	30	3	2	2	0.95	0.05	0.05
5	1200	30	2	1	2	0.95	0.05	0.05
6	1200	30	2	1	3	0.95	0.05	0.05
7	1200	30	2	1	2	0.95	0.04	0.02
8	1200	30	2	1	2	0.83	0.03	0.04
9	1200	100	5	3	3	0.95	0.04	0.02
10	1200	100	5	3	3	0.83	0.03	0.04

Table 2: Probability of acceptance, rejection and indeterminacy, AOQ and ATI of QSS-2 & QSS-3

QSS-2 & QSS-3											
Pa		**Pr**		**Pi**		**AOQ**		**ATI $_{opt}$**		**ATI $_{pes}$**	
QSS-2	**QSS-3**	**QSS-2**	**QSS-3**	**QSS-2**	**QSS-3**	**QSS-2**	**QSS-3**	**QSS-2**	**QSS-3**	**QSS-2**	**QSS-3**
0.72	0.70	0.19	0.19	0.15	0.15	0.04	0.04	83.69	85.24	175.60	177.03
0.66	0.57	0.38	0.40	0.17	0.18	0.03	0.02	155.18	170.32	197.45	220.66
0.74	0.72	0.22	0.23	0.09	0.09	0.02	0.02	97.77	99.10	169.88	170.79
0.72	0.70	0.19	0.19	0.15	0.15	0.04	0.04	140.21	143.38	328.85	331.79
0.52	0.48	0.61	0.67	0.11	0.11	0.03	0.02	581.80	608.60	728.56	753.78
0.62	0.58	0.41	0.43	0.04	0.04	0.03	0.03	365.12	377.37	419.84	431.30
0.78	0.75	0.32	0.33	0.02	0.02	0.03	0.03	225.88	234.54	248.36	256.82
0.77	0.75	0.22	0.23	0.09	0.09	0.02	0.02	148.25	152.59	274.93	278.75
0.99	0.99	0.03	0.03	0.06	0.06	0.04	0.04	101.84	101.84	224.86	224.85
0.96	0.96	0.01	0.01	0.37	0.38	0.03	0.03	100.84	100.84	665.75	665.69

Table 3: Comparative Table (n=30, CN=2, CT=1,I=2)

	n	C_N	C_T	I	Classical statistics(Pa)	Fuzzy Logic(Pa)	Neutrosophic Logic (Pa,Pr,Pi)
QSS-2	50	2	1	2	0.47	(0.47,0.31)	(0.42,0.52,0.24)
QSS-3	50	2	1	2	0.43	(0.43.0.29)	(0.39,0.55,0.23)

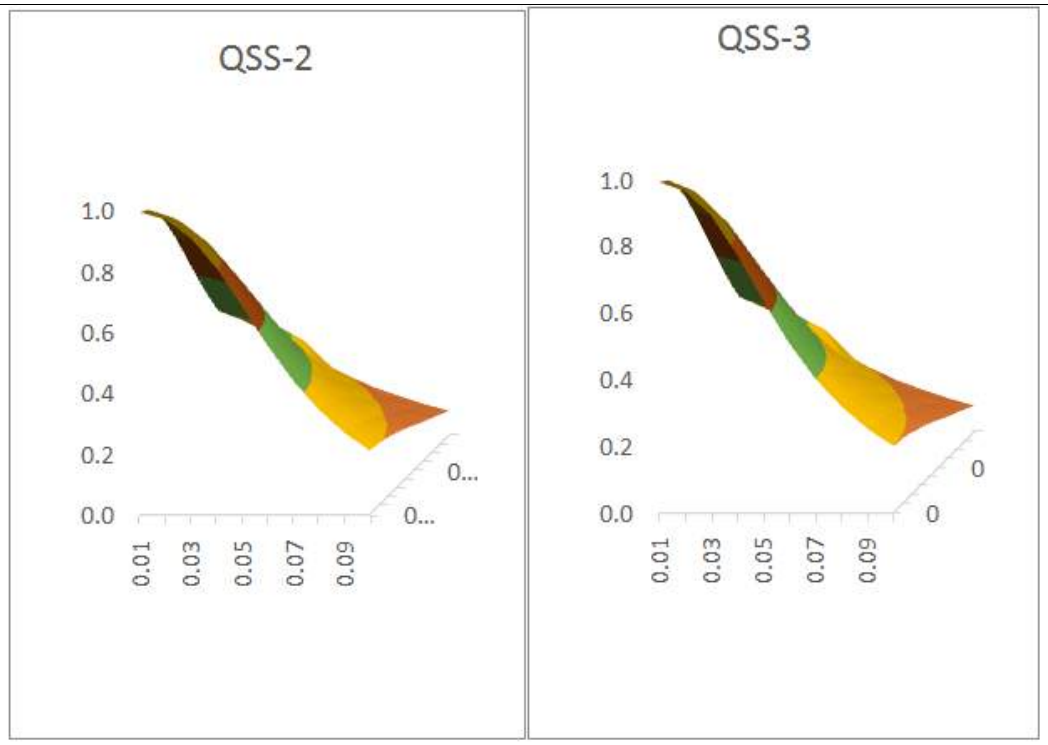


Fig:1

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RESEARCH ARTICLE

A Systemic Epidemiological Analysis of the Rising Prevalence of Low Back Pain among Educators: Occupational Risk Factors and Preventive Strategies

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ABSTRACT

Low back pain (LBP) is a common musculoskeletal disorder among educators, significantly affecting their health, productivity and quality of life. The teaching profession involves prolonged standing, poor posture, repetitive movements and high work-related stress, all of which contribute to the increasing prevalence of LBP. An extensive web-based search was done on various platforms, viz. PubMed, PubMed Central, Web of Science, Google Scholar, MEDLINE, Academia, etc., with the help of keywords used for searching data related with low back pain, occupational hazards, musculoskeletal disorder, prevalence, risk factors, academicians, teaching profession, etc. It was observed that significant proportion of educators experience chronic or recurrent LBP, with female teachers and those with longer teaching experience being more susceptible. The key contributing factors include prolonged static postures, inadequate workplace ergonomics, high workload, and stress. Further physical inactivity, obesity, and psychological stress exacerbate LBP. Preventive strategies such as ergonomic interventions, physical activity, posture correction, and stress management have shown effectiveness in reducing LBP symptoms. However, workplace policies supporting spinal health remain inadequate in many educational institutions. While addressing LBP in educators requires a multidisciplinary approach, including workplace ergonomics, physiotherapy and awareness campaigns should be considered as well as future research should focus on longitudinal studies to assess the long-term impact of preventive

interventions. Implementing structured occupational health programs can improve teacher well-being and overall educational efficiency.

Keywords: Low back pain, educators, occupational health, ergonomics, musculoskeletal disorders, prevention.

INTRODUCTION

Low back pain (LBP) is a widespread issue among workers in both developed and developing nations. As a significant global public health concern, LBP is one of the most common musculoskeletal disorders experienced in everyday life, with a lifetime prevalence of 84%. It often results in severe discomfort, expensive medical treatments, and lost work time [1,2]. LBP is characterized as pain occurring between the 12th rib and the lower gluteal folds, with or without radiating leg pain, and can stem from various causes [2]. It is generally classified into two types: "specific" and "non-specific" LBP. Non-specific LBP refers to pain without a clearly identifiable cause or pathology, whereas specific LBP arises from distinct pathological or physiological conditions, such as disc herniation, infection, inflammatory arthropathy, tumors, osteoporosis, or fractures [3]. Although LBP is not life-threatening, it remains a significant global health issue. It is frequently associated with restricted movement, often aggravated by physical activity and posture, and may also involve referred pain [4]. While several individual factors contribute to LBP, growing research highlights occupational exposure as a key risk factor. In fact, workplace-related factors are estimated to account for 37% of LBP cases worldwide [1]. Several factors contribute to the risk of developing lower back pain (LBP), including gender, age, lifestyle, and an individual's psychosocial profile. Work-related physical demands, social support, and pain perception also play a role. LBP can be aggravated by activities such as frequent heavy lifting, prolonged use of vibrating equipment, and leading a sedentary lifestyle. Additional contributing factors include weak abdominal muscles, obesity, smoking, increased lumbar lordosis, scoliosis, cardiovascular diseases, low socioeconomic status, and a high body mass index (BMI). Many of the modifiable risk factors for LBP are occupational in nature, such as poor posture, prolonged sitting, twisting, bending, stooping, and lifting heavy objects [5]. The World Health Organization (WHO) has identified lower back pain (LBP) as one of the top three occupational health concerns to be monitored through surveillance[6]. LBP has significant mental health impacts, including anxiety, depression, and insomnia, while its physical effects include reduced physical performance and a decline in overall health. Since LBP predominantly affects individuals of working age, it can hinder social participation and limit one's ability to perform job-related tasks. Due to its substantial direct and indirect effects on quality of life, workplace productivity, and absenteeism, LBP is recognized as the leading cause of musculoskeletal disability worldwide [7,8].

MATERIALS & METHODS

An extensive web-based search was done on various platforms, viz. PubMed, PubMed Central, Google Scholar, Web of Science, MEDLINE, Academia etc., were searched with the following keywords: work-related musculoskeletal disorders, low back pain, occupational hazards, musculoskeletal disorder, prevalence, risk factors, academicians, teaching profession and prevention strategies etc. All studies written in simple English comprising of any design or methodological quality were included.

RESULT &DISCUSSION

Low back pain (LBP) is a significant public health issue worldwide, affecting individuals across various professions. The teaching profession, in particular, has been identified as a high-risk group for developing LBP due to the nature of their work, which often involves prolonged standing, sitting, and repetitive movements. Teachers are often

required to maintain static postures for extended periods, such as standing while lecturing or sitting while grading papers. These activities can lead to musculoskeletal disorders (MSDs), with LBP being one of the most common complaints. Several studies have investigated the prevalence of LBP among teachers globally, revealing varying rates depending on the region and specific teaching environment: A study done by Hoy *et al*.(2018) explained that the global prevalence of LBP among teachers ranges from 50% to 70%. This high prevalence is attributed to the physical and psychological demands of the profession [9]. Another study done by Omokhodion *et al*.(2017) reported a prevalence rate of 68.5% among secondary school teachers in Southwest Nigeria [10]. A study done in China by Zhang et al.(2019) indicated a prevalence rate of 58.9% among primary and secondary school teachers. Another study done by Rugulies *et al*.(2016) found that 54.3% of school teachers in Europe experienced low back pain [11]. da Silva *et al.* (2018) explain that a Brazilian study found a prevalence rate of 66.7% among school teachers [12]. A study conducted by Gupta et al.(2018) states that higher secondary school teachers in Kanpur 27% experienced acute episodes of LBP, with an annual prevalence of 23.1%. Additionally, 58% of these teachers had minimal disability, 35.8% had moderate disability, and 5% had severe disability due to LBP [13]. A study conducted by Tsuboi *et al.* (2002) reported that the prevalence of lower back pain (LBP) among teachers in Japan was 20.4% in males and 23.2% in females. The higher prevalence of LBP compared to previously mentioned studies may be attributed to inadequate school facilities, low morale, poor socio-economic conditions, and a lack of awareness regarding strategies to manage and reduce excessive workloads in schools.

In the current study, 60.20% of female teachers experienced LBP compared to 39.39% of male teachers. This disparity is likely due to the cultural and social expectations placed on women, requiring them to handle most household responsibilities, leading to an increased workload and higher risk of LBP. Additionally, since women generally have a lower pain threshold than men, they are more likely to report experiencing pain [14]. As per Chakravarthy *et al.* (2020) study indicate that 51 instructors (63.7%) had lower back pain as a result of occupational hazards affecting their professional growth. Thirteen male teachers (16.25%) and sixty-seven female teachers (83.75%) of this group reported having LBP. Female teachers are more prone to experience LBP than their male counterparts [15]. Another study done by Swati suman *et al.* (2021) states that 41.10% of Odisha's secondary school teachers had LBP, with female teachers having a higher frequency than male educators. The contributing factors that negatively impact teacher's health and welfare, such as an excessive workload, sleep disturbances (particularly for female educators), extended standing in the classroom, and physical inactivity, can lead to lower back pain (LBP) [16]. A study done by Nilani (2014) explain that low back pain among primary school teachers due to excessive work load had reported the prevalence of LBP varies from 12% to 95% among school teachers, which is significantly greater than that of other professional categories. Teachers who participate in high-intensity sports and gymnastics programmes at their schools run a greater risk of suffering from acute and chronic lower back pain (LBP) injuries, which frequently leave them permanently disabled [17].

CONCLUSION

Low back pain is a significant occupational health issue for teachers, with a high prevalence and multifaceted risk factors. Preventive measures such as ergonomic adjustments, regular physical activity, posture awareness, and stress management can help reduce the risk of low back pain. Additionally, schools and policymakers should prioritize workplace ergonomics and health education to support teachers' long-term physical well-being. Addressing low back pain in the teaching profession is essential for improving both teacher performance and overall quality of education. Future research should focus on evaluating the effectiveness of preventive strategies and exploring the role of cultural and socioeconomic factors in low back pain among teachers.

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REVIEW ARTICLE

A Review of Current Approaches in the Treatment of Alzheimer's Disease and their Challenges

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ABSTRACT

Alzheimer's disease is an advancing neurodegenerative disorder, which prevails as the leading cause of dementia worldwide, imposing a considerable strain on individual caregivers and healthcare systems. Despite years of research, transformative therapeutic interventions and curative approaches are still undetermined. A comprehensive investigation of the pathophysiological mechanisms underlying Alzheimer's disease, including amyloid beta-plaque accumulation, tau protein, hyperphosphorylation, neuro inflammation, and oxidative stress. Currently adopted modalities such as cholinesterase inhibitors, amyloid targeting therapies, and anti-inflammatory agents are critically evaluated, emphasizing their mechanism of action and clinical limitations. The evolving neuroprotective strategies, the potential of repurposed drugs, and the challenges associated with early diagnosis and biomarker development. By improving the limitations of present treatment regimen and exploring innovative therapeutic techniques, highlighting the urgent need for pioneering treatments to counter disease progression and improve patient health outcomes.

Keywords: Alzheimer's disease, Aβ plaques, neurofibrillary tangles, Neuroinflammation, Oxidative Stress.

INTRODUCTION

Alzheimer's disease is a pervasive neurodegenerative disease, majorly detrimental to the elderly population. Being a consequential factor for notable amount of dementia cases, the need for widespread awareness and preventative actions still persists. The disruptive challenges faced by people afflicted with Alzheimer's disease are altered cognitive and behavioural functions, yet determining the importance of research, caregiving support, community engagement and health education. Despite its unfavourable impact on the learning abilities and daily functioning, AD lays an epicentre for interdisciplinary collaboration, innovation in treatment modalities and compassionate care practices focusing on promoting the life quality for the effected individuals and their caretakers.(1) Alzheimer's disease is a multiplex neurodegenerative disease, preying on the population of millions. People's age is conducive to its increased incidence, contributing to the challenges for families, communities and healthcare system. (2)Genetic factors and mutations of genes - APP, PSEN1, PSEN2 together with APOE gene variations significantly augment the progress of "late onset" Alzheimer's disease.(3)Being the leading form of dementia, generally, older people becomes the victim of Alzheimer's disease, substantially declining their cognitive abilities. Healthcare disparities, lifestyle choices and genetic predisposition also aids in prevalence variations.(2) Anticipatory measures are needed to be taken to create awareness about Alzheimer's disease in order to mitigate it's social, financial and healthcare burdens, promoting individualized approaches to its treatment and prevention.(4)

IMPORTANCE OF NEUROPROTECTIVE STRATEGIES IN AD:

In the treatment landscape of Alzheimer's disease (AD), focusing on neuroprotective strategies is paramount due to their potential to slow or halt the progression of cognitive decline and neuronal damage as shown in figure 1. While treatments like inhibitors targeting gamma- and beta-secretases, Ab vaccination, Cu–Zn chelators, cholesterol-lowering drugs, statins, and NSAIDs are anticipated, neuroprotective approaches offer promise by safeguarding neurons from degeneration and preserving cognitive function. These strategies aim not only to alleviate symptoms but also to address underlying mechanisms contributing to neuro degeneration, thus presenting a holistic approach towards managing AD and enhancing the quality of life for affected individuals.(5)we explore the current therapeutic approaches for Alzheimer's disease (AD) and their limitations; while also delving into the various mechanisms of action and the underlying pathophysiology and their associate risk factor are shown in figure 2. By examining existing treatments in relation to the disease's pathophysiological mechanisms, we aim to provide insights into the challenges of AD.

ALZHEIMER'S DISEASE PATHOPHYSIOLOGY

Brain cells and connections get less healthy and less able to work as Alzheimer's gets worse.(6) For neurons to send information to each other, which is a key part of how our brains work, we need to know how synapses work. Neuroinflammation, oxidative stress, and the growth of Aβ plaques and neurofibrillary tangles can all make it hard for neurons to talk to each other and for synapses to work right. The main signs of Alzheimer's are forgetting things and having trouble learning new things. People with Alzheimer's disease have nerve growth factor and other important chemicals outside of cells that are out of balance. It is very important for neurons to live and grow back, as well as for connections to form and stay in place. If this process is slowed down, nerve damage and loss of work can happen faster.(7)

Amyloid-beta plaques and neurofibrillary tangles

Aβ plaques and neurofibrillary tangles (NFTs) are two of the most well-known signs of Alzheimer's disease that can be found in the brain. AMYL beta proteins build up in the brain and form A^2 plaques. The amyloid precursor protein (APP) is cut in a way that makes this happen. These plaques get in the way of nerve cells doing their normal jobs. They are found in the brain between nerve cells.(8) A strange phosphorylation of tau protein leads to neurofibrillary tangles. In most cases, tau protein is very important for keeping neurons' cytoskeletons in good shape. In Alzheimer's disease, on the other hand, the tau protein gets too much phosphorylation and stops working properly, which causes

it to get stuck inside nerve cells Nerve cells are breaking down because of this mess, which makes the brain work less well.(9)

Neuroinflammation and oxidative stress

Neuroinflammation and toxic stress play a big role in how Alzheimer's disease develops. When Aβ plaques and neurofibrillary tangles build up, immune cells such as microglia and macrophages are activated. This leads to an inflammatory reaction. The inflammatory reaction causes more cell damage in the brain and might make Alzheimer's disease progress faster. Free radicals are unstable chemicals that hurt cells. This is called oxidative stress (10)It is a disease that can happen to someone. There is proof that people with Alzheimer's disease have more oxidative stress in their brains. Free radicals can do a lot of damage to important parts of cells, like DNA, proteins, and lipids. Damage like this can make neurons less effective and, over time, kill cells).(11) This oxidative stress also contributes to the production and buildup of amyloid beta and the abnormal phosphorylation of tau protein, both of which can speed up the development of Alzheimer's disease.

Neuronal damage and synaptic dysfunction: Deciphering the Consequences of Pathological Changes

As Alzheimer's gets worse, brain cells and synapses become less healthy and less able to work. Understanding how synapses work is important for how information gets sent between neurons, which is a key part of how our brains work. The buildup of Aβ plaques and neurofibrillary tangles, along with neuroinflammation and oxidative stress, can make it hard for neurons to talk to each other and for synapses to work properly.(12) The main signs of Alzheimer's disease are forgetfulness and trouble learning new things. Nerve growth factor and other important external signalling molecules are out of balance in people with Alzheimer's disease. This balance is very important for neurons to live and grow back, as well as for making and keeping synapses. (13)Any problem with this process can speed up nerve damage and loss of function.

MECHANISM AND THEIR TREATMENT APPROACHES OF ALZHIMERS DISEASE

Alzheimer's disease is a complex neurodegenerative disorder characterized by a multifaceted pathology involving neuroinflammation and oxidative stress. These two interrelated mechanisms play a crucial role in the development and progression of the disease, leading to neuronal dysfunction and eventual cognitive decline. Understanding the intricate relationship between neuroinflammation and oxidative stress is essential for developing effective therapeutic interventions and improving patient outcomes as mentioned in table 1, 2 and 3.(14)

CHALLENGES IN EXISTING TREATMENTS OF ALZHEIMER'S DISEASE:

Alzheimer's disease (AD) is a complicated neurological condition that presents numerous difficulties for caretakers and researchers alike.(28) Even while our understanding of the disease's cellular and molecular causes has advanced significantly, we still lack effective treatments to stop the disease's progression and their challenges in existing treatment shown in figure 3.(29) The lack of trustworthy biomarkers makes it difficult to diagnose AD, which is one of the main obstacles in the area. Furthermore, the majority of treatment strategies focus on amyloid-beta plaques and have produced unsatisfactory outcomes.(30) A rising body of research suggests that future treatments for AD should take into account repurposing already-approved medications to target a variety of disease processes and as mentioned in table 4 and 5.(31)

Challenges of approved medications: (35)

Donepezil

Elevated levels can occur in individuals with liver dysfunction, those who metabolize CYP2D6 slowly, and in those taking concurrent inhibitors of CYP2D6 or CYP3A4, such as sertraline.

Galantamine

Levels may rise in individuals with hepatic and renal impairment, as well as in those who metabolize CYP2D6 slowly.

Memantine

The Canadian package label suggests regular eye examinations because of the potential deterioration of corneal disease. Reduction in clearance occurs with alkaline urine and impairment of liver and renal functions.

Rivastigmine

Concurrent use with β blocker therapy should be avoided. Clearance rates are heightened among smokers and diminished in instances of liver and moderate renal impairment. However, in cases of severe renal impairment, clearance rates are elevated.(42)

CONCLUSION

Undoubtedly, it's evident that there's a clear necessity for enhanced drug therapies to combat Alzheimer's disease (AD). The exploration of novel symptomatic treatments holds profound importance due to the incapacitating nature of these symptoms for patients. While significant strides have been made in understanding the disease, effective interventions targeting its underlying mechanisms remain elusive. The progress has been made in slowing disease progression and managing symptoms, the quest for a definitive cure persists. The evolving landscape of Alzheimer's research underscores the importance of continued exploration, innovation, and collaborative efforts to ultimately enhance the quality of life for individuals affected by this devastating condition. Moving forward, continued research, collaboration, and innovation will be vital in advancing treatment modalities and ultimately improving outcomes for individuals affected by Alzheimer's disease.

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Table 1: Mechanism of the Alzheimer's disease

Pathway	Mechanism	Impact on Alzheimer's
Neuroinflammation	Chronic activation of the immune system in the brain, leading to the release of pro-inflammatory cytokines and mediators.	Neuronal damage, synaptic dysfunction, and cognitive impairment. Exacerbates the formation of amyloid-beta plaques and neurofibrillary tangles. (14)
Oxidative Stress	Imbalance between the production of ROS and the body's antioxidant defense mechanisms.	Causes oxidative damage to cellular components which, leads to neuronal dysfunction and death. Impairs mitochondrial function and energy metabolism. (15)(16)
Amyloid-beta Accumulation	Aggregation and deposition of amyloid-beta peptides in the brain, forming insoluble plaques.	Initiates a cascade of events including synaptic dysfunction, neuroinflammation, and oxidative stress, ultimately contributing to neurodegeneration.
Tau Hyperphosphorylation	Abnormal hyperphosphorylation of the tau protein, leading to the formation of neurofibrillary tangles. (17)	Disrupts the normal function of tau, causing microtubule destabilization and neuronal dysfunction.(18)

Table 2: Different stages of mechanism of AD(19)

Early stage	Intermediate stage	Late stage
• In the early stages of Alzheimer's disease, neuroinflammation and oxidative stress begin to manifest, leading to the initial accumulation of amyloid-beta and hyperphosphorylation of tau protein.	• As the disease progresses, the self-perpetuating cycle of neuroinflammation and oxidative stress amplifies, further exacerbating the formation of amyloid-beta plaques and neurofibrillary tangles. This results in widespread neuronal dysfunction and synaptic loss.	• In the late stages of Alzheimer's, the cumulative effects of neuroinflammation, oxidative stress, and the accumulation of pathological proteins lead to extensive neurodegeneration and profound cognitive impairment. This ultimately culminates in the severe deterioration of the patient's mental and physical capabilities.

Table 3:Treatment Approaches

Sl. No	Treatment Approach	Drugs /Agents	Natural sources	Effective constituents
1.	Cholinesterase inhibitors	Rivastigmine & Tacrine	Salvia miltiorrhiza	Diterpene cryptotanshinone(20) (21)
2.	Amyloid-targeting	ALZ-801	Coptidisrhizoma	Berberine (22)(23)
3	Targeting tau	Atropine and Pirenzepine.	Cinnamomum zeylanicum Taxus Brevifolia	Cinnamaldehyde and Procyanidin Paclitaxel (24)(25)
4	Anti-inflammatory agents	NSAIDS like, Ibuprofen	nipponica Morus alba	Quercetin (26)
5	NMDAR antagonists	Phencyclidine, Ketamine, memantine, and Dizocilpine Memantine	Corydalis decumbens Platycladusorientalis	Protopine and (+)-tetrahydropalmatine 15-Ethoxypinusolidic (27)

Table 4: Discussing about several challenges in AD treatment:

Navigating Challenges in Alzheimer's Disease Treatment	Challenges in Exploiting Erythropoietin (EPO) as a Neurotherapeutic	Challenges in hydrogen therapy for AD
Focus on Early Detection: Determining AD biomarkers such as tau and Aβ42 at an early stage is critical for possible intervention.	**Difficulties with EPO in Neurotherapy:** Poor BBB penetration and blood-related side effects restrict EPO's ability to protect the brain.	**Challenges of Hydrogen Therapy in the Treatment of AD:** Its limited solubility creates obstacles that restrict the effective dosage that can be inhaled through gas and prevent its widespread use.
Study that is Gender-Specific: Due to women's increased risk of	**Improving EPO for AD Treatment:** Better EPO derivatives should emphasize	**Overcoming the Difficulties of Hydrogen Delivery:**

AD, specific study addressing hormonal and metabolic differences is needed to improve treatment efficacy for both genders. (32)	safety in addition to efficacy in neurodegenerative illnesses by optimizing brain delivery and treatment outcomes.(33)	Novel strategies are required to effectively cross the blood-brain barrier and deliver high quantities of liquid hydrogen to the brain.34)

Tables 5: Challenges of approved drugs:

DRUG	MECHANISM OF ACTION	CHALLENGES
1) Donepezil	A reversible non-competitive inhibitor of acetylcholinesterase.	Syncope, Insomnia, QT prolongation,Dizziness,Bradycardia,neuroleptic malignant syndrome.
2) Galantamine	Reversible, competitive inhibitor of acetylcholinesterase and a modulator of the nicotinic acetylcholine receptor.	Dizziness, syncope, falls, bradycardia, heart block. decreased appetite, weight loss., Stevens-Johnson syndrome, and other rashes.
3) Memantine	Non-competitive NMDA antagonist	elevated blood pressure and low blood pressure, along with constipation and diarrhoea. .
4) Rivastigmine	Acetylcholinesterase and butylcholinesterase inhibitor	Dizziness, syncope, falls, bradycardia, and heart block. Insomnia, fatigue, headache, and tremor, loss of appetite.

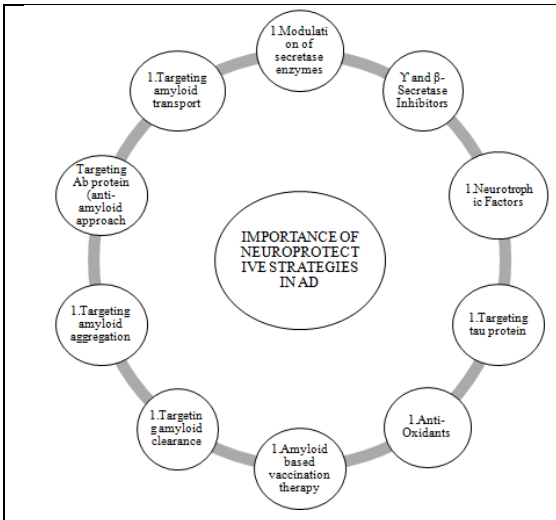


Figure 1:-Importance of neuroprotective strategies in Alzheimer's disease (1)

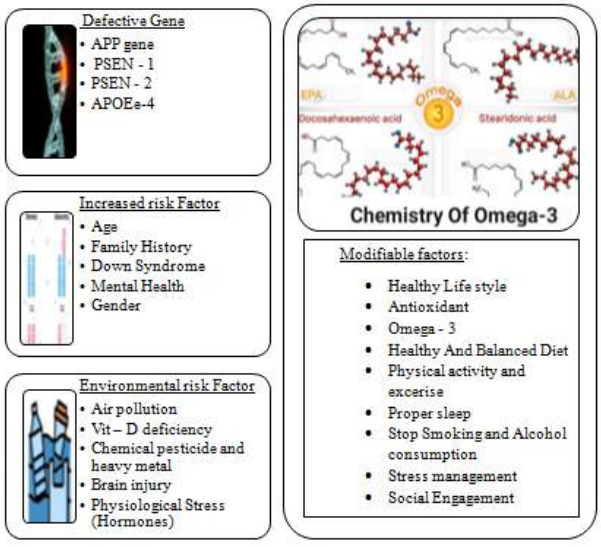


Figure 2: -Risk factors causing Alzheimer's disease.

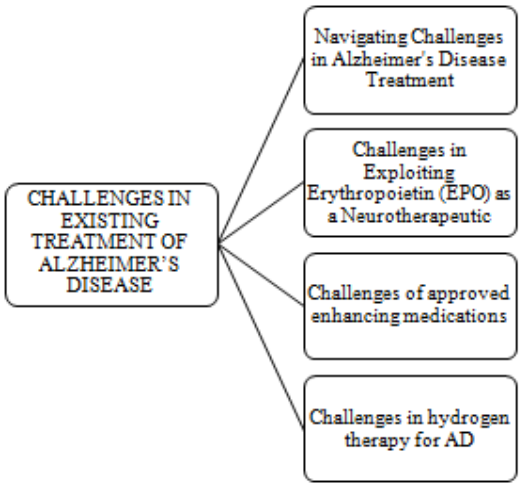


Figure 3: - Challenges in existing treatment in AD

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RESEARCH ARTICLE

Enhanced Biometric Identification Systems: Deep Learning-Based Fingerprint Classification with VGG16 Model

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ABSTRACT

Biometric systems authenticate individuals based on unique physiological or behavioral traits for identification and access control, providing heightened security compared to traditional password- based methods. Automatic fingerprint recognition is widely employed for its reliability and uniqueness, yet fingerprint classification remains challenging in large- scale recognition systems due to variability, noise, and ambiguity. This paper presents a deep learning approach to fingerprint classification, utilizing the VGG16 model for feature extraction and classification. By employing precise algorithms, our method accelerates identification by reducing the number of comparisons needed during fingerprint retrieval. Our framework, tested on the FVC2004 DB1 database, demonstrates significant advancements in accuracy, highlighting deep learning's efficacy in enhancing biometric identification systems.

Keywords: Fingerprint categorization, neural networks, VGG16 model, structure, identification, distinct, deep neural networks (DNN).

INTRODUCTION

In recent years, the concept of personal identity has become increasingly crucial, prompting the widespread adoption of biometrics as a preferred method of authentication. Biometrics is hailed as the most secure and robust means of authentication, surpassing traditional methods such as passwords [8]. These systems employ advanced technologies to uniquely and efficiently identify individuals, presenting a viable alternative to conventional password-based

approaches. A study reveals that users are opting for smartphone biometrics as a substitute for passwords due to its enhanced security features tailored for modern technologies. Biometrics operates as an automated validation method relying on physical or behavioral characteristics, including fingerprints, voice, face, iris, speaker recognition, keystroke dynamics, and signature verification [1]. Among these, fingerprint recognition stands out as a prominent biometric technology, renowned for its permanence and uniqueness in identity verification. Its applications range from access control with a limited user base to large-scale database searches for criminal investigations [2]. Fingerprint recognition techniques, particularly fingerprint minutiae-based methods, outperform traditional fingerprint pattern-based approaches by representing each fingerprint as feature vectors. These vectors efficiently filter through vast fingerprint databases to identify a match using automated matching algorithms. The success of a fingerprint recognition system hinges on its precision and efficiency, demanding discriminative and compact features. Most algorithms rely on minutiae's local structures for their discriminatory power and robustness. Recent research endeavors have delved into exploring the edges' structure to enhance recognition performance, primarily due to limitations encountered by minutiae-based algorithms in small areas containing few minutiae. This paper explores representing the structure of fingerprint edges using Deep Neural Networks (DNNs). DNNs excel in learning complex, high-dimensional, nonlinear mappings from extensive datasets, thereby ensuring the extracted features remain somewhat invariant to nonlinear distortions [3].

LITERATURE SURVEY

Conventional methods for finger-vein recognition rely on the extraction of vein patterns from input images or the enhancement of these images to extract surface features. However, inaccuracies in detecting these vein patterns can significantly undermine recognition accuracy. Moreover, selecting the optimal filter for surface feature extraction poses a considerable challenge due to the diverse characteristics inherent in different image databases. To tackle these issues effectively, this study proposes a novel finger-vein recognition approach based on convolutional neural networks (CNNs), designed to exhibit robustness across various database types and environmental conditions Through rigorous experimentation utilizing both proprietary finger-vein databases and the widely used SDUMLA-HMT finger-vein database, the proposed method showcases superior performance when compared to traditional techniques [4]. Furthermore, another significant endeavor investigates the impact of convolutional network depth on accuracy within the realm of large-scale image recognition. This study meticulously evaluates networks of increasing depth using architectures featuring small (3×3) convolution channels. Intriguingly, the findings reveal that substantial enhancements over existing configurations can be achieved by elevating the depth to 16–19 weight layers. Additionally, the study demonstrates the robust generalization capabilities of their representations across diverse datasets, thereby achieving state-of-the-art results. Notably, to foster further advancements in leveraging deep visual representations within computer vision, the authors have made two highly effective ConvNet models openly accessible [5]. Moreover, this paper introduces a groundbreaking framework termed collaborative and context-aware visual query answering (C2VQA) aimed at seamlessly integrating multi-modal data streams. This framework is intricately designed to address the specific challenges inherent in biometrics forensic integration (BFI), leveraging methodologies akin to Show and Tell models. By extending the principles of Visual Query Answering (VQA) and the Visual Turing Test (VTT), C2VQA bridges deep semantic analysis and joint embedding using sophisticated deep learning techniques. Its repertoire includes utilizing vector space as skip-grams and leveraging long-term dependencies via gated recurrent networks for context prediction. Furthermore, employing multi- task learning, including conformal prediction, enables enhanced control and meta-reasoning. Most notably, C2VQA adopts an interactive dialogue approach to rectify misinformation and uncertainty, thereby adeptly handling realistic VQA challenges prevalent in open-ended scenarios [6].

Our Approach

OVERVIEW OF METHODOLOGY

Convolutional neural networks (CNNs) have emerged as powerful tools for image processing and object classification, particularly since 2012 when they began outperforming other machine learning techniques across various datasets. This success prompted the decision to construct a deep learning-based classifier. Given the limited availability of data to train the system from scratch, we employed several workaround strategies to develop robust classifiers. The macro-architecture of VGG16 can be seen in Figure 1. The name "VGG" originates from the Visual Geometry Group at Oxford University. Their seminal work emphasized the significance of network depth in the advancement of CNNs for image classification, advocating for the use of even relatively small 3x3 convolution filters. The VGG16 architecture comprises five blocks of convolutional layers: the first two blocks consist of 2 layers each, while the last three consist of three layers each. Each block is followed by a max-pooling layer of size 2x2, down sampling the input four times post-pooling. Subsequent to the fifth convolutional block, two fully- connected layers with 4096 neurons each are present, followed by a final fully- connected layer with 1000 neurons. ReLU activation is applied to neurons in each hidden layer, while Softmax activation is

employed for neurons in the last fully- connected layer.

Datasets and Implementation

The process described involves preparing a dataset for training and testing a Deep Neural Network (DNN), specifically the VGG16 model, for finger image classification. Here's a breakdown of the steps taken:

Data Collection and Organization

A set of 10 distinct finger images, representing the digits 0 through 9, was gathered. Each finger class comprises 8 unique images of the same finger, each exhibiting different impressions or variations. These images were then resized to a standardized dimension of 150x150 pixels to ensure uniformity in the dataset.

Data Augmentation

To augment the dataset and introduce variability, each of the 8 images within a class was duplicated. This resulted in a total of 480 images per class, multiplying the initial 8 images by 60 times (8 * 60 = 480).

Dataset Composition

The final dataset consists of 4800 images in total, with each finger class containing 480 images.
Out of these, 3840 images were allocated for training the DNN (VGG16 model), while the remaining 960 images were reserved for testing purposes.

Training and Testing Split

The dataset was divided into two subsets: a training set and a testing set. The training set, comprising 3840 images, was used to train the DNN, enabling it to learn the patterns and features necessary for finger image classification. The testing set, consisting of 960 images, was kept separate and used to evaluate the performance of the trained model.

Visualization

Figure 2 in the document likely illustrates a subset of images from the prepared dataset, showcasing examples of finger images belonging to different classes. These visualizations provide a glimpse into the diversity and variability present within the dataset, highlighting the different impressions and variations of each finger across the classes. Overall, this rigorous dataset preparation process ensures that the trained DNN model is exposed to a diverse range of finger images, facilitating robust learning and accurate classification of finger images based on their respective classes.

Working model of VGG16 for image classification

The VGG16 network architecture is widely used for image classification tasks and consists of multiple layers designed to process input images and produce classification results. Here's a detailed explanation of how the VGG16 model works:

Layer Architecture Overview

The VGG16 architecture, as depicted in Figure 3, comprises several layers organized in a sequential manner, resembling a multilayer feedforward process.

The input image is fed into the network, and it traverses through each layer successively until it reaches the output layer, where the final classification result is obtained.

Convolutional Layers and Down- Sampling

At the initial layer, VGG16 employs 3x3 convolutional filters with a stride of 2 to down-sample the input by a factor of two, similar to the effect of a pooling layer. This down-sampling operation reduces the spatial dimensions of the input while extracting relevant features. Following the initial layer, there are three consecutive blocks of convolutional layers before another down-sampling operation is performed using a similar convolutional layer without pooling. This pattern of down-sampling followed by convolutional layers continues for several layers deep within the network.

Final Layer and Classification

The final layer of the VGG16 network architecture is a global average pooling layer, which generates one thousand feature maps (for ImageNet datasets) and averages them to obtain a final output. The resulting output is a one-thousand- dimensional vector representing the likelihood scores for each class in the classification task. This vector is then fed into a softmax layer, which applies the softmax function to produce probability scores indicating the likelihood of the input image belonging to each class. The class with the highest probability score is selected as the predicted class for the input image.

Activation Function

Throughout the convolutional layers, the rectified linear unit (ReLU) activation function is used. ReLU introduces non-linearity into the network, enabling it to learn complex patterns and features from the input images.

$$\mathbf{f(y) = max\ (y,\ 0)}$$

In summary, the VGG16 architecture effectively processes input images through convolutional and pooling layers, extracting features and performing down- sampling operations to facilitate accurate image classification. The final classification result is obtained by passing the output through a softmax layer, with ReLU activation functions used for non- linear transformations within the network.

Experiments

In this section, we delve into the details of the datasets utilized in our analyses and outline the key aspects of our methodology. We begin by introducing the datasets employed and elucidate the rationale behind our chosen approach. Subsequently, we explore various metrics for evaluating performance and discuss different data preprocessing techniques. Finally, we conduct a comparative analysis with state- of-the-art methods and present our findings. Our approach involves leveraging Transfer Learning, a technique that entails borrowing knowledge acquired from a pre- trained network designed for image classification tasks. Specifically, we utilized the VGG16 network, which was originally trained on the FVC2004 dataset. This network exhibited strong performance, making it a suitable foundation for our classifiers. Additionally, we partitioned the FVC2004 dataset, comprising 4800 images, into distinct classes to facilitate classification tasks. The model training process can be divided into two main stages: feature extraction and model fine-tuning. During feature extraction, the VGG16 network is utilized to extract relevant features from the input images. Subsequently, the model is fine- tuned to adapt its parameters to the specific characteristics of our dataset. The proposed method employs 4800 images, each sized 150x150 pixels, for training. The total number of parameters involved in the training process, computed layer by layer, amounts to 15,781,194. Details

regarding the number of parameters and the output shape of each convolutional layer are presented in Table 1 for reference. By employing Transfer Learning with the VGG16 network and meticulously training our model, we aim to achieve superior classification performance and contribute to the advancement of image processing techniques.

Efficiency evaluation

The computational efficiency of feature extraction is assessed by implementing the proposed methodology using Python programming language with Tensorflow. This involves utilizing Python and Tensorflow to execute the feature extraction process efficiently, allowing for a thorough evaluation of the method's performance in terms of computational speed and resource utilization.

CONCLUSION

This paper utilizes the VGG16 framework as a foundational architecture to develop deep neural models for novel finger impression verification. Two key figures, Figure 4 and Figure 5, are presented to illustrate the training and testing performance of the VGG16 model. This figure depicts the accuracy of the VGG16 model during the training and testing phases. It provides insights into how well the model performs on both the training data (used for training the model) and the testing data (used for evaluating the model's generalization to unseen data). By comparing the training and testing accuracies, researchers can assess the model's ability to learn from the training data and make accurate predictions on new, unseen data. Figure 5 illustrates the loss (error) incurred by the VGG16 model during the training and testing phases. The loss metric quantifies the difference between the predicted outputs of the model and the actual labels in the dataset. A lower loss indicates better performance, as it suggests that the model's predictions are closer to the ground truth labels. By monitoring the training and testing loss over epochs,

researchers can evaluate the model's convergence and generalization ability.

Additional Insights

In this task, the authors note that no additional modification beyond adjusting the input image sizes was necessary. This suggests that the VGG16 framework, with its robust architecture, is capable of accommodating changes in input data without requiring extensive modifications to the model architecture. Moreover, the authors highlight the potential of utilizing powerful neural networks like VGG16 in broader authentication and verification efforts. They suggest that as deep neural networks continue to evolve, improvements in training speed, performance, and model flexibility can significantly enhance their applicability in image verification tasks and other domains. In summary, this paper demonstrates the effectiveness of the VGG16 framework for finger impression verification tasks and underscores the broader potential of deep neural networks in authentication and verification applications.

FUTURE WORK

The proposed strategy for fingerprint verification offers potential for extending to latent fingerprints, addressing challenges in forensic science. Leveraging partial fingerprint images and noise simulation enhances the model's ability to handle noisy data. Adapting the model to latent prints involves training on diverse datasets to extract relevant features despite noise and partial visibility. Further improvements can be achieved by exploring advanced neural network architectures like ResNet, DenseNet, or EfficientNet. Additionally, integrating specialized fingerprint recognition algorithms such as minutiae- based matching or ridge-based methods can enhance accuracy. Overall, extending the strategy to latent fingerprints promises to enhance forensic identification capabilities through improved accuracy and versatility.

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Table: 1 VGG16 Parameter with output Shape

VGG16 Layers	Output Shape	No. of Parameters
CONV-64	(None, 150, 150, 64)	1792
CONV-64	(None, 150, 150, 64)	36928
CONV-128	(None, 75, 75, 128)	73856
CONV-128	(None, 75, 75, 128)	147584
CONV-256	(None, 37, 37, 256)	295168
CONV-256	(None, 37, 37, 256)	590080
CONV-256	(None, 37, 37, 256)	590080
CONV-512	(None, 18, 18, 512)	1180160
CONV-512	(None, 18, 18, 512)	2359808
CONV-512	(None, 18, 18, 512)	2359808
CONV-512	(None, 9, 9, 512)	2359808
CONV-512	(None, 9, 9, 512)	2359808
CONV-512	(None, 9, 9, 512)	2359808
FC	(1x1x128)	1048704
FC	(1x1x128)	16512
Predictions	(1x1x10)	1290

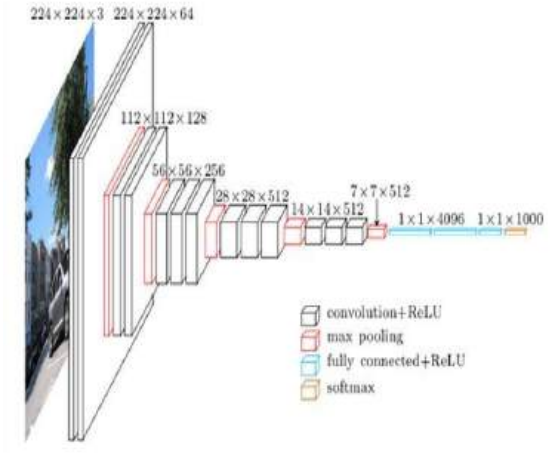


Figure 1: Macro-architecture of VGG16



Figure 2: FVC2004 dataset [13]

InputLayer: input_1-InputLayer
Block 1:
block1_conv1: Conv2D
block1_conv2: Conv2D
block1_pool:MaxPooling2D
Block 2:
block2_conv1: Conv2D
block2_conv2: Conv2D
block2_pool:MaxPooling2D
Block 3:
block3_conv1:
Conv2D**block3_conv2**:
Conv2D**block3_conv3**:
Conv2D
block3_pool:MaxPooling2D
Block 4:
block4_conv1:
Conv2D**block4_conv2**:
Conv2D**block4_conv3**:
Conv2D
block4_pool:MaxPooling2D
Block 5:
block5_conv1:
Conv2D**block5_conv2**:
Conv2D**block5_conv3**:
Conv2D
block5_pool:
MaxPooling2D**Flatten Layer**:
flatten –

Figure 3:VGG16 network layer architecture

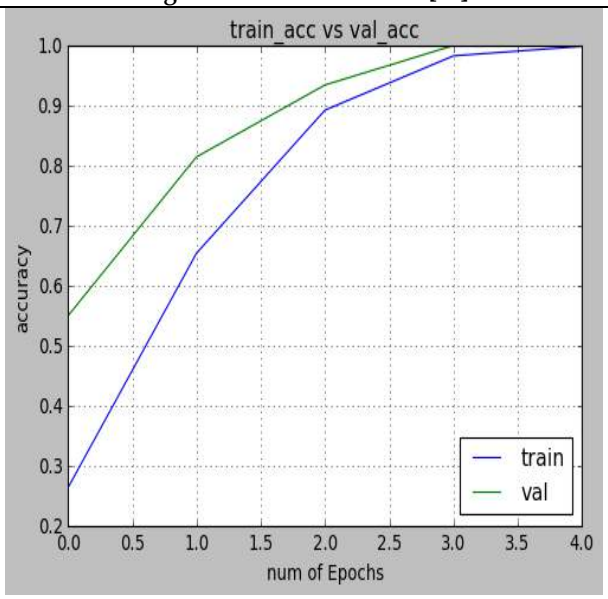


Figure 4: VGG16 Training vs. Testing Accuracy

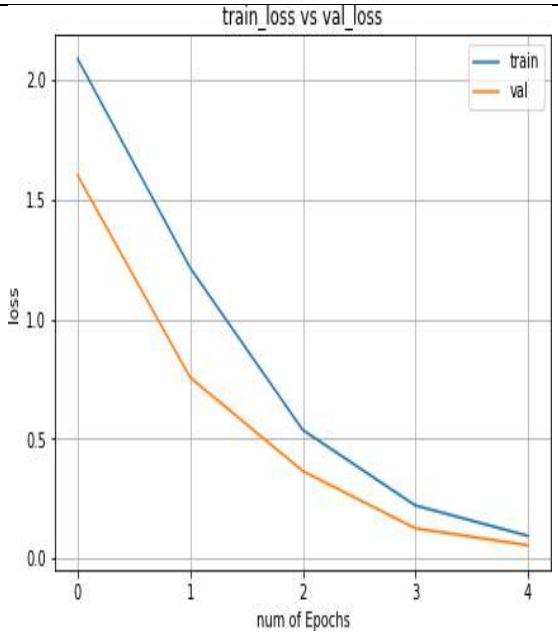


Figure 5: VGG16 Training vs. Testing Loss

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RESEARCH ARTICLE

Exploring the user Experience Design of a Website for Mental Health

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ABSTRACT

In recent years, mental health issues have become a widespread concern, with many individuals experiencing the adverse effects of stress and burnout in their daily lives. The media and social networks have played a vital role in raising awareness and highlighting the impact of mental health issues on society. Despite the long-standing attention given to mental health, the priorities and resources dedicated to this issue have been worryingly low due to several concerns such as the cost of seeking medical consultation and trustworthiness of the medical professionals. Online platforms and discussion forums have emerged as a viable alternative to traditional medical consultation, providing guidance and support to those suffering from mental health issues. However, the usability and user experience of these online platforms are critical factors that determine user satisfaction and, ultimately, their effectiveness in promoting recovery. This study aims to investigate the impact of usability and user experience design on user satisfaction and identify ways to improve these factors. The study uses usability testing and heuristic evaluation as the primary methodologies to achieve these objectives.

Keywords: Usability, User Experience Design, Online Platforms, User Satisfaction, Heuristic Evaluation, Usability Testing

INTRODUCTION

The COVID-19 pandemic has had a significant impact on mental health. While early concerns about the virus focused on respiratory failure, new data suggests that the pandemic's effects are more widespread. Public health measures taken to curb the spread of COVID-19 disrupted daily life for many people around the world, leading to increased psychological difficulties. However, access to evidence-based therapies is limited, with only a small percentage of individuals with mental health issues having access to effective treatments. (Knapp and Wong, 2020). Despite the growing need for mental health support, the effectiveness of technology-driven interventions remains low due to usability concerns. Many mobile health websites are available, but few have undergone usability testing. Simply having a mental health application on a device does not guarantee its usage or efficacy in improving mental health. Collaboration among healthcare providers, technology developers, and mental health experts is vital to address limitations in technology-driven interventions. Online mental health interventions have the potential to provide accessible care to people in rural areas and those who prefer anonymity. However, these interventions face challenges related to usability, effectiveness, accessibility, cost, and availability. Furthermore, evidence suggests that people rarely use mental health applications for extended periods. (Christensen and Griffiths, 2002, Farrell and McKinnon, 2003). This study aims to identify areas of poor user experience in mental health websites and provide recommendations for improvement. One example of an independent mental health website is Psych Central, which is edited and authored by mental health experts. Psych Central has been recognized as one of the 50 Best Websites on the Internet and receives six million unique visitors monthly. Health line acquired Psych Central in 2020. The significance of user-centered and UX design has surged in recent decades, especially with the proliferation of computers in workplaces. UX design revolves around a user's emotions, preferences, perceptions, physical and psychological reactions, behaviours, and achievements before, during, and after engaging with websites or applications. A product's success often hinges on its user experience, a highly subjective, dynamic, and variable aspect. User experience is influenced by three main factors: the system, the user, and the usage context. Usability testing assesses system usability, gathering data and recommendations to enhance interfaces in software development. Usability refers to how easily and efficiently a website or web application can be used by individuals, even without prior internet experience. It aims to ensure that users can navigate and interact with a digital product without frustration. Key usability goals include clear information presentation, intuitive search functions, and adherence to established user mental models. User experience, on the other hand, takes a holistic approaches, considering users' thoughts, emotions, and perceptions throughout their interaction with a product. Improving usability can enhance user comfort while utilizing the site and increase site popularity, benefiting both users and service providers. (McLellan *et al*. 2012)

RELATED WORKS

A systematic approach to usability through testing ensures a better user experience. By observing users, we identify what works and what doesn't, leading to improved interface design. Usability testing is now integral throughout development, particularly for web applications. (Shneiderman and Plaisant, 2005).

Usability in websites

As per ISO standards, Usability encompasses effectiveness, efficiency, and user satisfaction in achieving specific goals. It involves a software product's capacity to be understood, learned, and appealing to users under specific circumstances. In 1993, Nielsen acknowledged the importance of usability, defining it as about learnability, efficiency, memorability, errors, and satisfaction (Nielsen, 1992b). To design useful websites, the first step is understanding the user's needs and characteristics. Web usability has its roots in research on user-centered design and human-computer interaction, and highly usable websites are those that are clear and intuitive to the user. Web design combines graphic design and usability engineering, which have differing ideas about what constitutes a successful user interface. (Lazar.et .al, 2006). An interface should not be created only for aesthetic appeal or for use by

people with disabilities. It would score significantly higher on usability tests if they were created using the three concepts of early attention on users, empirical measurement, and iterative design.

Usability in Mental Health sites

Usability is a critical aspect of human-computer interaction that determines the effectiveness of a user interface. It ensures that the product is user-friendly, efficient, and engaging. In the past, software developers focused on creating programs with the most functionality, but as more features were added, usability became a crucial problem. Poor usability causes the majority of development projects to fail, primarily due to the lack of user involvement and incomplete user needs assessment. Poor usability is a contributing factor to low engagement with mental health applications. A contributing element is the poor 18 usability of mental health applications (Torous *et al.* 2018). For instance, a usability test of four popular mood tracking applications found that more than 50% of individuals with depressive disorders encountered some level of difficulty and took an excessive amount of time to enter their mood as data into the site and eventually retrieve this data (Sarkar et al. 2016). Investigation into user's use of health applications included a nationwide survey. They found that the time needed to enter data (a usability issue) was the main deterrent to using applications, followed by losing interest and learning about hidden charges. (Krebs, P, Duncan, D.T., 2015). Therefore, both producers and users can benefit from good usability in terms of costs, support, competition, quality, training, support, satisfaction, productivity, reduce time, easiness, efficiency, effectiveness, and saving time.

Usability Testing and Evaluation Method

Usability testing is an essential tool for identifying usability issues in a website or product. Choosing the right testing method is crucial to determine a system's usability and pinpoint issues. (Shneiderman and Plaisant, 2005). User experience questionnaires are used to measure the subjective attitude of the user toward the test object (B. Laugwitz et al. 2008). There are different types of testing techniques, inquiry techniques, and inspection techniques, each adhering to a set of activities. Remote usability testing is an effective method used when usability specialists and test subjects are in different locations, offering the benefits of flexibility and cost savings. (Tom,2009). Heuristic evaluation can be used in the early stages of software development, while formal user testing can only be used after interface design has been implemented. SUS is a cross-sectional approach to examine how user profiles affect ratings for items that make use of one such instrument (S. McLellan, 2012). The ten ratings are added up to produce a broad indicator of perceived usability. There are five uplifting and five derogatory statements (A. Bangor *et al*. 2009).

PROPOSED METHODS

Usability tests and Heuristic evolution were adopted for the study. The facilitator, tasks, and participant are the main components in the majority of usability tests. The facilitator assigns tasks, observes behaviour, and provides feedback. Follow-up questions may be asked to gather more information. Usability testing involves real-life tasks for participants and can be either specific or open-ended depending on study objectives and testing type. The testing should involve a realistic user performing tasks created by the facilitator and providing feedback.

Task setup

Users were briefed about the test before conducting the test. Test was conducted in remote manner. The test was conducted with 10 participants between the age 20-40. Tool used for the user testing is 'User brain' an online platform. 'User brain recorder' will automatically starts the screen recording and audio recording. 'User brain manager' was used to analyze and interpret the data which were collected from the questionnaire. Facilitator conducted the test and observed the user's actions on the screen.

User Experience Questionnaire (UEQ)

The user experience questionnaire (UEQ) is a commonly used survey to gauge consumers' subjective opinions about the usability of products. The table below shows 6 scaling factors and their corresponding questionnaires.

System Usability Scale (SUS)

System Usability Scale (SUS) used to assess the usability of a wide range of web-based or technology-based applications in order to enhance them. It comprises a 10-item questionnaire with five possible responses—strongly agrees to strongly disagree—given to respondents. This is used to find out the overall usability level of the system which was taken for the study. This table can be used to gauge whether the application's usability is satisfactory or not.

Heuristic Evaluation

The process of heuristic evaluation involves specialists using general guidelines to assess the usability of user interfaces during independent walkthroughs and indicate problems. According to 10 heuristic principles the expert will inspect the site and give their report in a way to evaluate the user experience of the site. The interviewers' expertise and daily experience allowed them to give technical advice on usability and suggest improvements and provide valuable insights on cutting-edge market strategies.

RESULT ANALYSIS AND INTERPRETATION

Usability test was conducted with 10 participants such as 5 Male and 5 Female users to find out the user experience level of mental health sites. Tests were performed on desktop and mobile phones in asynchronous remote testing method and psych central website with 8 tasks. Test was on psych central website with 8 tasks. Test results were collected from all the participants and concluded the test with the help of theoretical frameworks like UEQ and SUS and feedback from the users. Every user in User testing successfully completed their task and responded to all questionnaire. In 10 participants 5 users were uses similar websites often, 2 of them uses sometimes, 1 user always uses similar websites, 1 user uses rarely and 1 usernever used a similar website.

User experience questionnaire

User Experience Questionnaire has 3 main scales. They are attractiveness, pragmatic quality, and hedonic quality. Pragmatic quality has three sub scales perspicuity, efficiency and dependability Hedonic quality has two sub scales Stimulation and Novelty. The items are scaled from -3 to +3. Thus, -3 represents the most negative answer, 0 a neutral answer, and +3 the most positive answer. According to the data interpretation on UEQ user satisfaction level is good which shows in figure1.

System Usability Scale

All values are scaled here from 0 to 4. Instead of changing the range of potential values from 0 to 40, this changes it to 0 to 100. Anything with a SUS score of 68 or higher wouldbe deemed above average, whereas anything with a score of 68 or lower would be considered below average.

Correlation Test

The strength of a relationship between two variables is measured by Correlation Analysis (CA). Correlation is significant at 0.05 level for all analysis.

According to the data interpretation on SUS user satisfaction level is 70%. According to the table designed by Bangor, the value of all design belongs to the acceptable category which is above 70. The gathered SUS score for this site was 70.5 which was considered too comes under interpretation acceptable. Majority of users feels that the system was easy to use. Users felt very confident while using the site. Most of the visitors feel that they needed to learn a lot of things before they could get going with this site. Visitors don't believe that most people would learn to use this site very quickly. Users thought that they need the support of a technical person to be able to use this system

Interpretation

The interface's usability and user experience are both fair to good. There are several functions and tasks that don't operate correctly or have a few minor problems. Users are generally happy with the UI, even though there are a few small usability issues.

CONCLUSION

According to the usability test and heuristic evolution employed in the study, Psych central's usability and UXD are above average. The interface includes problems with page clutter, inconsistent font sizes, and the usefulness of some buttons, according to data from focus groups and the heuristic evolution study. Users believe that the interface's usability isgenerally decent even when it has such issues. Users are fairly content withthe system.There are so many studies needed on the mental health application and sites. This study has helped in understanding the user experience and theusability of the mental health site reference to psych central.

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Table 1: UEQ Scaling Measures

scales	Questionnaires
Attractiveness	How does the product fare with customers?
Perspicuity	Is it simple to become accustomed to the product? How easy is it to utilize the system?
Efficiency	Can users do their duties with minimal effort?
Dependability	Does the user perceive themselves as in charge of the interaction?
Stimulation	Is using the product interesting and inspiring?
Novelty	Does the product exhibit creativity and innovation? Are customers interested in the product?

Table 2: Usability satisfaction level according to SUS

SUS SCORE	Interpretation
<50	Not Acceptable
50-70	Marginal
>70	Acceptable

Table 3: Mean values for the main scales of UEQ

SCALE	MEAN VALUE	INTERPRETATION
Attractiveness	1.016667	Above average
Pragmatic quality	0.941667	Below average
Hedonic quality	0.9375	Above average

Table 4: Mean values for the sub scales of UEQ

SUB SCALE	MEAN VALUE	INTERPRETATION
Attractiveness	1.016667	Above average
Perspicuity	0.75	Below average
Efficiency	1.25	Above average
Dependability	0.825	Below average
Stimulation	0.775	Above average
Novelty	1.1	Good

Table 5: Interpretation of Pearson Correlation Coefficients

Correlation coefficient (r)	Variable 1	Variable 2	Interpretation
0.678	Enjoyable	Efficiency	A high level of site efficiency leads to a more enjoyable user experience.
0.670	Friendly Level	Motivated Feel	A user's motivation to use a site increases when the site is perceived as user-friendly and easy to use.
.760	Understand ability	Efficiency Level	When the site is easy to understand, visitors find it efficient to use.
0.635	Efficiency Level	Secure Feel	Visitors perceive a site as efficient when it is secure
0.638	Organized Feel	Innovative Level	A well-organized site tends to be more innovative, while a disorganized site is often less innovative
-0.924	Expectation Meet Level	Boring Level	A site that fails to meet user expectations can become boring and lose user engagement
0.730	Expectation Meet Level	Interesting Level	A site is considered interesting to users when it meets their expectations, leading to satisfaction
0.692	Attractiveness	Stimulation	A good level of attractiveness in the site increases its

			stimulation sub-scale, leading to increased motivation and interest for the user.
0.698	Efficiency	Perspicuity	Efficient sites increase the Perspicuity sub scale, making them easy and clear to understand for users

Table 6: Overall mean value and interpretation of SUS

Mean value	Interpretation
70.5	Acceptable

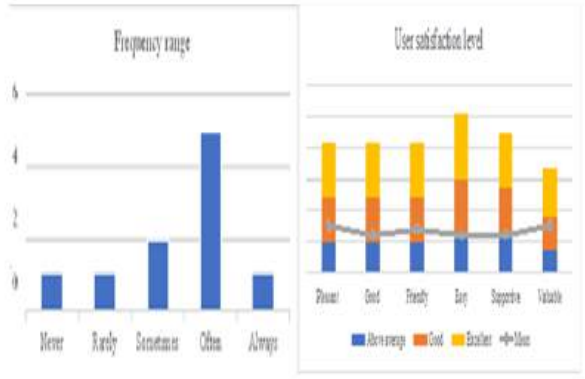


Figure 1. Frequency range among Focus Group and User satisfaction level according to UEQ

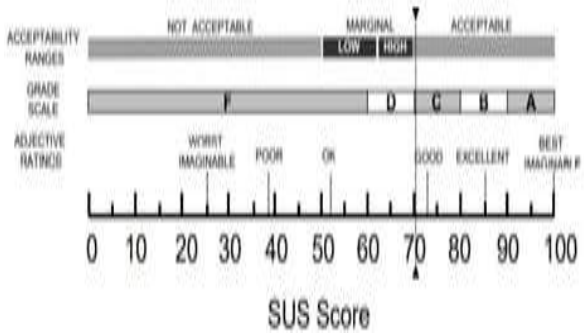


Figure 2. SUS Score of psych central web portal on Bangor's scale

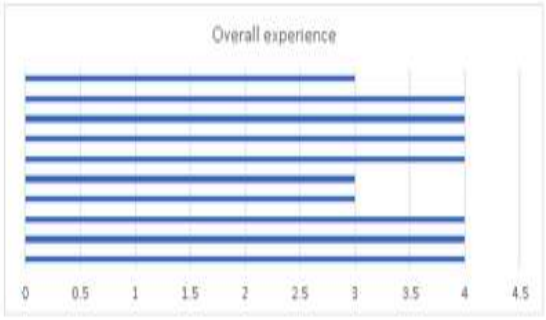


Figure 3.User satisfaction according to feedback

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RESEARCH ARTICLE

d-Lucky Number of Derived Graphs

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ABSTRACT

In this paper we apply a d-lucky labeling on some special graphs like tadpole graphs, sun graphs, lollipop graphs, friendship graphs and its generalizations. We prove that these graphs admit d-lucky labeling and also find a sharp bound for the d-lucky number for the same.

Keywords: Lucky labeling, d-lucky labeling, Tadpole Graph, Lollipop Graph, Sun Graph, Friendship Graph.

INTRODUCTION

In this paper, we consider all graphs are simple, undirected and connected. Moreover specifically we dealt with some special structured graphs like tadpoles, lollipops, friendship etc. The concept of labeling first introduced by A. Rosa [7] which means assignment of label to the vertices or edges or both subject to the conditions. It has many applications such as scheduling exams, sports, flight schedules etc. The idea of lucky labeling was first proposed by Czerwinski et.al in [2] and elaborates the concept of d-lucky labeling by Indira Rajasingh *et.al* in [1]. In this paper, we obtained sharp bound of d-lucky number for the friendship graph and its generalization, tadpole graph, fan graph is two and also found sharp bound for lollipop graph and sun graph.

d- lucky labeling
Definition 2.1:[1]
Let $l: V(G) \rightarrow N$ is a vertex labeling. If for each pair of incident vertices of u and $v, c(u) \neq c(v)$ holds where

$c(u) = \mathrm{d(u)} + \sum_{\mathrm{v\in N(u)}} l(\mathrm{v})$, $c(v) = \mathrm{d(u)} + \sum_{\mathrm{u\in N(v)}} l(\mathrm{u})$,
Where d(u) represents the degree of u and $N(u)$ represents the open neighborhood of the vertex u in a graph, then the labeling l is a d-lucky labeling. A graph's d-lucky number is the smallest value of labeling required to label the graph.

Some special classes of graphs with $\eta_{dl}(G) = 2$
Definition 3.1:[4] A tadpole graph $T(p,q)$ is obtained from a cycle C_p and a path P_q by identifying a vertex to C_p to an end vertex of P_q.

Theorem 3.2: For a tadpole graph $T(p,q), p \geq 3, \eta_{dl}(T(p,q)) = 2$

Proof: Label the vertices of $T(p,q)$ as 1 and 2 alternatively, beginning with label 1 from left to right. The case p is even. Since $l(x) = 1$ and each member of $N(x)$ is labeled 2, we have $c(x) = \sum_{y\in N(x)} l(y) + d(x) = 6$. Since $l(y) = 2$ and each member of $N(y)$ is labeled 1, we have $c(y) = \sum_{x\in N(y)} l(x) + d(y) = 4$. Since the last vertex of C_p in $T(p,q)$ is labeled as 1,we have $c(x) = \sum_{y\in N(x)} l(y) + d(x) = 9$. Since label of the last vertex of T(p,q) is 1 or 2, then we have $c(y) = 3$ *or* 2. Thus $c(x) \neq c(y)$. The case p is odd. Since the first and last vertices of C_p in $T(p,q)$ are labeled 1,we have $c(x) = \sum_{y\in N(x)} l(y) + d(x) = 5$, $c(y) = \sum_{x\in N(y)} l(x) + d(y) = 8$. Since $l(x) = 1$ and each neighbor vertex of x is labeled 2, we have $c(x) = \sum_{y\in N(x)} l(y) + d(x) = 6$. Since $l(y) = 2$ and each neighbor vertex of y is labeled 1, we have $c(y) = \sum_{x\in N(y)} l(x) + d(y) = 4$. Thus $c(x) \neq c(y)$. It is clear that d- lucky sum of adjacent vertices are distinct. Hence $\eta_{dl}(T(p,q)) = 2$. See figure 1 for d- lucky labeling of tadpole graph $T(6,9)$.

Definition 3.3:[4] A collection of p triangles with a common vertex makes up a friendship graph, it is denoted by f_p.

Theorem 3.4: The d-lucky number of friendship graph f_p is 2.

Proof: Let G be a friendship graph f_p. Label the common vertex 'a' of a graph G as 1 and label all the other vertices of a graph G as 1 , 2 alternatively. Since $l(a) = 1$ and each neighbor vertex of x is labeled 1or 2, we have $c(a) = \sum_{y\in N(a)} l(y) + d(a) = 5p$. Since $l(x) = 1$ and each neighbor vertex of x is labeled 2, we have $c(x) = \sum_{y\in N(x)} l(y) + d(x) = 5$. Since $l(y) = 2$ and each neighbor vertex of y is labeled 1, we have $c(y) = \sum_{x\in N(y)} l(x) + d(y) = 4$. It is clear that no two adjacent vertices have the same d- lucky sum. Hence fan graph admits d- lucky labeling and η_{dl} (G) is 2. See figure 2 for d- lucky labeling of friendship graph f_6.

Definition 3.5:[4] The generalized friendship graph $f_{p,q}$ is a collection of p cycles (all of order q) meeting at a common vertex.

Theorem 3.6: For generalized friendship graph $f_{p,q}$, $\eta_{dl}(f_{p,q}) = 2$.

Proof: Let G be a generalized friendship graph $f_{p,q}$. Label the common vertex 'a' of a graph G as 1 and label all the other vertices of a graph G as 1 and 2 alternatively. If $l(a) = 1$ then we have $c(a) = \sum_{x\in N(a)} l(x) + d(a) = 5p$ When q is odd, $c(a) = 4p$ when q is even. Since $l(x) = 1$ and each neighbor vertex of x is labeled 1 or 2 then we observe that $c(x) = \sum_{y\in N(x)} l(y) + d(x) = 5$. Since $l(x) = 2$ and each neighbor vertex of y is labeled 1, we have $c(x) = \sum_{y\in N(x)} l(y) + d(x) = 4$. It is clear that d- lucky sum of all the vertices in a generalized friendship graph are pair wise distinct. Hence $\eta_{dl}(f_{p,q}) = 2$. See the figure 3 for d-lucky labeling of generalized friendship graph $f_{6,4}$.

Definition 3.7: [4]A fan graph F_k $(n \geq 2)$ is obtained from $P_k = V_1 V_2 V_3 \ldots V_k$ by joining a vertex u to every vertex of P_k.

Theorem 3.8: For a fan graph F_k, $\eta_{dl}(F_k) = 2$.

Proof: Let $G = F_k$ be a fan graph. Label the vertices in G as 1 and 2 alternatively, beginning from the common vertex u. If $l(u) = 1$, by labeling of G the adjacent vertices of x are labeled as 1 and 2 alternatively, then we have $c(u) = \sum_{v \in N(u)} l(v) + d(u) = \lceil 5k/2 \rceil$ where $d(u) = k$. Consider x_i be the vertices of the path P_k. Since $l(x_1) = 2$ and each member of the open neighborhood $N(x_1)$ is labeled 1, we have $c(x_1) = 4$. For $2 \leq i \leq k-1$, If $l(x_i) = 1$ and each neighbor vertex of x_i is labeled 1 or 2 then we have $c(x_i) = 8$. Since $l(x_i) = 2$ and each neighbor vertex of x_i is labeled as 1, we have $c(x_i) = 6$. Suppose $l(x_k) = 1$, then we have $c(x_k) = 5$. Suppose $l(x_k) = 2$, we have $c(x_k) = 4$. It is clear that, no two adjacent vertices have the same d- lucky sum. Hence $\eta_{dl}(F_k) = 2$. See the figure 4 for d- lucky labeling of fan graph F_k.

Definition 3.9:[4] A Sun graph S_k is defined as the graph obtained from a cycle C_k by adding a pendant edge to every vertex in the cycle.

Theorem 3.10: For Sun graph S_k, $\eta_{dl}(S_k) = 2$.

Proof: Consider S_k be a sun graph. Assume the vertices in C_k of S_k be x_i and pendent vertex be y_i for $1 \leq i \leq k$.

Case 1: when k is even. Label the vertices in C_k of S_k as 1, 2 alternatively, starts with 1 from left to right and label the pendent vertices as 1. Since $(x_i) = 1$, each neighbor vertex of x_i is labeled 2 and pendent vertex is labeled 1, then we have $c(x_i) = \sum_{y \in N(x_i)} l(y) + d(x_i) = 8 \; where \; d(x_i) = 3$. Since $l(x_i) = 2$,each neighbor vertex of x_i is labeled 1 and pendent vertex is labeled 1, then we have $c(x_i) = \sum_{y \in N(x_i)} l(y) + d(x_i) = 6 \; where \; d(x_i) = 3$. If $l(y_i) = 1$, the adjacent vertex with y_i is labeled as 1 or 2 then we have $c(y_i) = 2 \; or \; 3$. Observe that, d- lucky sum of all the vertices in a sun graph are pair wise distinct. Hence $\eta_{dl}(S_k) = 2$ when k is even. See figure 5 for d-lucky labeling of sun graph S_4.

Case 2: when k is odd. Label the vertices in C_k of S_k as 1 ,2 alternatively, starts from left to right and label the pendent vertices as 1.Let x_i be the vertex in C_k of S_k, $1 \leq i \leq k$. Since $l(x_1) = 1$,then we have $c(x_1) = 7$. If $l(x_i) = 1$ then we have $c(x_i) = 8, 2 \leq i \leq k$. If $l(x_i) = 2$ then we have $c(x_i) = 6, 2 \leq i \leq k-1$. Consider y_i be the pendent vertices of S_k. If the label of adjacent vertex of y_i is 1 , $1 \leq i \leq k$, then we have $c(y_i) = 2$. If the label of adjacent vertex of y_i is 2 , $1 \leq i \leq k$, then we have $c(y_i) = 3$. It is clear that, d- lucky sum of all the vertices in a sun graph are pair wise distinct. Hence $\eta_{dl}(S_k) = 2$ when k is odd. See figure 6 for d-lucky labeling of sun graph S_5.

Definition 3.11:[4] A lollipop graph $L(n, m)$ is obtained from a K_n and a path P_m by identifying a vertex of $K_n$to an end vertex of P_m.

Theorem 3.12: For a lollipop graph $L(n, m)$, η_{dl} (L(n,m)) = n-1.

Proof: Label the vertices of $K_n$in $L(n, m)$ excluding the last vertex of K_n in $L(n, m)$ from 1 to $n-1$ in the anticlockwise direction. Label the last vertex of K_n as 1 which is adjacent with the end vertex of P_m in $L(n, m)$. Let x_i be the vertex in K_n $for \; 1 \leq i \leq n-1$. Since $l(x_i) = i$, we have $c(x_i) = \sum_{y \in N(x_i)} l(y) + d(x_i) = \frac{n^2+n-2i}{2} \; where \; d(x_i) = n-1, for \; 1 \leq i \leq n-1$. Let x_n be the vertex of K_n . Since $l(x_n) = 1$, then we have $c(x_n) = \sum_{y \in N(x_n)} l(y) + d(x_n) = \frac{n^2+n}{n} \; where \; d(x_n) = n$. Label the vertices of $P_m$in $L(n, m)$ as 1 and 2 alternatively, starts from left to right. Let x_j be the vertex of P_m in $L(n, m)$ where $n+1 \leq j \leq n+m$. Since $l(x_{n+1}) = 1$ and each neighbor vertex of P_m in $L(n, m)$ is labeled 1 and 2, then we have $c(x_{n+1}) = \sum_{y \in N(x_{n+1})} l(y) + d(x_{n+1}) = 5 \; where \; d(x_{n+1}) = 2$. If $l(x_j) = 1, n+2 \leq j \leq$n+m-1,then we have $c(x_j) = \sum_{y \in N(x_j)} l(y) + d(x_j) = 6 \; where \; d(x_j) = 2$. If $l(x_j) = 2, n+2 \leq j \leq$n+m-1,then we have $c(x_j) = \sum_{y \in N(x_j)} l(y) + d(x) = 4 \; where \; d(x_j) = 2$. Suppose $l(x_{n+m}) = 1$ and neighbor vertex of x is labeled 2, then we have $c(x_{n+m}) = \sum_{y \in N(x_{n+m})} l(y) + d(x_{n+m}) = 3 \; where \; d(x_{n+m}) = 1$. suppose $l(x_{n+m}) = 2$ and neighbor vertex of x is labeled 1, then

we have $c(x) = \sum_{y \in N(x)} l(y) + \ d(x) = 2$ *where* $d(x) = 1$. It is clear that d- lucky sum of adjacent vertices are distinct. Hence $\eta_{dl}(L(n,m)) \ = \ n - 1$.

CONCLUSION

In this research paper, we found the d-lucky number for the tadpole graph, lollipop graph, friendship graph, generalized friendship graph, sun graph and fan graph. In our next paper, We will give the d-lucky number for some non isomorphic connected graphs.

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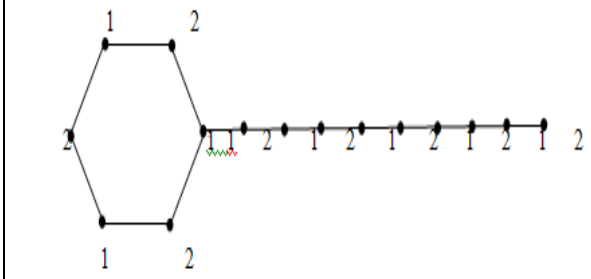


Figure 1: d- lucky labeling of tadpole graph T(6,9)

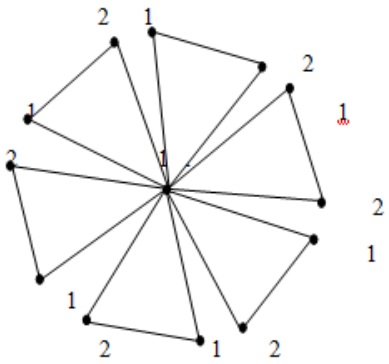
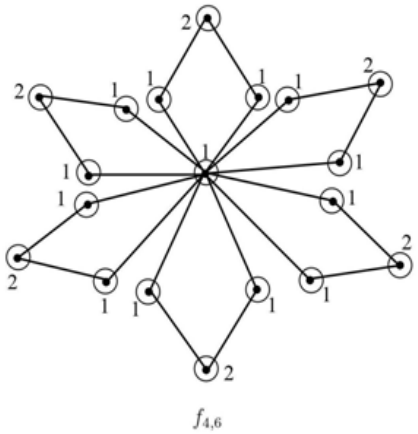


Figure 2: **d- lucky labeling of friendship graph** f_6



$f_{4,6}$

Figure 3: d-lucky labeling of generalized friendship graph $f_{6,4}$

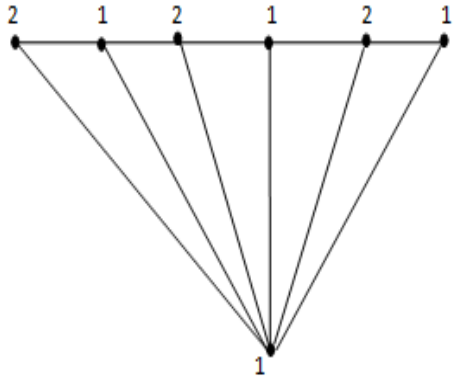


Figure 4: for d- lucky labeling of fan graph F_6

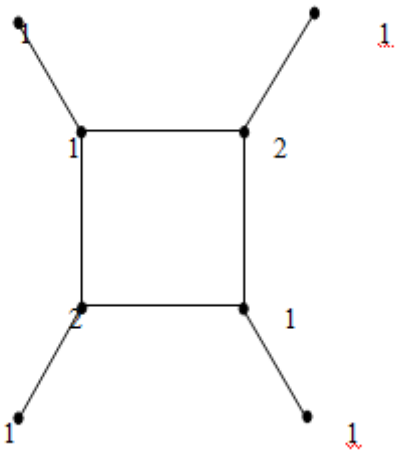


Figure 5: for d-lucky labeling of Sun graph S_4

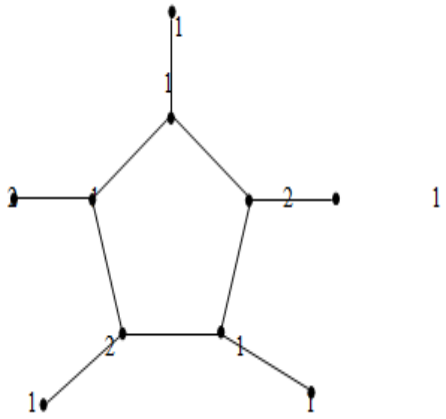


Figure 6 for d-lucky labeling of Sun graph S_5

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RESEARCH ARTICLE

Role of Uttarbasti in the Management of Tubal Blockage – A Case Study

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ABSTRACT

This case report highlights an interesting approach to treating tubal blockage. Tubal disease is responsible for 25-35% of female infertility[1]. Infertility is defined as the inability to conceive within one year of unprotected sexual activity. Approximately 8% to 10% of couples worldwide face infertility issues. The prevalence of infertility in India is about 15-20 million. One in six couples presenting to a health practitioner complains of infertility, and of these, 14% have a tubal factor. Tubal blockage may involve the proximal, distal, transient, or permanent occlusion of the tubes. The present study was carried out to evaluate the role of *Uttarbasti* in treating tubal blockage. In this case report, the patient suffered from tubal blockage, which led to infertility for seven years. For six years, she was on allopathic treatment but did not achieve any results, so she turned to *Ayurvedic* treatment. A detailed history revealed the involvement of vitiated *Kapha* and *Vata Dosha*, along with *Agnimandhya*. In *Ayurveda*, *Uttarbasti* is the ideal *Sthanika Chikitsa* for addressing tubal blockage. The patient was treated with classical *Vamana* followed by *Shamana Chikitsa* for three consecutive cycles, along with two cycles of *Uttarbasti*. After undergoing *Ayurvedic* interventions, including *Uttarbasti* and internal medicines, her post-treatment HSG report showed that both fallopian tubes were patent.

Keywords: Tubal blockage, Infertility, *Uttarabasti*, *Shodhana Karma*, *Shamana Aushadhis.*

INTRODUCTION

The most common causative factor of female infertility is tubal blockage. The causes of female infertility are classified into ovulatory factors, tubal factors, cervical factors, uterine factors, infection factors, and unexplained factors [2]. In *Ayurveda*, several *Acharyas* have compared *Artavavaha Srotas* with the fallopian tubes, including the ovary as well.

Sushruta Acharya has described their attachments based on the above-mentioned characteristics of *Artavavaha Srotas*, another description of the fallopian tube can be drawn from its attachment to the extra *Ashaya*, which is the *Garbhashaya* in females, as described by *Sharangadhara Acharya* [3]. According to some authors, the description of *Gavinis* in the *Atharvaveda* is also compared with the fallopian tubes, as evidenced by references in the context of conception. The fallopian tube being a part of the uterus is anatomically accepted as the site of fertilization. *Artavaha Srotas* are responsible for the formation of *Beeja* and for carrying the *Beejaroopa Artava* and injury to this *Srotas* can cause the following three features mentioned by *Sushruta Acharya, Vandhyatwa, Maithuna Asahishnata*, and *Artavanasha* [4]. Hence, the *Kshetra* stated by *Sushruta Acharya* can be considered the *Adhishthana* for the vitiation of the *Doshas*. In *Ayurveda* the understanding of tubal blockage differs significantly from contemporary medicine. The pathogenesis of this condition is defined as the accumulation and vitiation of *Doshas*. Therefore, approaching tubal infertility in *Ayurveda* involves identifying *Vandhyatva* [5] based on *Nidanas* (causes) and *Samprapti* (pathogenesis). *Charaka Acharya* provides a framework for understanding newly diagnosed diseases by considering *Prakriti* (*Doshas*, the root cause), *Adhishthana* (*Dushya*, the seat), and *Linga* (*Lakshanas*, the features). In the comprehensive treatment of female infertility, *Uttarabasti*[6] plays a crucial role by exerting both direct local action and systemic effects on the reproductive system. Recognizing the importance of *Uttarabasti*[7] in addressing female infertility, this case report aims to compile evidence-based clinical trials conducted at the Department of *Prasuti Tantra* and *Streeroga*, JSS *Ayurveda* Medical College and Hospital, Mysuru. The objective is to present these trials systematically, shedding light on the efficacy and benefits of *Uttarabasti* in treating tubal blockage.

CASE STUDY

Case Description

Chief complaints

A 32 year old married woman residing in Mandya reported the Prasuti tantra and Stree roga outpatient department (OPD) with the complaints of anxious to conceive even after trying for 7 years of unprotected intercourse with active marital life of 7 years.

History of Present illness

The patient gives the history of 7 years of active marital life and she is anxious to conceive after undergoing spontaneous abortion. As per the patient she conceived soon after 6 months of marriage, but was not able to continue the pregnancy because of spontaneous abortion during her 3rd month of pregnancy. For which she approached gynecologist and she was diagnosed with left tubal blockage and Right tube is patent. For which she underwent treatment but not get satisfactory result. So she approached our hospital for further management.

Family History

Mother has H/O HTN on medication. No any Family history of infertility or other major illness.

History of past illness

K/C/O- PCOS since 1 year, She had no H/O any thyroid dysfunction, diabetes mellitus and hypertension or any other major illness.

Surgical History

Not Significant

Personal History

- Appetite: Good
- Diet: mixed diet,
- Habit: the lady had no any habits.
- Micturition: 4 to 5 times / day
- Bowel: once / day.

- Weight: 51 Kg
- BP: 120/80 mmHg

Occupation
Housewife

Married Life
The couple had a married life of 7 years. It was a non – consanguineous marriage.

Menstrual History
- Menarche :13 years
- LMP: 19/2/2022
- Interval: 22-24 days
- Duration of flow during cycles: 2- 3 days (2pads /day)
- Discomfort: No any discomfort.

Obstetric History
Nulliparous- P0 A1 L0 A1- Spontaneous abortion at 3 MOA after 3 Months of marriage.

Contraception History
Not significant

Ashtavidha Pariksha
- *Nadi:- Kaphavataja*, 78b/min
- *Mala:*- once a day
- *Mutra:*- 4-5 times in day time
- *Jivha:- Lipta*
- *Shabda:- Spashta*
- *Sparsha:- Mrudu, Anushna Sheeta*
- *Drik:- Prakruta*
- *Aakruti:- Madhyama.*

Dashavidha Pariksha
- *Prakruti:- Kaphavata*
- *Vikruti:- Kapha vata*
- *Sara:- Madhyama*
- *Samhanana:- Madhyama*
- *Pramana:- Madhyama*
- *Satmya:- Madhyama*
- *Satva:- Madhyama*
- *Aahara shakti:- Abhyavarana- Madhyama Jarana- Hina*
- *Vyayama shakti:- Hina*
- *Vaya:- Madhyama*

General Examination
- BP: 120/70 mmHg
- P.R: 82/min
- R.R: 20/min

- Temperature: Afebrile

Systemic Examination

- Cardiovascular System- S1, S2 heared
- Respiratory System- AEBE and clear
- Nervous System- conscious, well oriented to time, place, person
- Musculoskeletal System- NAD

Gynaecological Examination

- P/S: Cervix normal in position, healthy and no abnormal discharges found, no fouls smell.
- P/V: Uterus normal in size & position, mobile – Anteverted, anteflexed fornices free and no tenderness was present.

Investigation

- USG(2021) - Suggestive of B/L PCOS.
- AMH(11/03/22) - < 0.30 ng/ml.
- TSH (10/03/22) - 5.69 mIU/ml.
- FBS (10/03/22) - 94 mg/dl
- HSG (25/08/2021) - Beaded left tube with patent right tube

Chikitsa given

Present study was a single case study. *Shodhana* followed by *Shamana Chikitsa* was administered. *Shodhana Chikitsa* was done in following manner in the month of APRIL 2022.

Deepana – Pachana was done for five days as the patient had *Ama lakshana.*

1. Tab. *Agnitundi Vati*: 1-1-1 B/F for 5 days
2. Tab. *Chitrakadi Vati*: 1-1-1 B/F for 5 days

Snehapana was started from 5/04/22 to 8/04/22 with *Varunadi Ghrita*. After *Samyak Snigdha Lakshanas* were found, the patient was given ***Sarvanga Abhaynaga*** with *Mahanarayana Taila* and ***Bashpa sweda*** for 2 day and posted for *Vamana.* The patient had about 6 *Vegas* and had *Madhyama Shuddhi*. The patient was advised by ***Samsarjana Krama*** for 5 days. After the completion of *Samsarjana Krama,* she was given oral medications (***Shamana Chikitsa*)** as follows:

1. *Mahanarayana Taila Nasya* 2 drops BD B/F alternate week.
2. Tab. *Pushpadhanva rasa* 2 BD A/F with warm water for 1 month.
3. *Sukumara Kashaya* 15ml BD A/F with warm water for 1 month.
4. *Phala sarpi* 30 ml OD B/F for 1 month.

Next follow up the patient visited after completion of her menstrual cycles, she was advised for ***Uttarabasti*** with ***Mahanarayana Taila*** for 3 days. *Uttarabasti* was done in the month of MAY 2022 with *Mahanarayana taila* for 3 consecutive days from 10/05/22 to 12/05/22. Adviced oral medications (***Shaman Chikitsa)*** as follows:

1. Tab. Septilin 2 BD A/F
2. Tab. Folic acid 1OD A/F
3. Tab. *Pushpadhanva Rasa* 1 TID after food
4. Tab. Ovarin 1TID A/F
5. *Mahanarayana Taila Nasya* 2drops BD B/F

*Sukumara kashaya*10 ml TID A/F. All the Medications given for 1 month 2nd cycle of ***Uttar basti*** started from (26/05/2022 to 28/05/2022) with ***Mahanarayana Taila.*** *Shaman Aushadhis* advised

1. Tab Septilin 2 BD A/F
2. Tab *Pushpadhanva Rasa* 2 OD AF
3. Syp *Sukumara Kashaya* with 1 pinch of *Tankana Bhasma*15ml BD AF
4. *Phalasarpi* 30ml OD B/F
5. *Mahanarayana Taila Nasya* 2drops BD B/F All medication given for 1 month

RESULT

On 17/06/2022 advised for HSG, on 22/6/22 patient came for follow up with HSG reports HSG report shows both fallopian tubes are normal in size and Normal peritoneal spillage of contrast media seen from both fallopian tubes Normal Hysterosalphingogram.

DISCUSSION

In Ayurveda the tubal blockage is understood as dominance of *Vata* with contributions from *Kapha,* the treatment would aim to pacify these *Doshas* and removes the obstruction. The fallopian tube being the "*Kshetra* for *Garbhadhan"* aligns with *Ayurvedic* principles of conception, where the fallopian tubes play a crucial role in transporting the egg and facilitating fertilization. It's fascinating how *Ayurveda* combines various treatment modalities, including *Shodhana* (purification or detoxification) and *Shamana* (pacification) to restore the health. This integrated approach addresses both the symptoms and the underlying imbalance *Doshas*. In this tubal blockage case, where *Kapha* obstruction is a significant factor, *Vaman* therapy works by eliminating the accumulated *Kapha* from the subtle channels. This clearance facilitates the opening of these channels, thereby alleviating the blockage. Additionally, by addressing the underlying imbalance in the *Doshas*, *Vaman* helps to pacify the aggravated *Kapha* and *Vata Dosha* as well. It's fascinating how *Vamana* therapy not only targets the physical symptoms but also influences the metabolic process and hormonal balance of the body. The regularization of the menstrual cycle and the boost in metabolism post-*Vamana* therapy are indicative of its holistic impact on the individual's well-being. *Uttara Basti* is a therapeutic procedure involving medicated *Ghrita* directly administration in to the intrauterine route which address issues like narrowing and blockages in the tubes, and gives strength to the internal reproductive organs. The drug use in this case is *Mahanarayan Taila* known for its properties to pacify both *Vata* and *Kapha Doshas* and also helps to alleviate aggravated *Apana Vata, Tila taila* present in the *Mahanarayana Taila* with its *Vyavayi* and *Vikasi* property enters in to the *Sukshma Srotas* and spread easily and pacifies the vitiated *Doshas. Yoni Pichu* with *Mahanarayana Taila* normalizes the vitiated *Vata* and *Kapha*. It also relieves the inflammation in the tubes with its *Shothahara* property. These formulations possess properties such as *Lekhaniya* (scraping) and *Vata-Kapha Shamaka* (balancing), which helps to remove blockage and restore the tubal functions.

CONCLUSION

Acharya Sushrutha has explained about *Garbhasambhava Samagri* i.e. *Rutu, Kshetra, Ambu, Beeja*. In this case report, *Kshetra* is affected as the fallopian tubes. The Doshas involvement in the tubal blockage is *Vata* and *Kapha. Sankocha* of the tubal lumen is caused by *Vata dosha* resulting in the narrowing of the tubes, and *Avarodha* of the lumen by *Kapha Dosha* resulting in the tubal blockage. *Shodhana* is the vital step in *Ayurvedic* management, *Vamana* helps in purifying the body, and due to its *Vyavayi, Vikasi, Ushna, Tikshna, Sukshma Guna* it removes the vitiated *Kapha Dosha.* *Uttara Basti* helps the medicated *Sneha* to reach the tubes and act on the narrowing and blockage directly. *Mahanarayan Taila,* with its *Vata* and *Kapha Hara* property, alleviates the aggravated *Apana Vata,* which is believed to be the root cause of *Yonivyapad. Tila Taila* present in *Mahanarayan Taila,* with its *Vyavayi* and *Vikasi* property, enters the minute channels and spreads easily which is result in the clearance of blockage.

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Figure:1

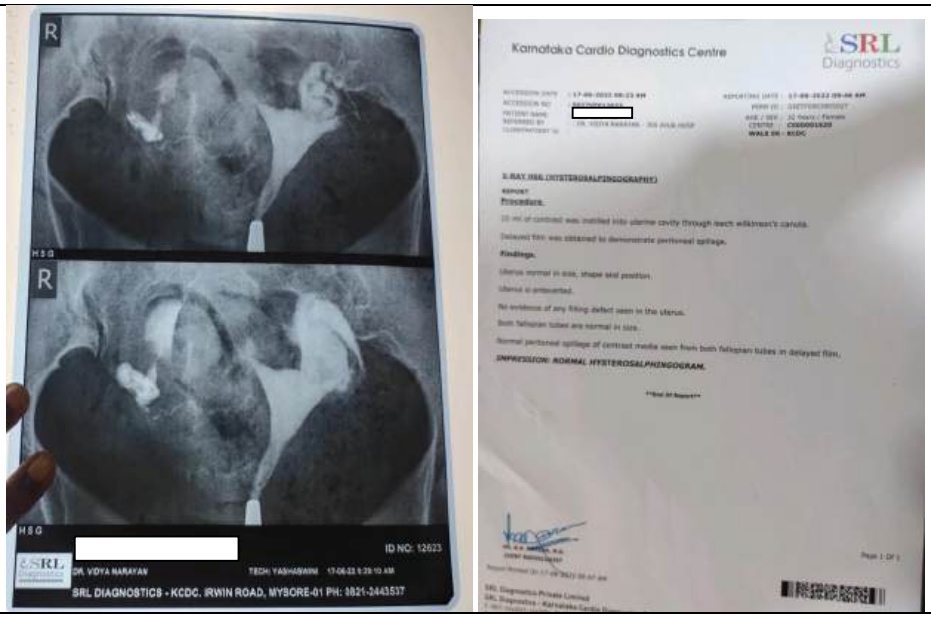

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SRL Diagnostics
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Findings.
IMPRESSION: NORMAL HYSTEROSALPHINGOGRAM.

Figure:2

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RESEARCH ARTICLE

A Clinical Study to Evaluate the Combined Efficacy of *Mahapaishachika Ghrita* Orally and *Balaswagandhalakshadi Taila Shiropichu* in Children with ADHD (UNMADA)

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ABSTRACT

Attention-Deficit Hyperactivity Disorder (ADHD) is a neuro developmental condition in children, characterized by symptoms such as inattention, hyperactivity, and impulsivity. These behaviours can lead to challenges in academic achievement, social interactions, and emotional well-being. Traditional treatments for ADHD often involve behavioural therapy and psycho stimulant medications, which can have side effects like irritability, sleep disturbances, and growth issues. Alternatively, Ayurveda offers different treatment approaches. Among these, *Mahapaishachika Ghrita* and *Shiropichu* with *Balaashwagandhalakshadi Taila* are being explored as potential remedies for ADHD. *Mahapaishachika Ghrita* is believed to reduce hyperactivity and increases attention span, supporting cognitive function, while *Shiropichu* may help promote mental balance and reduce hyperactivity. This study aims to evaluate the effectiveness of these Ayurveda treatments in managing the symptoms of ADHD. The present clinical trial is Planned to be conducted among 30 children aged between 3to 15years for a period of 6 weeks who have been diagnosed with ADHD and recruited from various centres in and around mysore, Karnataka. The effectiveness of the treatment will be evaluated using clinical features of unmada, *Ashtavibrama*( ) and standardized ADHD rating scale(SWAN rating scale) before, after treatment and after follow up The observations will be analysed based on the changes in the subjective and objective parameters used for assessing as described above will be evaluated by using appropriate statistical methods. The findings of the current study could offer a alternative and comprehensive approach to

managing ADHD, fostering cognitive development, reduction in hyperactivity and overall growth with minimal side effects.

Keywords: Attention-deficit hyperactivity disorder (ADHD), *Unmada, Mahapaishachika Ghrita, Shiro-Pichu*

INTRODUCTION

Attention-Deficit Hyperactivity Disorder (ADHD) is the most common neurobehavioral disorder in childhood, and it is one of the most widespread chronic health conditions affecting school-aged children(1) In India, the prevalence of ADHD is reported to be around 11%, with higher rates observed in lower socio-economic groups(2). As per the studies in the year between 2009 and 2019, the prevalence of ADHD among children and adolescents ranges from 7.6% to 15%, with males experiencing higher rates (9.4%) compared to females (5.2%). The peak prevalence in males is seen between ages of 8-15year, while in females around 7-15 years(3). A study in Mysore conducted in 2014 found an overall ADHD prevalence of 14.4%, with subtypes including Inattentive (4.1%), Impulsive/Hyperactive (3.4%), and Combined (6.9%)(4). ADHD is characterized by symptoms of inattention, poor impulse control, and hyperactivity. Children with ADHD often face challenges such as academic underachievement, difficulty in forming relationships with family members and peers, also with low self-esteem(5). Although the precise cause of ADHD remains unknown, several factors are believed to contribute to its development. These factors include family history, as the disorder tends to run in families, and environmental exposures to toxins, such as lead or other heavy metals, which can negatively impact brain development. Developmental factors, including low birth weight, premature birth, or maternal exposure to toxins (such as alcohol, tobacco), or stress during pregnancy, may increase the risk of developing ADHD(6). In contemporary medicine, behavioural therapy, occupational therapy are commonly used as the first line of treatment for ADHD in school-aged children. These therapies are often combined with psycho-stimulant medications, which are designed to enhance the release and inhibit the reuptake of dopamine. This helps to improve attention span, concentration, and control impulsivity. However, psycho-stimulant medications do not contribute to academic performance and are associated with side effects such as sleep disturbances, irritability, growth inhibition(7,8) In Ayurveda, although there are no direct references of Attention-Deficit/Hyperactivity Disorder (ADHD), certain abnormal behavioral patterns are discussed under the concept of *Unmada*. Given the nature of the symptoms, ADHD can be correlated with *Unmada*, which is considered a disorder of the *Manovaha Srota* (mental channels) and is characterized by an imbalance of the *Raja* and *Tama* guna. In the *Vedana Adyaya*, *Acharya Kashyapa* describes symptoms of *Unmada* such as *Pralapa* (incoherent speech), *Vaichintya* (excessive thinking), and *Arati* (distress)(9). These disturbances lead to the vitiation of *Dhee* (intellect), *Dhriti* (courage), and *Smriti* (memory), contributing to abnormal behaviors like inattention, hyperactivity, and impulsivity.

The underlying cause of this condition is believed to be a disturbance in the *Vatadosha*, which impairs the integration of *Sharirika* (physical) and *Manasika* (mental) *dosha*. Therefore, treatment focuses on normalizing *Vata*, promoting *Brimhana* (nourishment) for the senses, and using *Medhya* (intelligence-enhancing) therapies(10). *Charak a*re commends *Mahapaishachika Ghrita* for managing *Unmada*. It is believed to improve cognitive functions such as *Buddhi* (intellect), *Smrithi* (memory), and *Medha* (wisdom), and it is also beneficial for *Anga Vardhana* (growth and development) (11). *Ashta Vibhrama* refers to the eight forms of mental disturbances or derangements that can significantly impact an individual's cognitive and behavioral functions. These disturbances manifest in various ways, affecting the faculties of mind (*Manas*), intellect *(Buddhi*), emotions *(Bhakti*), character *(Sheela*), actions (*Cheshta*), and behavior (*Achara*). In conditions like ADHD, these disruptions are evident in the impaired thought processes, emotional responses, and social interactions. Children with ADHD may exhibit difficulties in social engagement, such as hyperactivity, inattention, Cognitive disruptions, such as indecision or improper sensory processing, may lead to a failure in distinguishing right from wrong or an inability to make appropriate choices. The disturbance in*Bhakti* may lead to erratic or excessive interests, while *Sheela Vibhrama* is seen in exaggerated or inappropriate

emotional responses like temper tantrums. *Cheshta Vibhrama* reflects in repetitive and compulsive behaviors, and *AcharaVibhrama* is evident in the inability to follow social norms or ethics, often seen in a lack of awareness of hygiene or improper dressing. Overall, these derangements create a disconnection from reality, social context, and self-awareness, resembling the features of *Unmada* (mental illness), thus playing a central role in the behavioral and cognitive challenges observed in ADHD. *Shiropichu* a form of *MurdhniTaila* therapy, is considered more effective than *Shiro Abhyanga* and less effective than *Shirodhara* and *ShiroBasti(12)*. As *Shirodhara* and *Basti* are less practical for use in children with ADHD as the children are more hyperactive and aggressive which makes it difficult to perform *Shirodhara* and *Shirobasti* in children, this study aims to evaluate the combined efficacy of *Mahapaishachika Ghrita* orally with *Shiropichu* using *Balashwagandalakshadi Taila(13)* in managing ADHD.

OBJECTIVES

The aim of this study is to create and validate a scale for evaluating *Ashta Vibhrama* in children diagnosed with *Unmada* (ADHD), assess the combined effectiveness of *Mahapaishachika Ghrita*orally and *Balashwagandalakshadi Taila Shiropichu* in addressing the clinical symptoms

METHODOLOGY

The study is a prospective, single armclinical trial. This trial has been approved by the Institutional Ethical Committee (JSSAMC/1533/2023-24) and duly registered in clinical trial registry of India (CTRI/2024/07/070527). The children and their parents were thoroughly informed verbally about the trial's objective, the nature of the pharmacological therapy, therapeutic procedures, follow-up, and any complications, as well as through written and informed assent. Patients of either gender, from the In Patient (IP) and Outdoor Patient (OP) department of Kaumarabhritya, JSS Ayurveda Medical College and Hospital, Mysuru, special health camps and other referrals were the source of the sample. The study includes children fulfilling the diagnostic and inclusion criteria which mentioned in table no.1 The study will involve a total sample size of 30 participants in the group, as it is a single-arm study. The participants will be evaluated primarily through the collection of medical, developmental, family, and socio cultural histories. The diagnosis of ADHD will be made according to the criteria outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), published by the American Psychiatric Association (APA) in 2013. The five criteria for diagnosing ADHD in children will include assessments of inattention, hyperactivity, and impulsivity, using appropriate questionnaires for diagnosis. Additionally, clinical features of *Unmada*, as described in the *Kashyapa Samhitha*, such as *Vaichithya* (mental instability), *Arati* (restlessness), will also be evaluated.

Criteria for assessment

The subjects will be assessed by subjective and objective parameters which are mentioned below;

For Subjective Parameters:

1. Clinical features of *Unmada* such as *Pralapa* (Delerium) and *Arathi* (Restlessness)(9)
   These will be graded as
   Grade 0-absent
   Grade 1- occasionally present
   Grade 2- Present
2. *Ashta Vibhrama*(eight forms of mental disturbances) viz Manas(mind), *Budhi* (intellect), *Samjna, Jnana, Sheela(*character*), Cheshta(*actions*)*and *Achara (*behavior*)Vibhrama* of *Unmada*gradings will be done

For Objective Parameters:

Scores of SWAN Rating scale (14).

Intervention

The trial drug *Mahapaishachika Ghrita and Balaashwagandhalakshadi Taila* will be procured / prepared from a GMP certified ayurveda pharmaceutical company Details of intervention and trial drug mentioned in table no.2

Follow up

All the patients will be assessed on the 0th day, 29th day and 42nd day, hence total duration of study 6 weeks

Statistical analysis

for Subjective criteria Wilcoxon signed rank or rank sum test and for Objective criteria Student t test and paired t test and appropriate non-parametric statistical test will be applied for analysis of the results.

DISCUSSION

ADHD is a well-established psychiatric condition that primarily impacts a child's ability to perform daily tasks. Individuals with ADHD typically exhibit behaviour such as excessive inattention, impulsivity, and hyperactivity, which are not aligned with their developmental stage (14). Current treatments for ADHD in contemporary medicine primarily include behavioural therapy and occupational therapy. However, these treatments often result in only minimal improvement in hyperactivity. Moreover, the symptoms can worsen significantly if the therapies are abruptly discontinued. This highlights a major drawback in the contemporary approach to treating ADHD. The primary method for addressing *Vata Dosha* typically includes *Snehana, Swedana*, and *Basti* among other therapies. However, this study primarily focuses on the incorporation of *Snehana* therapy for the treatment of ADHD. which includes both external and internal forms (16). In this study, external *Snehana* is administered through *Shiro Pichu* using *Bala Ashwagandha Lakshadi Taila*, while internal *Snehana* is provided with *Mahapaishachika Ghrita* (medicated ghee). *ShiroPichu* is a technique where a cloth or cotton pad is soaked in medicated oil and placed on the scalp, specifically over the Bregma, where rapid absorption at the cellular level is observed. This method is beneficial for strengthening the sensory faculties (*Indriya*).This procedure helps reduce cortisol levels while increasing serotonin production by stimulating melatonin secretion. As a result, it calms the child, promotes quality sleep, decreases hyperactivity, and improves attention span (17). The selected oil, *Bala Ashwagandha Lakshadi Taila*contains *Bala Ashwagandha Laksha* is particularly indicated for conditions like *Unmada*, making it an appropriate choice for this treatment (18)

Mahapaishachika Ghrita contains ingredients such as *Jatamamsi*, *Haritaki*, *Vacha*, and *Katuk*i, which are known for their *Ushna* (hot) potency and properties that balance *Vata* and *Kapha*, as well as their ability to purify the channels (*Sroto Shodana*)(19). The therapeutic benefits of *MahaPaishachika Ghrita*, Role of its ingredients in balancing *Vata* and *Kapha.*These properties help clear blockages in the channels, promoting better absorption of medicinal compounds. Additionally, as *Ghrita* is a lipophilic substance, it nourishes neuronal cells by crossing the blood-brain barrier and enhances neuroplasticity in brain cells. It also supports the secretion of dopamine-producing neurotransmitters, which act as mood stabilizers, improve attention span, and reduce hyperactivity. Additionally, the carminative effect of *Ghrita* helps in reducing *Ama* (toxins), a primary contributor to disease, and enhances the bioavailability of the medication, supporting overall therapeutic efficacy. The mode of action of *Shiropichu* in the treatment of *Unmada* (psychological disorders) can be understood through both local and systemic effects. Local effects involve the absorption of medicinal oils via the transdermal route, which depends on factors such as the type of oil, concentration, contact duration, and skin condition. Specifically, the scalp, due to its thinner skin, absorbs the oil more quickly, leading to enhanced absorption and therapeutic effects. The oil's components, including its ability to penetrate the skin and reach the blood vessels, help in improving circulation, particularly cerebral circulation, which is vital during times of stress. This local treatment directly impacts the psychological state by alleviating symptoms hyperactivity and inattention by stimulating the neurotransmitters like dopamine and serotonin, which are often caused by prolonged muscular contractions(20). Systemically, *Shiropichu* effect on the central nervous system (CNS) is linked to cellular absorption and circulation. The medicinal oil's properties,

including *Tikshana* (penetrating), *Vyavayi* (spreading), and *Sukshma* (subtle), enable it to quickly reach the *Manovaha Srotas* (mental channels) and influence the *Manasdosha* (mental imbalances), particularly *Raja* (passion) and *Tama* (inertia). As the oil interacts with these mental channels, it balances and corrects *Manasikavikaras* (mental disorders) through its *Bhrimhana* (nourishing), *Balya* (strengthening), *Vatashamana* (calming Vata), and *Medhya* (intelligence-enhancing) properties. Furthermore, Shiropichu's action on the *Tarpak Kapha, Sadhak Pitta,* and *Pran Vayu* helps regulate the mind-body balance, thus reducing symptoms of psychological distress, The therapeutic properties of the oil enable it to correct the vitiation of the mind and promote mental clarity and stability, making it an effective treatment for *Unmada.* Hence based upon above references the following study has been designed to understand the role of combined effect of *Shiro pichu* with *Bala Ashwagandha Laskhadi Taila* and intake of *Mahapaishachika Ghirta* in ADHD.

CONCLUSION

The primary objectives of the proposed clinical trial is to improve the child's functional independence and quality of life by alleviating the core symptoms of the disorder. Due to the nature of ADHD and its associated comorbidities, long-term treatment is often necessary, with gradual improvements observed after each course of therapy. Ongoing scientific research is required to further define *Ayurveda* role in managing these conditions.

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Table:1 Scores of SWAN Rating scale

Category of score	Type or condition of ADHD
Sum of 1-9 questions is 6 or greater.	Inattentive type
Sum of 10-18 questions is 6 or greater.	Hyperactive/Impulsive type
If both the sums of 1-9 and 10-18 questions are 6 or greater.	Combined type
If neither sum is 6 or greater	No ADHD or the symptoms are being controlled with current treatment.

Table 2: Details of inclusion and exclusion criteria

Inclusion criteria	Exclusion Criteria
1) Children in between the age group of 3-15 years irrespective of gender, religion and socioeconomic status.	1) Know cases of Systemic and other Developmental disorders.
2) Already diagnosed cases of ADHD (ICD-10-CM F90.0)	2) Know cases of any genetic disorders.
3) New cases of ADHD fulfilling the Diagnostic criteria as per DSM 5.	3) Diagnosed cases of psychological illness.

Table 3: Details of Intervention

Particulars	Details	
Trial drug and mode of administration	*Mahapaishachika Ghrita* Oral	*Balashwagandalakshadi Taila* External: *Shiropichu*
Dosage as per Kashyapa Samhitha [18]	3-6 years - 6ml 6-10 years-8ml 10-15years-12ml } In Divided Doses	30ml/procedure
Timeof administration [21]	Just before having food	Morning before bath
Frequency	Twice a day - morning and night	Once a day in 2 courses- 1^{st}-7^{th} day - 1^{st} course 15^{th} – 21^{st} day – 2^{nd} course
Anupana [22]	Luke warm water	NA
Duration	28 days	14 days in 2 courses; 30 minutes/day
Follow up	42^{nd} day (i.e. 14^{th} day after stopping trial drug administration)	

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RESEARCH ARTICLE

A Non-Invasive Management of Sakana Vatham (Cervical Spondylosis) through Traditional Siddha Varmam Manipulation and External Application of Veera Poochu (Anointing) - A Case Report

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ABSTRACT

Cervical Spondylosis is a degenerative disorder of the Cervical Spine, resulting in neck pain, stiffness, and limited mobility. The symptoms of Cervical Spondylosis can be clinically correlated with *Sagana Vatham* by Siddha point of view. To assess the effectiveness of non-invasive management of *Sakana Vatham* (Cervical Spondylosis) using Siddha *Varmam* manipulation and *Veera Poochu* (anointing). A 44 years old, male patient presented with complaints of chronic neck pain, stiffness, radiating pain and limited range of motion was reported on Ayothidoss Pandithar Hospital (Dept. of *Varma Maruthuvam*), National Institute of Siddha, Chennai. He was diagnosed as cervical Spondylosis. It was diagnosed by his symptoms, clinical examination, X-RAY finding and neck disability index score (NDI). He was administered for *Varmam* therapy consisting of manipulation of specific *Varma* points and external application of *Veera poochu*. The patient received two sessions per week for 48 Days (On 1st and 4th day of week). After Completion of seven weeks of the treatment, the patient got symptomatic relief and improved day to day activity, patient's neck pain and disability index score improved from pain score 22 to 17 and better recovery in radiating pain and range of motion. The observations infer that *Varmam* manipulation and external application of *Veera poochu* has significant benefits treatment for managing

Sagana Vatham (Cervical Spondylosis). Further research is needed to determine the efficacy and safety of *Varmam* treatment in broader populations.

Keywords: Anointing, Cervical Spondylosis, Neck Disability Index Score, *Sagana Vatham*, Siddha, *Veera Poochu*

INTRODUCTION

Cervical Spondylosis (CS) is a wide-ranging term used to describe the degeneration of discs that occurs with age, affecting the cervical vertebral bone, facet joints, and other surrounding joints and their supporting soft tissues. This degeneration leads to more strain on the cervical spinal column, causing the formation of bony growths (osteophytes) and other degenerative alterations in the surrounding tissues include the facet joints, the posterior longitudinal ligament (PLL), and the ligamentum flavum [1]. The typical symptoms include individuals experiencing neck pain, which may also radiate to the arm. There is widespread tenderness in the neck area, and there is a restriction in all types of movements. Neurological symptoms are usually observed in one or two specific spinal nerve roots [2]. The levels most often impacted are C6-C7, with C5-C6 coming in second. Cervical Spondylosis that causes symptoms typically shows up as pain in the neck. In the overall population, the rate of neck pain at any given time can be anywhere from 0.4% to 41.5%, with the rate of new cases over a year varying from 4.8% to 79.5%, and the likelihood of experiencing it throughout life could be as great as 86.8%. According to the Global Burden of Disease 2015 study, low back and neck pain is the leading cause of years lived with disability (YLD) and the fourth highest cause of disability-adjusted life years (DALYs) [3-5]. According to the Siddha Medicine, *Sagana Vatham* is one of the *Vaatha* diseases mentioned by *SiddharYugi Munivar* in his *Yugi Vaithiya chinthamani*. The *Sagana Vatham* signs and symptoms can be clinically correlated with the Cervical Spondylosis [6]. *Varmam* represents a distinctive method of healing in Siddha medicine that targets specific energy centres, known as *Varmam* points, to enhance overall health and well-being. Through the application of accurate force at these specific anatomical locations, practitioners seek to encourage healing and equilibrium. What sets *Varmam* apart is its remarkable success in addressing a variety of health conditions, especially those related to the musculoskeletal and nervous systems. It is believed that the *Vaasi* energy is stored and activated at certain *Varmam* sites, and that it is essential to the body's normal functions. The precise activation of these points (*Mathirai Alavu* (pressure) – 1/4,1/2,3/4,1 *mathirai*) is believed to support the treatment of various ailments. People who have a deep grasp of applying *Varmam* consistently, through the examination of *Vatham, Pitham, Kabam*, are considered capable of effectively treating diseases [7]. *Poochu* is one among 32 types of external therapies. *Poochu* is called as liquid poultice or anointing. It is defined as the topical application of medicated oil or herbal juices, decoctions after warming the gently over affected region. It may be also prepared by dissolving the herbal powders or tablets into juices or oil and then used. Generally it is applied slowly on the affected areas and then gently smeared for few minutes or till the heat subsides. This procedure involves the purification, lubrication, local healing, analgesic and anti-inflammatory action. It also removes toxins through skin and dilating all body channels for the cleansing and improving peripheral circulation [8]. This current case report throws light upon the use of *Varmam* Manupulation and *Veera Poochu* in the management of *Sakana Vatham* (Cervical Spondylosis). This case report adheres to the CARE guidelines.

CASE PRESENTATION

A 44 years old married, male patient working as tailor, a non-smoker was consulted in the Outpatient Department (OPD) of *Ayothidoss Pandithar* Hospital (Department of *Varma Maruthuvam*), National Institute of Siddha, Chennai on April 23, 2022. With chief complaints of pain in the neck with stiffness, radiating to the both shoulders and arms and limited range of motion without any neurological deficit, pain aggravating on prolonged sitting, heavy lifting, forward and backward bending since last 1 year. He had no relevant family history of the disease. He has no comorbid illness like hypertension, diabetes mellitus, epilepsy and other illness. The patient was non-vegetarian and

had a good appetite and sleep. Patient had history of using the Allopathic Analgesic drug for managing the pain on and off since last 1 year.

Clinical Findings

The patient was clinically examined shows loss of cervical lordosis. During palpation at cervical spine there was Tenderness over C5- C6 and C6 – C7 Cervical and para spinal region and mild warmth present. Range of movement was examined, it showed deduced and pain while flexion (40^{o}), while extension at 30^{o}, painful and pain radiating to shoulders lateral movements (30^{o}) and painful and restricted rotation (70^{o}). Spurling test was positive pain radiating to shoulder and upper arm and Chin chest test also positive. X- Ray findings shows Anterior Osteophytes changes in C5-C6 and C6-C7 spine, Subtle reduction in intervertebral disc height at C5 –C6 and C6- C7 and Endplate sclerosis at C5, C6 and C7. On examination based on Siddha principles, it was observed that *Pithavadha Naadi* was predominant. Then by the assessment of *Mukutram*, in *Vatham – Viyanan* and *Samanan*, in *Pitham – Sathagam* and *Kabam – Santhigam* were affected.

Intervention

- 1st day - Purgation therapy (*Agathiyar kuzhambu* – 200 mg in the morning along with ginger juice)
- 2nd day - Medicational rest
- 3rd day onwards - *Varmam* Manipulation with External Application (*Veera Poochu)*
- (For the duration of the study, patients are asked to visit the hospital's OPD twice a week)

The patient went through purgation therapy as per the first line of treatment, administered with *Agathiyar kuzhambu* – 200 mg was given to the patient in the morning along with ginger juice. Every visit involved the use of *Varmam* Manipulation with External Application (*Veera Poochu*) to treat the patient, and the prognosis and clinical evaluation were documented as directed. Both before and after the treatment, scores on the Neck Disability Index (NDI) were obtained. Patients were instructed to follow up at the outpatient department (OPD) for an additional month following their treatment term.

***Veera Poochu* (Anointing)**

Ingredients

- *Kombarakku (Coccuslacca)*
- *Chukku (Zingiber officinale)*
- *Velliparuthi* juice *(Pergulariadaemia)*

Method of preparation

Above mentioned ingredients have been powdered and grinded with *veliparuthi juice* and subjected to heat. It was applied over the cervical region [Figure 1 & 2].

Duration: 2 sitting per week for 48 Days (On 1stand 4th day of week) [9].

Varmam* Procedure (*Thalai Kazhuthu Thadaval)

After careful examination, the patient was treated with *Varmam* Therapy (*Thalai kazhuthu thadaval)* [Figure 1 & 2] [10]. It is carried out in accordance with the SOP that is referenced in the *Varmam* literature. Stimulated *Varmam* points and their locations were detailed in the Table 1.

***Varmam* method**

Position: Sitting position , Site: Head and Neck, Pressure: ½ *Mathirai*, Duration: 15 Minutes.

Neck Disability Index Score (NDI)

The Neck Disability Index (NDI) is a widely used, self-reported questionnaire designed to assess the level of disability and pain experienced by individuals with neck disorders, such as Cervical Spondylosis which was developed by Vernon and Mior in 1991. It assesses different aspects of daily life that are impacted by neck pain, such as the intensity of the pain, personal care, lifting, reading, working, driving, sleeping, recreation, concentration, and

headaches. Each item is assessed on a range of 0 (no disability) to 5 (complete disability), with a total score that can range from 0 to 50. A greater percentage is then calculated from the NDI score; higher values indicate a higher degree of disability [11].

An effective tool for assessing the level of neck discomfort and disability is the NDI. An effective diagnostic tool that can be used for:

- Assessing the severity of neck pain and disability
- Monitoring changes in symptoms over time
- Evaluating the effectiveness of treatments
- Facilitating communication between healthcare providers and patients

Here, NDI is used to measure the impact of *Varma* therapy with *Veera Poochu* on neck disability and pain, providing a standardized and validated outcome measure to quantify the treatment's effectiveness. NDI score before and after treatment was given in Table 2.

DISCUSSION

The case report describes the Cervical Spondylosis presented with main complaints of Neck pain and stiffness, pain extending to the shoulders and arms and limited range of motion without any neurological deficit, pain aggravating on prolonged sitting, heavy lifting, bending since last 1 year. Clinical examination supports diagnosis and X- Ray findings anterior osteophytes changes in C5-C6 and C6-C7 spine, subtle reduction in cervical intervertebral disc height at C5 –C6 and C6- C7 and Endplate sclerosis at C5, C6 and C7. Prior to treatment, the Neck Disability Index Score was 24, but it decreased to 12 following treatment. The efficacy of *Varma* therapy with *Veera Poochu* external application in alleviating there is evidence of cervical spondylosis symptoms as the Neck Disability Index (NDI) scores have significantly decreased from 24 to 12. *Veera Poochu*, an external application in *Varma* therapy, has drugs *Kombarakku (Coccuslacca), Chukku (Zingiberofficinale)* [12-15] and *Velliparuthi juice (Pergularia daemia)* [16-18] possess anti-inflammatory, analgesic, and anti-spasmodic properties, making it an effective treatment for Cervical Spondylosis and other musculoskeletal conditions. The anti-inflammatory properties of *Veera Poochu* help reduce swelling and pain in the affected area, while its analgesic properties provide relief from pain and discomfort. Additionally, the anti-spasmodic properties of *Veera Poochu* help relax muscle spasms and improve mobility, further contributing to its therapeutic efficacy. This impressive development highlights the possibility of *Varma* therapy as a further therapeutic strategy for Cervical Spondylosis. The substantial reduction in NDI scores suggests that *Varma therapy* with *Veera Poochu* external application can effectively mitigate the debilitating effects of Cervical Spondylosis, enhancing the overall quality of life for individuals afflicted with this condition. In conclusion, *Varmam* therapy and *Veera poochu* have been revealed to effectively relieve pain and improves mobility with Cervical Spondylosis (*Sagana Vatham*) patient, as determined by the Neck Disability Index Scale (NDI). The treatment resulted in a significant decrease in disability scores, with no adverse reactions reported. This case study suggests that *Varmam* therapy combined with *Veera poochu* is a secure and efficient treatment option for managing Cervical Spondylosis (*Sagana Vatham*), offering promising results for pain relief and symptom management. Substantial large-scale researches are required to confirm the efficacy of Siddha treatment for this illness. Future clinical studies in larger populations are necessary to confirm the therapeutic effectiveness of *Varmam* and *Veera Poochu* in the treatment of Cervical Spondylosis.

PATIENT PERCEPTIVE

The patient expressed high satisfaction with the treatment, reporting an immense reduction in pain and an apparent improvement in his quality of life. He was deeply impressed with the effectiveness of the *Varmam* and *Poochu* (Anointing) treatment, which has greatly reduced the frequency of his pain episodes, allowing him to experience a marked enhancement in his overall well-being.

INFORMED CONSENT

Informed consent in written manner was obtained from the patient before treatment initiation.

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DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1. The *Varmam* points stimulated over the head and neck regions

Sl. No.	*Varmam* Name	Location	Manipulation Technique	Duration
1	*Aasamaikaalam* (figure 1a)	Temperomandibular joint (2 f.b above tragus)	Use the middle fingers to press and hold upward direction 3 times.	20 seconds
2	*Uchivarmam* (figure 1b)	Bregma of The Skull	Use the middle 3 fingers to press and rotate in clockwise and anticlockwise direction 3 times.	20 seconds
3	*Chevikuththivarmam* (figure 1a)	Located in the depression felt between the tragus and mandibular joint when the mouth is slightly open.	Use the middle fingers to press and hold upward direction 3 times.	20 seconds
4	*Alavadivarmam* (Figure 1a)	Angle of mandible	Use the middle fingers to press and hold upward direction 3 times.	20 seconds
5	*KazhuthupakkanadukkuVarmam* (Figure 1a)	Middle of Stenoclavicular Tendon	Use the middle 3 fingers to press and rotate in clockwise and anticlockwise direction 3 times.	10 seconds
6	*VilanguVarmam* (Figure 1c)	Supra clavicular fossa	Use the middle fingers to press and hold upward direction 3 times.	10seconds
7	*BalaVarmam* (figure 1b)	The middle of the frontal bone	Use the middle fingers to press and hold upward direction 3 times.	10 seconds
8	*ThilarthaVarmam* (figure 1b)	At the junction of frontonasal suture and internasal suture	Use the middle fingers to press and hold upward direction 3 times.	20 seconds
9	*KannadiVarmam* (Figure 1b)	Frontalonasal suture 2fb below	Use the middle fingers to press and hold upward direction 3 times.	30 seconds

10	*KomberiVarmam* (Figure 1b)	Tip of nose	Use the thumb fingers to press and hold upward direction 3 times.	20 seconds
11	*SirumkolliVarmam* (Figure1d)	Over the lambda of the skull	Use the thumb fingers to press and hold upward direction 3 times.	20 seconds
12	*PidariVarmam* (Figure 1d)	Over the nape of the neck, in the depression directly below the occipital protuberance.	Use the thumb fingers to press and hold upward direction 3 times.	30 seconds
13	*Mudichivarmam* (Figure 1d)	Over the cervical prominence	Use the middle 3 fingers to press and rotate in clockwise and anticlockwise direction 3 times.	20 seconds
14	*KakattaiKaalam* (Figure 1d)	Supra clavicular fossa on both sides	Use all five fingers to hold for 3 times simultaneously on both sides.	20 seconds

Table 2: Improvement in subjective parameters - Neck Disability Index Score (NDI)

S.No	Neck Disability Index Score (NDI)	Before Treatment	After Treatment
1	Pain Intensity (0 = No Pain to 5 = Severe Pain)	4 (patient reports frequent pain)	2 (patient reports occasional pain)
2	Personal Care (Washing, Dressing, etc.) (0 = No difficulty to 5 = unable to perform)	3 (patient reports moderately difficulty with personal care due to neck pain)	1 (patient reports mild difficulty with personal care)
3	Lifting weights (0 = No difficulty to 5 = unable to perform)	3 (patient reports moderately difficulty weights lifting with due to neck pain)	2 (patient reports slight difficulty weights lifting)
4	Reading (0 = No difficulty to 5 = unable to perform)	2 (patient reports some difficulty with reading due to neck pain)	1 (patient reports mild difficulty with reading)
5	Headaches (0 = No difficulty to 5 = headaches almost all the time)	2 (patient reports some difficulty with Headaches)	0 (patient reports no Headaches)
6	Concentration (0 = No difficulty to 5 = difficulty in concentrating)	2 (patient reports slight difficulty with Concentration due to neck pain)	1 (patient reports mild difficulty with Concentration)
7	Work (0 = No difficulty to 5 = unable to perform)	3 (patient reports moderately difficulty with Work due to neck pain)	1 (patient reports mild difficulty with Work)
8	Driving (0 = No difficulty to 5 = unable to perform)	3 (patient reports moderately difficulty with Driving due to neck pain)	2 (patient reports slight difficulty with Driving)
9	Sleeping (0 = No difficulty to 5 = completely disturbed sleep)	2 (patient reports some difficulty with Sleeping due to neck pain)	0 (patient reports no difficulty with Sleeping)

10	Recreation (0 = No difficulty to 5 = unable to perform)	1 (patient reports slight difficulty to participate in all my recreation activities)	1 (patient reports slight difficulty to engage in all my recreation activities)
Total		**24**	**12**

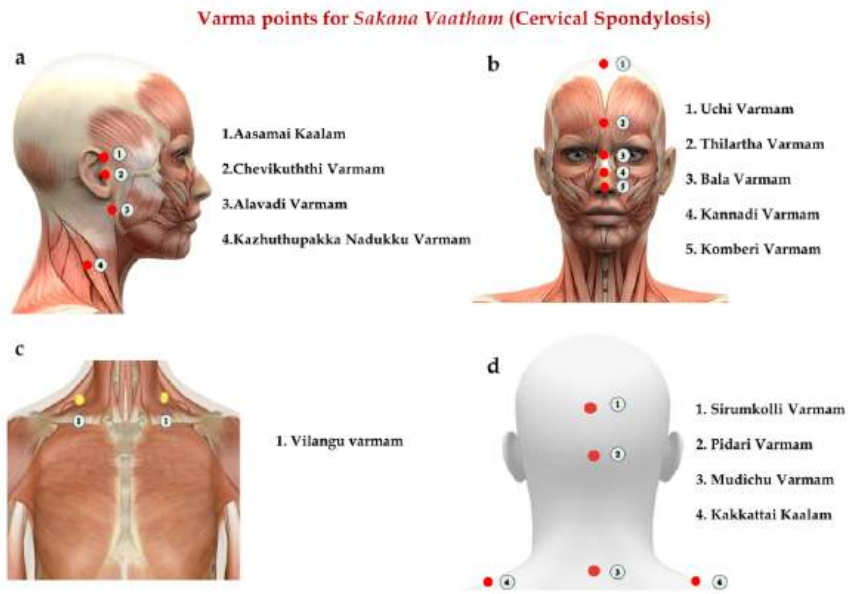


Figure 1: Varma points for *SakanaVaatham* (Cervical Spondylosis)



Figure 2. Application of Varma points and *VeeraPoochu* over Cervical region

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RESEARCH ARTICLE

Data Science in Weather Analytics in India: An Exploration of Weather Patterns and Trends

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ABSTRACT

The Indian Weather Data Analysis project analyses climate in different regions and cities of India using Data Science and Python. They're analyzing key weather factors — wind speed, humidity, precipitation— to detect trends and correlations. The project demonstrates how pandas is used for cleaning and organizing data, while confirming the accuracy of the data, correcting any missing or incorrect data. Weather trends are visualized by using Matplotlib which helps run the data interpretation. By means of thorough investigation, this paper aids in a step towards understanding Indian weather variability and its influence on decision-making process and meteorological research.

Keywords: Python, Pandas, Humidity, Data Visualizations, Weather Analysis, Data Science.

INTRODUCTION

India is such a vast and varied nation with varied topography that influences public health, urban growth, agriculture, and the general economy in great impact. In the meteorological branch, weather prediction has long been a difficult issue. Key to comprehending daily life as well as long-term development plans is variations in the weather, including temperature swings, monsoons and extreme occurrences [1,2]. Climate change has added to this: over the past few years we have seen irregular quantities of rainfall, rising temperatures, and increasing levels of

pollution, all of which directly affect weather analysis thus making it quite vital. The requirement for efficient climate monitoring and forecasting is further driven by the reports of notable climatic changes affecting different sectors made by the Indian Meteorological Department (IMD). Short-range rainfall forecast accuracy is crucial if one is to understand India's monsoon fluctuation. Comparatively the results of the Weather Research and Forecasting (WRF) model using data from the India Meteorological Department (IMD) allow one to evaluate rainfall distribution and discover systemic biases across different sites [4,5]. Using a dataset "Historical Weather Data for Indian Cities" from Kaggle, this sense we are looking at understanding weather trends for important Indian cities. The dataset has 77,1264 records and 28 columns covering the period from 2009 to 2019 free by any missing values. In particular, the study focuses on eight major cities—Pune, Mumbai, Delhi, Hyderabad, Jaipur, Kanpur, Nagpur and Bengaluru—to analyze differences in temperature, humidity, wind speed, cloud cover, precipitation and moon phase [6]. A detailed picture of these shown in Fig. 1, Using Python for data science, such as cleaning and visualization, this project will explore seasonal trends and regional climate variations, and highlight long term environmental effects. An in-depth study of daily variations in temperature, moisture and wind provides useful information for many industries. IPCC has predicted that in the future, India would experience more weather extremes, such as heat waves, floods, cyclones, drought, etc. [7]. In agriculture, for instance, know-how of precipitation trends assists in planning crop cycles and irrigation. The energy sector can use temperature data to forecast power demand, while public health authorities can use the joint trends in air quality and temperature during heat waves for mitigating health risks associated with heat waves[2,4,7].According to Rosenberger et al. (2002), weather is the most important factor influencing airplane operations, causing 70% to 80% of passenger delays and costing airlines hundreds of millions of dollars in lost revenue annually (Lan et al. 2006). Few studies have examined how climate change affects meteorological parameters that are relevant to aviation thus far (Williams and Joshi 2013).

Here, we measure the anticipated effect on aircraft performance of visibility and cloud cover [8,9,10]. Moreover, analysis of weather patterns is utilized in urban planning and disaster management to design resilient infrastructure and manage water resources effectively. This study combines techniques that requires data analysis, thus allowing for a much greater understanding of the climate situation of India. The results can help policymakers, environmental scientists, and businesses make better decisions, support sustainable development and improve disaster preparation [2,11]. This paper centers on one such innovative approach—The five main steps of weather data analysis are depicted in the flowchart. Data gathering and dataset loading are the first steps. Data preparation includes building a "city" column, standardising forms (such as 24-hour time), and merging data. Steps in the data cleaning process are looking for missing information, correcting data kinds, and deleting extraneous data—like 2020 rows. Examined in exploratory data analysis (EDA) include relationships (such as cloud cover relative to sun hours), trends (such as seasonal temperature swings), and anomalies (like extreme weather events). Finally, the visualisation stage creates graphs, emphasises discoveries, and pulls ideas from code explanations and observations. Data cleaning—which deals with missing values, data type adjustment, and outlier identification—comes next to guarantee data quality. Once the data has been cleansed, data merging is done to combine datasets as needed for an exhaustive study. Data analysis comes next, involving statistical computations and pattern analysis to uncover perceptive information. Programs include Matplotlib, Seaborn, and Plotly are used following analysis to visually present data in an understandable manner. Deeper into this study, we will investigate the methodology, dataset, evaluation, and consequences of this novel approach in the framework of India's Weather. The main contributions of the paper "Indian Weather Data Analysis" as follows [2]: Analysed comprehensively for comprehensive weather: Using extensive historical meteorological data, the study looks at temperature fluctuations, humidity levels, cloud cover, and precipitation patterns in a select few selected cities. These observations aid in forecasting climate trends and how they will affect different industries. Impact on Agriculture (Farming & Food Security): We evaluate the impact of weather factors including temperature, wind speed, and rainfall on crop output, irrigation requirements, and seasonal farming cycles. Predictive insights can help farmers in key agricultural hubs like Nagpur and Kanpur implement effective planting and harvesting plans.

Flood Risk Assessment (Mumbai, Hyderabad, Bengaluru)
Because of the intense monsoons, cities like Bengaluru, Hyderabad, and Mumbai regularly experience urban floods. Our study provides practical insights for flood prevention and mitigation techniques by identifying drainage vulnerabilities and rainfall trends.

Transportation & Aviation (Mumbai, Bengaluru, Delhi)
Road safety, railway efficiency and aviation operations are all greatly impacted by weather conditions. The study provides information that helps aviation and transportation agencies enhance scheduling and safety protocols by examining Delhi's fog patterns, Mumbai's monsoon interruptions, and Jaipur's heat waves.

Urban Planning & Infrastructure Development (Jaipur, Pune, Bengaluru)
In expanding metropolises like Jaipur, Pune, and Bengaluru, issues including water management, urban heat islands, and declining air quality are major problems. In order to ensure sustainable infrastructure development and smart city projects, this study offers insights into climate-based planning.

Disaster Management
The study contributes to gaining knowledge about early warning for extreme weather events such as heatwaves, thunderstorms and flash floods. These findings can be used by disaster management organizations in Kanpur, Hyderabad, and Mumbai to improve their response and readiness plans.

Future Implications for Sustainability
This study lays the groundwork for real-time weather-based forecasting models by combining machine learning and predictive analytics. Cities will be better equipped to respond to the difficulties posed by climate change and increase their overall resilience if they have a better understanding of the historical climate trends in Pune, Mumbai, Delhi, Hyderabad, Jaipur, Kanpur, Nagpur, and Bengaluru.

RELATED WORKS

Many research has examined how important weather patterns are to important sectors, thereby providing insightful analysis of climate variability and its consequences. While Rajini Kanth *et al.* (2021) examined Indian weather datasets, exposing important tendencies for predictive analysis [1,2], Sheikh *et al.* (2021) analysed data mining techniques for weather forecasting. Essential data source for weather-related research, the Indian Meteorological Department (IMD) offers notable reports on climate changes [3]. While Bhomia *et al*. (2014) assessed the accuracy of the WRF model in projecting Indian monsoon rainfall [4,5], Tolani et al. (2019) performed a long-term statistical analysis of extreme weather occurrences, therefore supporting disaster risk management. The historical weather dataset of Kaggle has helped research on urban and regional weather patterns in Indian cities even more [6]. The 2021 study on flash flood hazards in desert cities by Hassan et al. [7] clarified urban resilience techniques. Aviation operations are much influenced by weather; hence this field of study is absolutely important. While Kulkarni et al. (2016) evaluated the economic losses caused by winter fog in New Delhi, therefore highlighting financial difficulties for the aviation industry, Gultepe (2021) examined the impacts of visibility, wind, and precipitation on aviation [8,9]. While Shaharban (2021) looked at the wider consequences of climate change for disaster management [10,11], Coffel and Horton (2020) investigated severe temperature effects on flying performance. This study builds on earlier works by using historical meteorological data and visualising tools to evaluate how weather affects urban design and aviation over main Indian cities. The results help to guide better decisions on reducing disruptions caused by weather and increasing aircraft safety.

PROPOSED WORK

The intended endeavor would examine Indian meteorological data to tackle problems with temperature fluctuations, flood prediction, urban planning, aviation safety, disaster management, and agricultural sustainability throughout Pune, Mumbai, Delhi, Hyderabad, Jaipur, Kanpur, Nagpur, and Bengaluru. Many times, conventional methods of weather prediction fail to detect climatic patterns influencing many different sectors. This work presents a data-driven method using analytical and data visualizing techniques to understand weather trends and their implications. Using advanced visualization tools, our approach detects trends and connections in meteorological data. The primary components under analysis are the following:

- Changes in temperature (effects on urban heat islands and agriculture)
- Precipitation and humidity (effects on aviation and flash flood prediction)
- Wind patterns (impacting coastal operations and disaster management)
- Visibility and cloud cover are essential for urban planning and aviation.

PROPOSED ALGORITHM

Here is the proposed algorithm for finding different trends and patterns of weather elements in Indian weather using Data Analysis:

Algorithm for Indian Weather Data Analysis

Step 1: Data Collection

- Gather a comprehensive dataset containing features related to Indian weather.

Step 2: Data Preprocessing

- Handle missing values, outliers, and inconsistencies in the dataset.
- Combine and merge datasets.
- Standardized formats by converting them to 24-hour time, for example.
- Make "city" a new column.

Step 3: Data Cleaning

- Check for missing values and handle them.
- Correct data types (such as dates and times) that are inaccurate.
- Eliminate any irrelevant or insufficient information (such as old records).

Step 4: Exploratory Data Analysis (EDA)

- Examine correlations (such as humidity and cloud cover).
- Determine patterns, such as seasonal variations in temperature.
- Find irregularities, such as severe weather occurrences.

Step 5: Visualization

- Create graphs that help in understanding.
- Highlight the main findings obtained from the visualizations.
- Load the required visualization libraries.

Step 6: Insight Extraction

- Describe the coding approach.
- Write a summary of the EDA and visualization observations.
- Examine trends that impact various industries.

PSEUDO CODE

Here's a pseudo-code presentation of the proposed algorithm for finding different trends and patterns of weather elements in Indian weather using Data Analysis:

```
# Step 1: Data Collection
dataset = load_dataset()
# Step 2: Data Preparation
```

```
# Merge and combine datasets
merged_data = indianweather_datasets(dataset)
# Standardize formats (e.g., convert to 24-hour time)
standardized_data = standardize_formats(merged_data)
# Create a new column 'city'
data_with_city = add_city_column(standardized_data)
# Step 3: Data Cleaning
# Check for missing values
cleaned_data = handle_missing_values(data_with_city)
# Adjust incorrect data types (e.g., dates, times)
formatted_data = adjust_data_types(cleaned_data)
# Remove incomplete or irrelevant data (e.g., outdated records)
filtered_data = remove_irrelevant_data(formatted_data)
# Step 4: Exploratory Data Analysis (EDA)
# Study relationships (e.g., cloud cover and humidity)
relationships = analyze_relationships(filtered_data)
# Identify trends (e.g., seasonal temperature changes)
trends = identify_trends(filtered_data)
# Detect anomalies (e.g., extreme weather events)
anomalies = detect_anomalies(filtered_data)
# Step 5: Visualization
# Create graphs for better understanding
visualizations = generate_graphs(filtered_data)
# Highlight key findings
highlighted_findings = highlight_key_findings(visualizations)
# Import necessary libraries (matplotlib,seaborn,plotly for further analysis)
import_visualization_libraries()
# Step 6: Insight Extraction
# Explain the code approach
explain_code_approach()
# Summarize observations from EDA and visualization
summary = summarize_observations()
end_process()
```

This pseudo-code outlines the main steps of the algorithm, from data collection, preprocessing, cleaning, exploratory analysis, visualization, and insight extraction are all covered in this outline of the meteorological data analysis process. Every stage guarantees organized data processing, significant pattern recognition, and efficient visualization for well-informed decision-making.

VISUALIZATION AND RESULT ANALYSIS

- Data visualization assists in exploring business insights to achieve business goals in the right direction. It helps to correlate the data from the visual representations or graphical representations. It allows for fast analysis and instantly digests critical metrics.
- It enables enterprises to stay on top of their game by discovering the latest trends through data visualization tools.

This Visualization shows the trends in excessive heat for each city over the course of several months or years. It indicates possible heatwave periods by assisting in determining the times and locations of high heat index values. Which is helpful for organizing heat reduction initiatives and comprehending the seasonal effects of high temperatures. In this heatmap, Cities like Delhi and Kanpur regularly have higher heat indices, with Kanpur having the highest readings (e.g., 65 in 2010). This implies that some cities are subject to more intense heat waves than others. The comparatively constant heat index values in coastal towns like Mumbai (Bombay) are probably caused by tempering sea breezes. Because of its temperate environment, Bengaluru routinely has the lowest heat index values. Several important links are revealed by the Weather Factors Correlation Matrix. Max temperature has a slight negative correlation with humidity (-0.50) and a minimal effect on wind speed (-0.01), but it has large positive associations with min temperature (0.76), feels like temperature (0.73), heat index (0.73), and wind chill (0.80). The minimum temperature is positively correlated with wind chill (0.76), feels like temperature (0.81), and heat index (0.81). The correlation between variables such as wind chill, heat index, and feels like is nearly perfect (0.95 -- 1.00). While humidity has a moderately negative association (-0.51) with wind chill, it has poor connections with most other parameters. Overall, there is a substantial correlation between temperature and factors, but there are smaller correlations between temperature and humidity and wind speed.

The yearly precipitation levels in various cities over a number of years are depicted in this bar chart, which also shows geographical differences, seasonal variability, and rainfall trends. It assists in determining which years have extreme weather, evaluating how local precipitation is affected by climatic trends, and identifying changes in precipitation that might be a sign of urbanization or climate change. Bombay routinely receives the most precipitation in this dataset, with rainfall exceeding 1000 mm in 2010, 2011, and 2019. Rainfall is milder in cities like Hyderabad and Pune, and it has increased noticeably in 2019. On the other hand, as a result of regional climate variations, precipitation is lower in Kanpur and Jaipur. This research emphasizes the differences in precipitation between cities. With everything considered, these analyses emphasize how weather patterns and agriculture are closely related, affecting soil health, crop yield, and irrigation needs. Policymakers and farmers can lessen the negative effects of extreme weather by implementing targeted strategies like effective irrigation, drought-resistant crop varieties, and climate-resilient farming practices by understanding how temperature, precipitation, humidity, and wind patterns interact. Cities that experience heavy rainfall events—more than 50 mm in an hour—that can cause flash floodare shown in these visualizations. These occurrences put lives, infrastructure, and transportation at danger by overtaxing urban drainage systems. A clear comparison of precipitation is made possible by the bar chart. Levels, determining that Kanpur and Pune are the cities most at risk. These revelations highlight the necessity of early warning systems, improved drainage infrastructure, and focused flood mitigation. An annual analysis of the risks of flash floods (2009–2019) is given by the scatter plot.

From 2009 to 2014, flash floods were uncommon, however after 2015, the dangers significantly increased. Pune continuously has the highest rainfall, a sign of the increasing threats associated with climate change. To lessen the effects of future disasters, cities like Bombay, Kanpur, and Pune need to implement disaster management plans right away. From 2009 to 2019, this line graph shows airport disruptions brought on by poor visibility and heavy cloud cover. The most disruptions occurred in 2010, especially in Bengaluru, where there were more than 100 disruption days. During this time, there were also noticeable increases in other cities like Hyderabad and Pune. Disruptions generally declined starting in 2015, while Bengaluru continued to see more interruption days. In 2016, Pune had a discernible uptick. While cities like Delhi, Jaipur, and Kanpur consistently displayed minimal interruption, Bengaluru continues to be the most vulnerable, underscoring the need for investments in weather forecasting and infrastructure. Because airports in high-disruption zones may need better infrastructure, including sophisticated Instrument Landing Systems (ILS) and increased runway illumination, to reduce delays, these findings are essential for urban development. In order to reduce operational disruptions and guarantee smooth air travel, future airport placement and development plans should also take past weather patterns into account. For example: Based on the number of disruption days in different places, the bar chart illustrates airport interruptions in 2014 caused by poor visibility and heavy cloud cover. With over 30 days of disruptions, Bengaluru experienced the most, showing serious difficulties with flight operations. Following 10 to 15 days of delays, Pune and Nagpur demonstrated a moderate

level of susceptibility. Hyderabad and Bombay had five to ten days, indicating fewer frequent impacts. There were only minor inconveniences in Kanpur, Delhi, and Jaipur—less than five days.

CONCLUSION & FUTURE WORK

This study offers a thorough examination of Indian weather patterns and how they affect important industries including big city disaster management, urban planning, agriculture, and aviation. We have discovered noteworthy patterns in temperature fluctuations, precipitation, and extreme weather by applying sophisticated visualization tools. In the aviation industry, where visibility, wind speed, and precipitation are critical factors in flight safety and scheduling, these insights can help improve decision-making. The accuracy of weather effect estimates could be improved for future research by including predictive modelling techniques, such as machine learning algorithms. Furthermore, adding real-time satellite data and climate projections to the collection could enhance early warning systems for severe weather occurrences. Strategies for climate resilience can be strengthened even more by integrating AI-driven decision support tools for urban planners and aviation.

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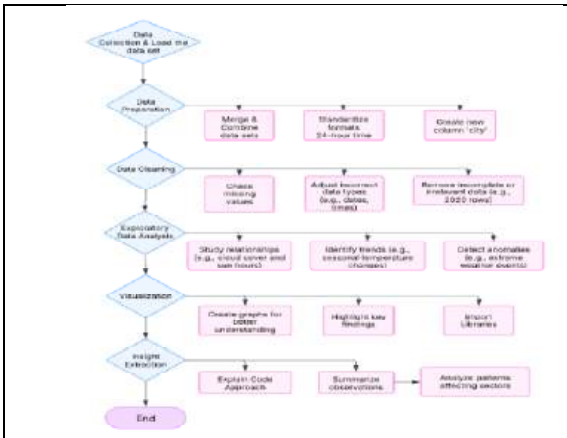


Fig. 1. Various Stages of Data Analysis

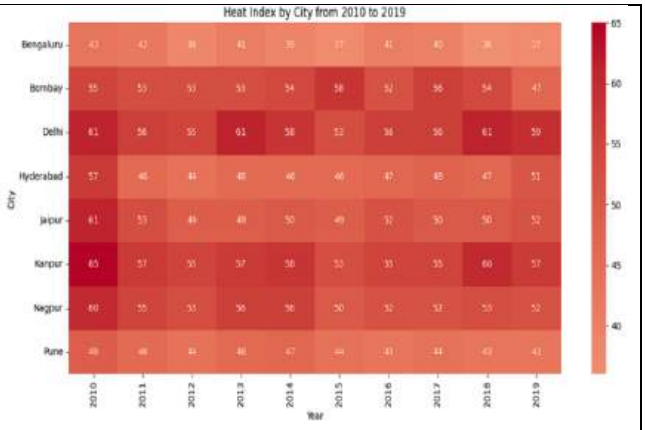


Fig. 2.Heat Index Analysis

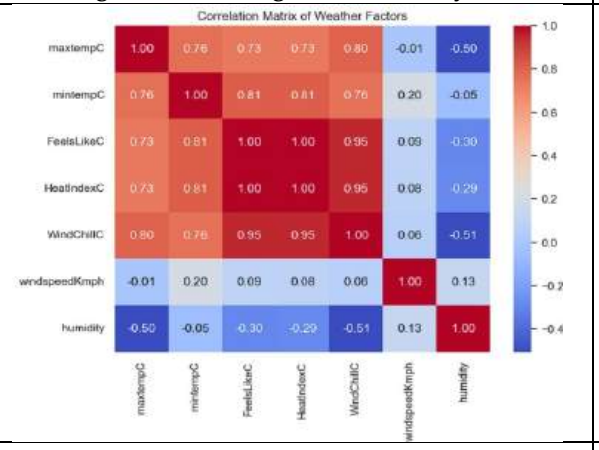


Fig. 3. Correlation Matrix of Weather Factors

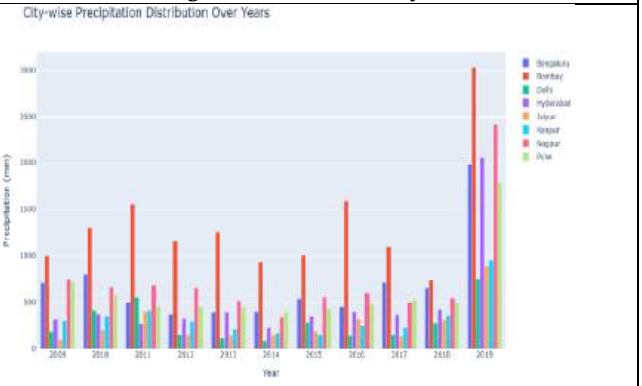


Fig. 4.City-wise Precipitation Distribution Over Years

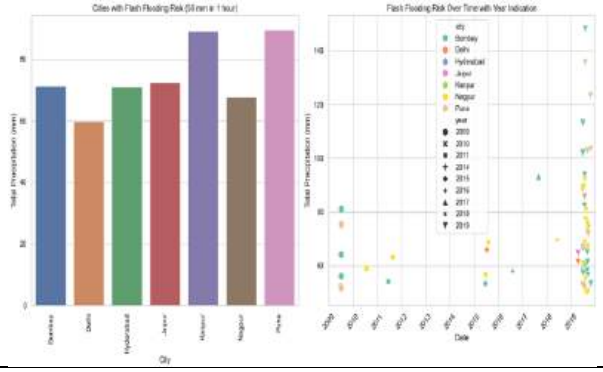


Fig. 5.Flash Flooding Risk in Cities Over Time

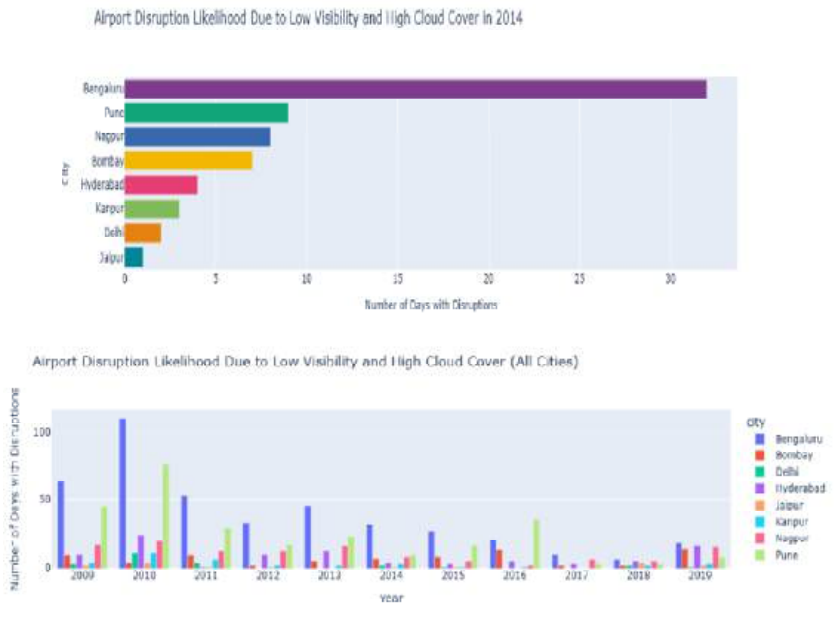


Fig. 6.Aviation Analysis

RESEARCH ARTICLE

Comparison of Effect of Pilates and Aerobic Exercises on Pain, Functional Status and Disability among Postmenopausal Low Back Pain

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ABSTRACT

Postmenopausal women with lower back pain may suffer from a lack of estrogen, which causes bone and muscle weakness, especially in the spine. Proper care is crucial to improving their quality of life, and Pilates can effectively reduce pain. To find out how the Pilates method and aerobic activities affect postmenopausal women with lower back pain in terms of pain, functional status, and disability. Postmenopausal women over 50 experiencing lower back pain were selected based on the criteria for inclusion and exclusion and divided into two groups at random: the Pilates group and the Aerobic group. Both groups underwent conventional physiotherapy, with one also incorporating various aerobic exercises and the other adding Pilates exercises. Participants from both groups showed improvements in pain reduction, disability, and improvement in functional status between their pre- and post-exercise values ($p<0.0001$). There is also a significant variation in post-exercise results between the two groups ($p<0.0001$), indicating that Pilates exercises along with conventional physiotherapy are more effective than aerobic exercises with conventional physiotherapy. Pilates exercises show a significant decrease in pain (numerical pain rating scale), and disability (Rolland Morris disability questionnaire) and a significant increase in functional status (6-minute walk test). Thus, we concluded that Pilates exercises along with conventional physiotherapy were more effective than aerobic exercises with conventional physiotherapy at relieving pain, improving functional status, and reducing pain-related disability.

Keywords: women's health, low back pain, exercise, quality of life.

INTRODUCTION

Preface to post-menopausal lower back pain

Menopause is when the activity of ovarian follicles decreases, resulting in a permanent loss of the menstrual cycle, diagnosed after 12 consecutive months of amenorrhea.[1] Menopause marks the end of irregular menstrual cycles and the onset of menopausal symptoms, marking the final stage of women's reproductive life.[2] Night sweats, flashes of heat, dryness of the vagina, and disturbed sleep are common symptoms that women may experience during menopause. [3] This transition can cause various metabolic and cardiovascular risks. Therefore, it is a crucial opportunity to take preventive measures to reduce symptoms and improve quality of life. [4] Several studies have shown that women in the postmenopausal stage are more likely to experience musculoskeletal pain due to estrogen shortage, which weakens bones and muscles and deteriorates collagen, which is found in intervertebral discs and causes lower back pain. [5]

Prevalence of low back pain in post-menopausal women

According to an Indian study, 41.0 % of 5798 people above the age range of 18 and under 80 had LBP. The prevalence of lower back pain was higher in the midlife age group especially among women (44.1%) compared to men [6] The general quality of life remains good even if those with lower back pain are more likely to have substantial handicaps. [7] Chronic pain and lasting disability due to lower back pain is especially common among India's poor labourers, due to the physically stressful nature of their jobs.[8] As they were afraid of being in pain, women often avoided engaging their bodies. This creates a vicious cycle in which a sedentary quality of life encourages poor posture, bone loss, muscle weakness, and lower back discomfort.[9] Understanding low back pain impact on postmenopausal women's quality of life is crucial for effective healthcare. Back pain relief can be achieved through stretching, heat/cold therapy, general activity, and back exercise. [10]

Effective methods for treating low back pain

Lower back pain treatment methods include surgeries, medications, and non-medical interventions. Physical activity is a suitable treatment with minimal side effects, especially beneficial for postmenopausal women and the elderly. [11] Aerobic exercise enhances health and prevents lower back pain by minimizing spinal load without impairing lower back muscle function. Over-exertion will, however, reverse the effect, so there is a need to select workouts with balance [12] Aerobic exercise is shown effective and safe in the treatment of lower back pain, in terms of reducing pain and improving aerobic capacity, and it has significant effects on clinical outcomes. [13] Aerobic exercise therapy is better than electrotherapy or no treatment in improving short-term results in depression, pain, and disability in chronic lower back pain patients but, when assessed alone, can only make small alterations.[14]

Pilates as an alternative method

Studies have revealed that weaker muscles, including the multifidus and transverse abdominis, can result in decreased spinal stability and lower back pain. This study concentrates on deep trunk muscles, pelvic floor muscles, and core, highlighting the significance of pelvic muscles as the floor of the lower back. Pilates is a useful treatment for lower back pain, improving posture, core strength, flexibility, and overall well-being through coordination of movement and breathing.[15] The Pilates technique is a popular exercise form used by dance instructors and choreographers to prevent dance-related injuries and promote a safe post-rehabilitation. The traditional method of Pilates exercises can be demanding and needs to be modified for physiotherapeutic interventions.[16] Pilates form training is an effective practical therapy for lower back pain it addressing all relevant components and provides significant benefits such as improved functional capacity and a return to regular daily living. [17] Pilates exercises, performed on mats or specialized equipment, focus on deep breathing and concentration. Participants usually sit or lie, using gravity to stabilize their core. Many exercises have a flexion bias and do not involve weight-bearing.[18] Pilates mat work in various positions is employed to avoid tension in the joints and muscles. They increase the body's efficiency by conditioning lower trunk muscles, that stabilize the body. Exercising these and pelvic muscles has been found to alleviate low back pain.[19]

MATERIAL AND METHODS

This study was focused on the comparison of the effectiveness of aerobic and Pilates exercises on postmenopausal women with lower back pain. The study was approved by ISRB 01/021/2023/ISRB/SR/SCPT. Eighty postmenopausal women aged between 50-60 participated in this lower back pain study. The study focuses on women with lower back pain who scored over 5 on the Numerical Pain Rating Scale and 40.0% on the Rolland Morris questionnaire. The research uses pain intensity, daily function, and aerobic activity tests to assess pain intensity and endurance. The study includes 50 participants in aerobic and Pilates groups, who undergo 15 minutes of conventional therapy of Interferential Currents (IFC) to reduce skin resistance, improve circulation, alleviate discomfort, restore neuro vegetative balance, and modulate sympathetic nervous system activity. The aim is to improve pain management and overall well-being.[25] For four weeks, this protocol was administered three days a week for 45 minutes a session. Data from the pre-test and post-test were collected to compare the results before and following the protocol regime after 4 weeks.

Aerobic exercise group

After performing conventional physiotherapy for 15 minutes participants were asked to perform a warm-up phase of slow walking before the brisk strolling. Slow walking entails moving slowly and observing movements by marking off the first 15 to 20 steps. Then, they were asked to perform brisk walking with a straight stance, aligned ankles, hips, and shoulders, and started with fast-paced walking. Brisk walking is a Moderate-intensity exercise usually increases heart rate and work of breathing, but you can still talk. The routine includes 30 minutes of brisk walking followed by a cool-down phase of slow walking for a total of 45 minutes. [14]

Pilates exercise group

After performing conventional physiotherapy for 15 minutes participants in this group were assigned to a Pilates mat exercise regime which was carried out for four weeks, three days a week under supervision of a Pilates instructor and a physiotherapist. Each session lasted for 30 minutes and the lumbar stretching as a warm-up and cool-down phase was included; the lumbar stretches consisted of a static stretch, which means holding the pose for 10 seconds and repeating it three times. The stretches involved standing forward, backward bends and side bends. The next stretch was the knee-to-chest in a standing position by flexing the hip. After warming up, they performed a series of Pilates exercises for 30 minutes. This session began with learning the six principles, which included breathing, concentration, control, precision, centre, and flow. They were then asked to perform arm and leg circles. These circles were performed for 3 repetitions and 5 sets. The second exercise was called the Neutral Spine exercise, where the three natural curves of the spine (cervical, thoracic, and lumbar) are maintained. The participant was informed to lay on their backs on a mat, with their knees bent and their feet resting on the ground and Arms should be kept by their sides and slowly push their lower back to the floor while focusing on their breathing pattern. They ought to stay in this posture for ten seconds and repeat 5 times. For the next exercise, they start by lying on their backs on the ground with both knees flexed and their feet flat. After exhaling they were asked to raise the pelvis and upper back gradually off the floor after performing a few pelvic tilts. They were instructed to hold this position for 10 seconds while inhaling, and while releasing their breath, they should slowly lower themselves back to the floor. Both their core and pelvic muscles are strengthened by this activity. During the leg kick exercise, the participants were laid on their stomachs with their foreheads resting on their hands and their legs touching the floor. They then tilted their pelvic bone downward, flexing their core, while bending their knees and keeping their thighs touching the floor. Finally, they were asked to point their toes. As for the next exercise, they were asked to assume a supine position with their legs fully extended and arms resting at their sides. They were instructed to inhale deeply and gradually flex one knee, drawing the leg towards the chest by grasping the ankle or thigh with a hand, while exhaling gently they should release the leg to its initial position. Repeat this sequence with the other leg, alternating for a total of 3 repetitions per leg. Then they performed the clamshell exercise. To begin, they should lie down on their side on the mat and bend their knees so that their thighs form a 90-degree angle with their body. They were instructed to make sure to rest their head on their arm to avoid straining their neck; they should keep their big toes together and start to slowly rotate their leg at the hip socket, allowing their top knee to open. While inhaling they were asked to open their

knees as far as comfortably without disrupting their alignment and then exhale slowly and return their knee to the starting position. Aim for 5 reps of this exercise.[18]

RESULTS

The sample was 50 participants aged 50-55, 30 (60.0%) aged 50-55 and 20 (40.0%) aged 56-60. The BMI of the subjects was less than 18.5,6 (12.0%). Pre-test measurements were taken, and the two groups received a four-week intervention. Post-test measurements were taken, and paired and unpaired t-tests were conducted. Mean and standard deviation values were computed. The study was to determine the impact of physical therapy on weight control. Table 1, compare the values of the aerobic group before and after the intervention using the numerical pain rating scale to assess pain, the 6-minute walk test used to assess the functional status, and the Rolland Morris questionnaire used to assess disability. The pre-test and post-test values for pain revealed a mean of 6.88 and 5.2, The mean for the 6-minute walk test was 322.48 prior to the intervention and 326.76 subsequent, The Rolland Morris questionnaire values revealed a mean of 17.16 prior and 14.52 after the intervention. Table 2 present the Pilates group's pain, functional status, and disability before and after intervention. Pain was assessed by numerical pain rating scale, functional status by 6-minute walk test, and disability by Rolland Morris questionnaire. Outcome revealed a significant reduction of pain (mean 7.32 to 4.2), improved functional status (mean 327.72 to 347.36), and reduced disability (mean 16.56 to 10.4). The study compared the post-test scores of two groups: Pilates and aerobic. The aerobic group had a mean pain score of 5.2, while the Pilates group had a mean score of 4.2. The 6-minute walk test showed a difference between the two groups. The Rolland Morris questionnaire showed a difference between the aerobic and Pilates groups. The Pilates group showed a significant decrease in discomfort compared to the aerobic group. The functional status of the Pilates group improved significantly compared to the aerobic group. The Pilates group also had less impairment than the aerobic group, indicating that the Pilates group had better results.

DISCUSSION

Post-menopausal women mainly suffer from low back pain because of estrogen deficiency that may result in weaker muscles and bones, along with other symptoms such as hot flashes, night sweats, joint and back pain, chronic fatigue, anxiety, depression, and sleep disorders. These physical, psychological, and sexual problems need to be managed for their health and well-being. A study of aerobic exercise effectively treats chronic lower back pain, as evidenced by the reduction of pain scores in the Roland-Morris Disability Questionnaire, Oswestry Impairment Questionnaire, Hospitalization Anxiety and Depressive Scale, and McGill Pain Questionnaire, suggesting its potential benefits for physical and mental health. [20] Our study utilized the Numerical pain rating scale, a widely used and more reliable method, instead of the MC Gill Pain Questionnaire, Rolland Morris questionnaire, and Oswestry, to assess the benefits of aerobic activity. A recent systematic review indicates that Pilates may not be the only treatment for chronic lower back pain since proper recruitment of deep trunk muscles may be more effective. Furthermore, the mechanisms of muscle retraining and awareness promotion may be more effective in chronic lumbago management despite ongoing controversy regarding their effectiveness.[21] Pilates is effective for chronic low back pain, but most studies focus on deep trunk strengthening. Our research emphasizes the importance of core, pelvic floor muscles, and deep trunk muscles in managing low back pain. These muscles serve as a floor for the lower back, making Pilates a crucial tool for pain management. Lee CW *et al*. suggest that strengthening internal core muscles like the transverse abdominal, soleus, diaphragm, and multifidus can prevent recurring lower back pain, while Pilates workouts can reduce progressive muscle wasting by lowering pain and preventing idleness, thus preventing further pain. [22] The study suggests Pilates, a form of exercise that targets abdominal, core, and pelvic muscles, effectively reduces pain, but it neglects the importance of disability and functional status in individuals with lower back pain. Franks J et al said that Pilates may be useful by increasing core strength in the trunk, pelvic region, and abdomen which can help some persons with low back discomfort. When measuring muscle thickness using real-time ultra sonography, Pilates proved to be no less effective than other physical activities, workouts, or similar doses to strengthen the core muscles.

[23] Pilates is a promising alternative to traditional physiotherapy for treating chronic physical stress-related lower back pain. It significantly reduces pain and continues even after a year by strengthening the diaphragm, hip flexors, glutes, and deep erector spinae, improving pain and posture.[24] Regarding these studies, most of the research had concentrated on the efficacy of aerobics or Pilates alone for the management of pain in the lower back stating that both exercises help in lowering the pain, with few comparisons between the two forms of exercise. This study compared pain, functional status, and disability in postmenopausal women as they were more prevalent in lower back pain, which was not concentrated in many studies. Lower back pain is a significant concern in the modern population, particularly in women during menopause. The lack of oestrogen during this phase weakens bones and muscles, leading to discomfort. This study focuses on postmenopausal women's lower back pain and compares aerobic and Pilates exercises. Results suggest that Pilates may provide additional benefits and potentially improve overall outcomes, such as pain, functional status, and disability in postmenopausal women with lower back pain. Therefore, Pilates exercises are more effective in reducing lower back symptoms than aerobic exercise.

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Table -1 -Comparison of Pre-Test and Post-Test Values of Numerical Pain Rating Scale,6minute Walk Test, Rolland Morris Questionnaire of Aerobic Group

OUTCOME	AEROBIC GROUP(25 participants)	Mean	SD	T value	P value
Numerical pain rating scale (pain)	Pre-test	6.88	0.83	10.4728	<0.0001
	Post-test	5.2	0.65		
6-minutewalk test (functional status)	Pre-test	322.48	13.11	8.6457	<0.0001
	Post-test	326.76	13.56		
Rolland Moris questionnaire (disability)	Pre-test	17.16	3.57	8.2286	<0.0001
	Post-test	14.52	2.99		

Table – 2 Comparison of Pre-Test and Post-Test Values of Numerical Pain Rating Scale, 6-Minute Walk Test, Rolland Morris Questionnaire of Pilates Group.

OUTCOME	PILATES GROUP (25 participants)	MEAN	SD	T value	P value
Numerical pain rating scale (pain)	Pre-test	7.32	0.99	11.8719	<0.0001
	Post-test	4.2	0.87		
6- minute walk test (functional status)	Pre-test	327.72	15.39	14.8059	<0.0001
	Post-test	347.36	15.78		
RollandMorris questionnaire(disability)	Pre-test	16.56	3.51	9.6328	<0.0001
	Post test	10.4	2.47		

Table 3 -Comparison Of Post-Test Values of Numerical Pain Rating Scale, 6-Minute Walk Test, Rolland Morris Questionnaire of Aerobic and Pilates Group.

OUTCOME	AEROBIC AND PILATES GROUP (25+25=50 participants)	MEAN	SD	T value	P value
Numerical pain rating scale (pain)	Aerobic post-test	5.2	0.65	4.6291	<0.0001
	Pilates post- test	4.2	0.87		
6- minute walk test (functional status)	Aerobic post-test	326.76	13.56	4.9393	<0.0001
	Pilates post-test	347.32	15.79		
Roll and Morris questionnaire (disability)	Aerobic post-test	14.52	2.99	5.3171	<0.0001
	Pilates post-test	10.4	2.47		

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RESEARCH ARTICLE

Added Effect of Darvyadi Dhoomapana in Kaphaja Pratishyaya (Chronic Simple Rhinitis)

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ABSTRACT

To determine the added effect of Dharvyadi Dhoomapana in Kaphaja Pratishyaya. Single blind randomized comparative clinical study was adopted. In the clinical trial, 44 subjects fulfilling the diagnostic and inclusion criteria were selected and randomly assigned into 2 groups Group –A and Group-B, out of them 2 dropouts were from each group. The children in Group A were treated with Chitrakahareetaki avaleha 10gm, twice a day after food for 14 days with lukewarm water as Anupana along with Darvyadi dhoomapana 3 puffs once daily in morning for 7 days. The children in Group B were treated with Chitrakahareetaki avaleha alone with a dose 10gm, twice a day, after food with lukewarm water as Anupana for 14 days. The results obtained after the clinical trial was analyzed statistically and all the observations were subjected to creative discussions. Overall assessment of all the therapy was assessed based on the significance of the statistical test values in both subjective and objective parameters. Both the groups showed effect in reducing the symptoms at the level of $p<0.05$. Even though both the groups were found to be effective in reducing the symptoms based on objective and subjective parameters, but better effect was in Darvyadi dhoomapana along with Chitrakahareetaki Avaleha group when compared to the Chitrakahareetaki avaleha alone group.

Keywords: Kaphaja Pratishyaya, Chronic simple rhinitis, Darvyadi Dhoomapana, Chitrakahareetaki Avaleha.

INTRODUCTION

Kaphaja pratishyaya is one of the Urdvajathrugata vikara where Kapha and Vata are said to be the predominant doshas involved in the manifestation of this condition.[1] Chronic simple rhinitis is a very common contagious disease seen in all over the world causing much distress and discomfort to the people.[2] Chronic simple rhinitis affects people of all the ages. In prosperous societies 20-40% of children suffer from chronic simple rhinitis [3]. The symptoms of chronic simple rhinitis show resemblance with the Lakshanas of Pratishyaya explained in Ayurvedic classics [1]. Kaphaja Pratishyaya is one of the Vyadhi, which is characterized by Nasasrava, Nasavarodha, Nasakandu, Kshavathu, Gatragaurava and Kasa [4]. Acharya Sushruta explained that if Pratishyaya is not treated in time then it may lead to Dushta Pratishyaya, associated with deafness, blindness, anosmia, cough, loss of appetite and oedema etc [5]. Acharya Charaka explained that if the disease is not treated properly or neglected, it may cause complications like Kasa and Kshaya [6]. This fact itself shows that Pratishyaya has been major problem to the physicians since long back. Hence this study was carried out to evaluate the comparative effect of Chitrakahareethaki Avaleha[7] with and without Darvyadi Dhoomapana [8] in children.

AIM

To determine the added effect of Dharvyadi Dhoomapana in Kaphaja Pratishyaya

Source of data

The subjects diagnosed with Kapha Pratishyaya attending the out patient department of Kaumarabhritya, Alva's Ayurveda Medical College, Moodbidri, Karnataka, India.

Diagnostic Criteria

Diagnosis will be done on the basis of symptoms of Kaphaja Pratishyaya ie; Sirogaurava, Nasasrava, Nasakandu.

Inclusion criteria

Subjects between the ages 12-16 years were selected irrespective of sex, occupation and socio- economic status.

Exclusion criteria

- Subjects below 12 years and above 16 years.
- Subjects suffering from diseases other than Kaphaja Partishyaya like (Vata, Pitta, Rakta, Sannipataja Pratishyaya)
- Subjects suffering from rhinitis associated with Tonsillitis, Pharyngitis.
- Any Other systemic diseases were excluded.

Administration of Drug

Group- A

Treated with Darvyadi Dhoomapanam for 7 days, as well as Chitrakahareetaki Avaleha (10-gram bd with lukewarm water after food) internally for 14 days.

Group - B

Treated with Chitrakahareetaki Avaleha (10-gram bd with lukewarm water after food) internally for 14 days and Darvyadi dhoomavarti (Dose – 3 puffs/ once daily in morning) for 7 days

Assessment criteria

Response of the treatment will be assessed on the basis of subjective and objective parameters before and after the treatment i.e., 7th and 14th day for both groups. Subjective parameters were Sirogaurava, Nasasrava, Galakandu, Nasakandu, Kasa, Aruchi whereas Objective parameters were Post nasal drip and Swollen turbinate.

OBSERVATION AND RESULTS

The clinical study was conducted in 44 diagnosed children of Kaphaja Pratishyaya fulfilling the diagnosing and inclusion criteria and divided in to two equal groups i.e., Group 'A' and Group 'B'. In Group 'A' Chitrakahareetaki Avaleha along with Darvyadi Dhoomapanam were given and for Group 'B' Chitrakahareetaki Avaleha was given. The treatment was carried out for 14 days for both groups. 2 drop outs occurred from each group, may be due to the less palatability of the drug or inconvenience of the children to take Dhoomapana. 56.81% of the children were males while 43.19 % were females. 22.72% belonged to the age of 12 years. Maximum children were belonging to mixed diet habit (61.64%). Maximum liking was observed for Madhura (59%), Lavana (22.72%), Katu (3.52%) Rasa. Maximum number of children were having Vatakapha Prakruti (47.7%), Vata and Kapha are considered to be the predominant doshas in the pathogenesis of Pratishyaya. 36.36 % were having Pittakapha Prakruti.56.81% are having Mandagni, 34.09% were having Vishmagni, 9.09% were having Teekshagni and none of the children were having Samagni. 56.81% of the children belong to a moderate digestive power and 34.09% belongs to very poor digestive capacity. Madhyama koshta were found in 43.18 %, Krura koshta in 31.81% and Mridu koshta in 25% of children. Madhura rasa were found in 59%, Lavana rasa found in 22.72% children. 38.63% of the children were having thin discharge, thick discharge in 61.36%. Atisheetambu pana and Sheetajala snana 52.27% and 50% respectively were seen as prime aggravating factors.

Sirogaurava

In Group A, 47.3% were improved after complete treatment and 78.94% were cured at follow up. In Group B, 7.89% were improved after treatment and 15.7% at follow up. Result showed that both groups were effective in treating Kaphaja Pratishyaya but Group A was comparatively more effective than Group B.

Nasasrava

In Group A, 15% were improved after treatment and 60% were cured at follow up. In Group B, 4.1% were improved after treatment and 27% at follow up. Result showed that both groups were effective in treating Kaphaja pratishyaya but Group A was comparatively more effective than Group B.

Galakandu

In Group A, 35.71% were improved after treatment and 89.28% were cured at follow up. In Group B, 9.5% were improved after treatment and 9.5% at follow up. Result showed Group A was effective in treating Kaphaja pratishyaya when compared to Group B.

Nasakandu

In Group A, 80% were improved after treatment and 80% at follow up. In Group B 16.6% were improved after treatment and 33.3%were cured at follow up. Result showed that both groups were effective in treating Kaphaja pratishyaya but Group A was comparatively more effective than Group B.

Kasa

In Group A, 57.14% were improved after treatment and 71.42% were cured at follow up. In Group B, 57.14% were improved after treatment and 57.14% at follow up. Result showed that both groups were effective in treating Kaphaja pratishyaya but Group A was comparatively more effective than Group B.

Aruchi

In Group A, 57.14% were improved after treatment and 71.42% were cured at follow up. In Group B, 30.76% were improved after treatment and 46.15% were cured at follow up. Result showed that both groups were effective in treating Kaphaja pratishyaya but Group A was comparatively more effective than Group B.

Post nasal drip

In Group A, 29.4% were improved after treatment and 67.64% were cured at follow up. In Group B, 14.81% were improved after treatment and 18.51% were cured at follow up. Result showed that both groups were effective in treating Kaphaja pratishyaya but Group A was comparatively more effective than Group B.

Swollen turbinate

In Group A 57.1% were improved after treatment and 71.4% were cured at follow up. In Group B 0% result obtained after treatment and follow up. Result showed Group A was effective in treating swollen turbinate, Kaphaja pratishyaya and Group B has no effect in treating this symptom.

DISCUSSION

Group 'A' shows highly significant result in reducing the symptoms like Sirogaurava, Gala Kandu, Nasa Kandu with p value <0.001. Group 'A' shows significant result in reducing the symptoms like Post nasal drip and swollen turbinate with p value <0.05. Both the groups show equal effect in reducing the symptom Nasasrava, Kasa and Aruchi. The disease Kaphaja Pratishyaya is primarily produced due to vitiated Vata and Kapha which leads to Sirogaurava, Nasasrava, Galakandu, Nasakandu, Kasa, Aruchi etc. While selecting the drugs to treat, this should have the properties of alleviating Vata and Kapha.

Discussion on Overall Effect of the Therapies:

For Group A, out of 20 subjects, 8 children (40%) got complete reduction of symptoms, 6 children (30%) showed marked improvement, 4 children (20%) shows moderate improvement, while 2 children (10%) had mild improvement. Whereas, for Group B, 3 children (15%) showed complete reduction, 4 children (20%) marked improvement, 8 children (40%) shows moderate reduction, 4 children (20%) shows mild reduction while 1 subject (5%) was observed with no reduction.

Discussion on selection of the drug

The disease Kaphaja pratishyaya is primarly produced due to vitiated Vata and Kapha which leads to Sirogaurava, Nasasrava, Galakandu, Nasakandu, Kasa, Aruchi etc. While selecting the drugs to treat, this should have the properties of alleviating Vata and Kapha. Considering these points, Chitrakahareetaki avaleha and Darvyadi dhoomavarti was selected for the study. Both drugs were taken from Yogaratnakara, Nasaroga chikitsa.

Discussion on selection of treatment modality [9]

While treating the Kaphaja prathishyaya, special attention should be given to the stages of the disease because the treatment approach of Amavastha, Pakwavastha and Dushta stages are entirely different. The medicines used in each of these stages will also be different. Along with the medicines if Pathyapathya is also prescribed in the line of treatment for the disease, it will go long way to improve the quality of life and immunity. Following points need better consideration during the treatment fixation. Long standing nature of the disease, puts the subject in an immune compromised state. Subject will be in a physical and mental challenged condition due to the symptoms like watery nasal discharge, heaviness of the head, throat itching, nasal itching etc. Chronic simple rhinitis must be regarded as a serious condition; because it can impact negatively affects the quality of life as well as produce complications. Long-term drug administration and diet restriction make the subject weak. By considering all these factors it can be concluded that our approach should treat the disease condition, as well as promote the immunity, physical and mental health of the subject.

Discussion on mode of action of drugs

Chitrakahareetaki Avaleha[7]

The causative factor for the production of complete etiopathogenesis of the disease, Kaphaja pratishyaya are Agni, Dhatus, Doshas, Vyadikshamatwa sakthi etc. So the ultimate aim of the treatment should be correcting in all this

involved factors. The concept of Agni is important in Ayurveda. Disturbances of Agni results in Ama formation which by itself may culminate in various. To sketch the mode of action of a drug it is also imperative to look into the Rasapanchaka or the properties by which it acts, screening the Rasa of the ingredients of Chitraka Haritaki Avaleha that Katu, Tikta, Katu Vipaka subsides the Nasa Kandu, Nasasrava, Kasa, Gala kandu, Agnimandhya etc. The drugs which were predominant of its Madhura Rasa and Madhura Vipaka, Snigdha, and Guru guna also elevates Vata. Among the functions ascribed to Madhura Rasa are Brimhana, Jeevana and Balya. These properties are very much favorable for building up tissues and may increase the Vyadhikshamatva and alleviate disease by its Vatapitta hara property. The rasayana effect of Chitrakahareetaki Avaleha was not be evidenced may be due to the short duration of drug administration. The Gunas present in the ingredients of the selected drug are Laghu, Ruksha, Tikshana are elevating Nasasrava, Kasa etc symptoms. Whereas Snigdha and Guru gunas acts as Balya, Tarpana and Brimhana. Virya is dominated by Ushna which has been also mentioned to be causing Vatakapha Shamaka, Pachana, Deepana etc actions.Chitraka has the inherent basic properties to digest Ama and also is the drug of choice for Deepana and Pachana. Chitraka has Katu vipaka and Ushna veerya, these properties help in digesting the vitiated Kapha. Chitrakahareetaki Avaleha contain Dashamoola, is known to alleviate Kapha and Vata hara. The Guda is also having important actions like Vataghana, Balya, Vrishya etc. It also contains Tri-katu Pippali, Maricha, Sunti are having Vata Kapha hara Dipana and Pachana properties. Yava Kshara helps in the penetration of the medicine to the target site.

Discussion on Dhumapana

Dhumapana is an old age practice in Indian System of medicine. Acharya Susrutha has explained in detail about Dhumapana. Acharya Charaka mentioned Dhumapana in Charaka chikitsa 5th chapter. In Sarangadhara samhitha, appropriate age for Dhoomapana was mentioned, it can start from 12 year up to 80 years. In the present study, age was taken in between 12 to 16 years. In view of Acharya Charaka, for Kaphaja vikaras, Vairechaka dhoomapana is indicated. Similarly, the period when Kapha get vitiated is the time suited for Vairechanika Dhoomapana, by considering this Darvyadi dhoomapana was advised at morning time. Dhumapana itself is Ruksha and Tiksha in nature, it may probably reduce the symptoms Nasasrava, Sirogaurava. Dhumapana had an immediate and local action on the nasal mucosa, helps in relieving Galakandu and Nasa kandu. Use of Dhuma helps to subside the Kapha dosha and clears the srotasas of the Urdwajatru.

CONCLUSION

The effect of both therapies on the symptom of Kaphaja Pratishya was significant expect in swollen turbinate, it was found insignificant in Group B. However, the combined group has provided comparatively more significant, which shows that for complete cure of the symptoms of Kaphaja Pratishyaya both the internal and external medication are necessary. Both the group shows significant result, but better result was found in Group A when compared to Group B. Group A shows a significant reduction of symptoms on the 7th day of treatment, it shows the added effect of Darvyadi Dhoomavarti. Evaluating all the results of the study it can be concluded as, there is significant effect of Darvyadi Dhoomapanam with Chitrakahareetaki Avaleha over Chitrakahareetaki Avaleha alone in Kaphaja Pratishyaya.

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RESEARCH ARTICLE

Navigating Regulatory Hurdles in Medical Devices Approval in U.S and E.U

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ABSTRACT

The aim of navigating regulatory hurdles in medical devices is to ensure that these products meet the necessary safety, effectiveness, and quality standards required by regulatory bodies, while facilitating timely access to the market. This process involves complying with local and international regulations, adhering to rigorous testing and documentation requirements, and addressing any potential risks associated with device development, manufacturing, and use. Ultimately, the goal is to achieve regulatory approval efficiently without compromising patient safety or product performance, thereby enhancing innovation and trust in medical devices within healthcare systems. Comprehending these regulatory environments is crucial for businesses looking to effectively and securely introduce cutting-edge medical products to the market. Finally collected the total number of medical devices approved from the year of 2022 to 2024 in U.S and E.U and results are Given in the graphical representation.

Keywords: Regulatory Compliance, Medical Device Approval, FDA (Food and Drug Administration), CE Marking.

INTRODUCTION

Since there are several regulatory organizations across the world that monitor the marketing of medical devices, it is challenging to provide a universal meaning for the term[1]. Even while these organizations frequently work together

and debate the definition generally, there are minor variations in phrasing that hinder a worldwide standardization of the concept of a medical device; as a result, the proper definition of a medical device varies by location. Since the two have distinct regulatory requirements, it is common for the definition of a medical device to include a section that aims to distinguish between medical devices and pharmaceuticals.[2] In vitro diagnostics are frequently acknowledged as a subtype of medical devices in definitions, and accessories are classified as medical devices. Medical gadgets are crucial for clinical decision-making and for enhancing patient outcomes. As a result, important performance metrics and objectives are met, including the Sustainable Development Goal of the prosperity and health (SDG3). However, access to functioning, necessary medical equipment is restricted in low- and middle-income countries (LMICs) healthcare institutions. According to aresearch evaluating LMICs' access to necessary technology for safe birthing, [3]40% of medical equipment was non-functional when compared to high-income nations (HICs), where fewer than 1% of medical equipment is broken This discrepancy results from LMIC hospitals' reliance on imported equipment, of which 80% is donated, as well as inadequate maintenance and usage training. This, in turn, makes equipment unreliable for prompt illness diagnosis, prevention, monitoring, and treatment, exacerbating disparities in general health outcomes that lead to the high death rates in LMICs. Creating internal mechanisms in LMICs to lessen reliance on imported medical technology might help close this gap, particularly in dire circumstances like COVID 19. When COVID-19 was declared a worldwide pandemic in March 2020, a number of HICs prohibited the importation of vital medical supplies, including such as patient monitoring and mechanical ventilators making it impossible for many LMICs that mostly depend on imported medical equipment to effectively care for critically ill COVID-19 patients.[4] Medical devices are tools, machinery, implants, or other apparatus used for the diagnosis, treatment, monitoring, or prevention of medical diseases. They vary from basic instruments like bandages and thermometers to sophisticated technological advancements like robotic surgical systems, pacemakers, and MRI scanners. In addition to helping the medical community deliver better treatment, these technologies are essential for improving patient outcomes and healthcare efficiency. Health authorities oversee the safety, effectiveness, and quality of medical equipment, emphasizing that they adhere to strict guidelines for patient safety.

Stages of Processing Medical Devices IN U.S [5]

About 1,700 distinct generic device types have been classified by the Food and Drug Administration (FDA), which has categorized them into 16 medical specialties known as panels. Depending on the degree of regulation required to ensure the device's efficacy and safety, each of these generic device types is placed into one of three regulatory classes. The following are the three classes and the prerequisites for each:(figure 1). Among other things, the sort of premarketing submission or application needed for FDA authorization to commercialize your product depends on the class to which it belongs. A 510k will be needed for marketing if your device is categorized as Class I or II and is not exempt. The restrictions on exemptions apply to all devices that are categorized as exempt. 21 CFR addresses the limitations of device exemptions; Parts 862–892. Unless your device is a pre-amendments device (one that was on the market before the medical device amendments were passed in 1976), Class III devices must have a premarket approval application (PMA). or significantly comparable to such a device), thus PMAs have not been required. A 510k will be the path to market in that scenario. Device categorization is based on both indications for use and the device's intended usage. As calpel, for instance, is designed to cut issue. In addition, categorization is risk based, that is, the danger the device poses to the patient and/or the user is a key factor in the class it is allocated. Devices in Class I are the least dangerous, while those in Class III are the most dangerous. All device classes are subject to general controls, as previously mentioned. The fundamental standards of the Food, Drug, and Cosmetic (FD&C) industry are known as general controls. Act that apply to all medical devices, Class I, II, and III. (Table 1) Certain steps must be taken during the medical device development process to guarantee design control and ensure that the final product is both safe and effective. Consequently, this encompasses the full product development cycle, from risk management to manufacturing, clinical trials, and medical device design. [6] For instance, the FDA outlined five steps for processing medical devices in order to get them ready for sale. "The methods used in, and the facilities and controls used for, the design, manufacture, packaging, labelling, storage, installation, and servicing of all finished devices intended for human use" are governed by its quality system regulation (QSR), which is comprised of these steps.(Figure2,3,4)

Stages of Processing Medical Devices In EU:[8]

Equipment or goods designed for medical use are known as medical devices. To prove that they full fill regulatory standards to guarantee their safety and functionality, products must go through a conformance evaluation in the European Union (EU). Although they are subject to EU Member State regulation, the European Medicines Agency (EMA) is involved in the process. After a medical gadget passes a conformance evaluation, manufacturers are able to stamp it with the CE (Conformité Européenne) mark. An audit of the manufacturer's quality system and, depending on the kind of device, a study of the manufacturer's technical documentation regarding the device's performance and safety are often part of the conformance assessment. Accredited notified entities are designated by EU member states to carry out conformance evaluations. Before awarding a CE certificate for some high-risk items, notified authorities are required to seek the opinion of particular expert panels. EMA provides technical and scientific support to these expert committees. Before granting a CE certificate, the notified body may occasionally need to get a scientific opinion from EMA. For several types of medical devices, 0EMA has distinct regulatory obligations, including. (Table2)

Role of EMA; - [9]

The quality, safety, and effectiveness of marketing authorization applications evaluated through the centralized process, including the performance and safety of a medical device in connection with its usage with a pharmaceutical product, are all evaluated by EMA. The medical device may be a part of the pharmaceutical product, be purchased independently from it, or be co-packaged with it. (Figure-3)

METHODOLOGY

The regulatory procedures involved in the approval of medical devices in the US and the EU are examined in this study using a qualitative research methodology. The following crucial stages make up the methodology's structure:

LITERATURE REVIEW

To determine the main regulatory frameworks, rules, and requirements for medical device approval in the US and the EU, a thorough analysis of the body of available literature is carried out. In addition to examining scholarly papers, business reports, and legal texts that address regulatory needs and difficulties, this entails looking over official documents from the European Medicines Agency (EMA), the European Commission, and the U.S. Food and Drug Administration (FDA).

Comparison of Regulatory Processes

The approval procedures in the two areas are compared. Classification systems, submission types (such as 510(k), PMA in the US and CE marking in the EU), clinical evidence criteria, approval timescales, and post-market surveillance duties are some of the important elements that are the subject of this research. The study also looks at how the regulatory processes for high-risk and low-risk devices differ, as well as the effects of recent regulatory changes like the European Union's Medical Device Regulation (MDR) update and the U.S. FDA's breakthrough device designation.

Analysis of Case Studies

To highlight the practical difficulties faced by manufacturers, a number of case studies of recent medical device approvals in the US and the EU are examined. The purpose of these case studies is to draw attention to devices that encountered major regulatory obstacles, such as licensing delays, issues achieving clinical evidence criteria, or difficulties adhering to new rules. The case studies shed light on real-world problems, such as how to interpret regulatory guidelines and how changes to regulations affect the approval process.

Interviews with Industry Experts

Key players in the medical device sector, legal specialists, and regulatory affairs specialists participate in semi-structured interviews. The purpose of the interviews is to obtain professional opinions on the difficulties manufacturers have while negotiating regulatory obstacles and methods for guaranteeing adherence and accelerating approval. Perspectives on current developments in regulatory reform and the changing regulatory environment in both areas are also offered by the interviewees.

Data Synthesis and Analysis

The findings from the literature review, regulatory comparison, case studies, and interviews are synthesized to identify common themes, challenges, and opportunities for manufacturers in navigating the regulatory pathways for medical device approval. A framework is developed to guide companies in addressing key regulatory hurdles and optimizing their approval processes in both the U.S. and E.U.

Recommendations for Stakeholders

Based on the analysis, the study provides actionable recommendations for medical device manufacturers, regulatory agencies, and policymakers to improve the efficiency and clarity of the approval processes. This includes suggestions for streamlining submission processes, enhancing communication between regulatory bodies and manufacturers, and ensuring that the evolving regulatory requirements are met without compromising patient safety.

RESULTS

If u see the Below Graphes it mainly explains about how many drugs are approved and out of that how many are the medical devices in the year 2022 total drugs are 55 in that only 41 are the medical devices and in the year 2023 total drugs are 65 in that medical devices are 51 and whereas 2024 total drugs are 42 in that 25 are the medical devices (Figure 4,5,6,7) If u see the above Graph it explains about that how many medical devices are recalled from the 2022-2024 if you see in the year 2022 60medical devices are recalled and where as in the year 2023 63 medical devices are recalled and in the year of 2024 93 medical devices are recalled.

Outstanding challenges in medical device regulation in the US and Europe.[15]

Both the US and European systems face similar issues in effectively regulating medical devices. Ensuring public health and certifying effectiveness of high-risk technologies requires robust evidence and review systems, which is now a significant concern. Device regulation applies in both the United States and Europe. In the US, there are concerns that many high-risk gadgets are examined using less rigorous review methods.3 Over the past decade, just about 2% of medical devices have received PMA.21 According to a GAO study22, only 79% of Class III devices passed PMA from 2003 to 2007, with the rest going through the 510(k) procedure. Unlike PMA, 510(k) filings often do not require direct evidence of safety and effectiveness, and only a small percentage have clinical data (10-15%).23 Furthermore, devices deemed substantial. Devices that were previously cleared by the FDA do not require premarket approval, even if they were not evaluated for safety and effectiveness. recalled due of a significant safety flaw.24 In a study of high-risk recalls in the US, 71% were cleared through the 510(k) process, while the remaining 7% were excused from review.25 Quality difficulties are also present, in addition to the quantity of strong evidence. The FDA found that over 50% of 510(k) submissions had quality issues, such as incomplete or missing device descriptions and indications.

E.U Results

If u see the Below Graphes it mainly explains about how many drugs are approved and out of that how many are the medical devices in the year 2022 total drugs are in that only 50 are the medical devices and in the year 2023 total drugs are in that medical devices are 96 and whereas 2024 total drugs are in that 116 are the medical devices (Figure 8,9,10,11**)**

If u see the above Graph it explains about that how many medical devices are recalled from the 2022-2024 if you see in the year 2022 409 medical devices are recalled and where as in the year 2023 389 medical devices are recalled and in the year of 2024 291 medical devices are recalled.

Reasons for the Recall of medical devices in USA: [20]

Mighty Bliss Electric Heating Pads

Following consumer complaints of Mighty Bliss electric heating pads burning their skin, overheating, sparking, burning, or exhibiting other electrical issues, Whele LLC is recalling the device.

Lumen Central Venous Access and Pressure Injectable

The Arrow MAC Two-Lumen Central Venous Access Kits and the Arrow Pressure Injectable Arrowgard Blue Plus Three-Lumen Central Venous Catheter (CVC) Kits are being recalled by Teleflex and their subsidiary Arrow International, LLC due to the possibility of a cross-lumen leak brought on by improper connections between the top and bottom housings of the Micro Clave Clear Connectors that are part of the kits.

Omnipod DASH Insulin

Following reports of PDM battery problems, Insulet is recalling the Personal Diabetes Manager (PDM) from the Omnipod DASH Insulin Management System. These problems include: Swelling of batteries battery fluid leaks excessive heat that might be a fire hazard

Cordis US Corp Recalls INFINITI Angiographic

The INFINITI Angiographic Catheter is being recalled by Cordis US Corp. because some of the goods were sent to customers without being sterilized. The manufacturer intends for the INFINITI Angiographic Catheter to be sent sterile straight to a third-party distributor, who will then transport the device to final consumers, including hospitals.[21]

Incubator/Warmer Correction

The usage instructions for the Giraffe OmniBed and Giraffe OmniBed Care Station are being updated by GE HealthCare and its subsidiary Datex-Ohmeda Inc. in response to allegations that the warmer heater doors may fall loose due to improperly tightened screws. A High Priority alert is triggered and canopy movement is halted if doors come loose. Users risk damaging the doors and maybe having them collapse on the patient if they try to push the canopy to continue moving.

Chest Compression Device Recall

The RMU-2000 ARM XR Chest Compression Devices are being recalled by Defibtech, LLC because of a motor issue that might prevent compressions from continuing. Serious negative health effects, such as patient injuries, therapy delays, and death from a lack of compressions to move oxygen throughout the body, can result from using the impacted product.[22] One person has been reported injured, and one person has died.

Reasons for the Recall of medical devices in EU

Medical device recalls in the European Union (EU) can happen for a variety of reasons, with safety being the primary concern. Recalls are issued when a medical device is found to pose a risk to patient health or fails to meet regulatory standards. Below are some of the most common reasons for medical device recalls in the EU:

1. **Safety and Performance Issues:** Devices that fail to perform as intended or malfunction during use can lead to recalls. This could be due to design flaws, manufacturing defects, or problems with the materials used in the device. For example, infusion pumps that deliver incorrect dosages or pacemakers with battery malfunctions [23]

2. **Injury or death risks:** : Devices that cause injury, illness, or death due to defects or inadequate design. For example, faulty surgical instruments that break during procedures or implants that fail to properly integrate with the body.
3. **Sterility and Contamination Issues:** Medical devices that come into direct contact with patients (such as surgical instruments, catheters, or implants) must be sterile. If a device is found to be contaminated with bacteria, viruses, or other pathogens, it could lead to infections and other serious health issues [24]
4. **Labelling and Instructions for Use (IFU) Errors**
   Medical devices that have incorrect or incomplete labelling may lead to incorrect use or misinterpretation by healthcare professionals. For example, dosage information on drug delivery systems, or instructions for use of surgical devices, can lead to misuse.
5. **Unexpected Device Interactions:** Medical devices that interact with other equipment, such as diagnostic tools or monitoring systems, may be recalled if the interaction leads to failures or compromised patient safety. For example, a device might cause incorrect readings on patient monitors or fail to integrate with hospital networks[25]

CONCLUSION

Before medical devices may be sold, they must pass a rigorous and complicated approval process that guarantees their efficacy and safety. Although both the US and the EU have strict regulatory regimes, their methods, purviews, and specifications are different. The regulatory barriers to medical device approval in the US and the EU will be compared in this talk, with an emphasis on the main issues, variations, and new developments in each area. Manufacturers face numerous obstacles while navigating regulatory barriers for medical device approval in the US and the EU, ranging from the intricacy of the approval processes to the need for clinical evidence and post-market surveillance. Although ensuring safety and effectiveness is a goal shared by both areas, their methods vary in terms of procedures, specifications, and deadlines. To thrive in both cutthroat and heavily regulated sectors, producers must remain alert and flexible as both markets change to meet new technological advancements and regulatory requirements.

CONFLICT OF INTEREST

The authors have no potential conflict of interest regarding this Investigation.

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Table-1: -Classification of medical devices

S.No	Device Classification	Required submission	Eamples
1.	**Class I** General Controls	Registration only unless 510(k) specifically required	elastic bandages, examination gloves, hand-held surgical instruments
2.	**Class II** General Controls and Special Controls	510(k) notification unless exempt -IDE possible	powered wheelchairs, infusion pumps, surgical drapes

3.	**Class III** General Controls and Premarket Approval	PMA application -IDE probable	heart valves, silicone gel-filled breast implants, implanted cerebella stimulators

Table 2: - Medical devices category and its responsibilities

s.no	Medical device category	EMA responsibility
1.	Combining medications with a medical device	In a centralized process for applying for medical products, MA evaluates the efficacy and safety of medications used in conjunction with medical devices.
2.	Medical equipment that contains an additional medication	The EMA scientific opinion on the quality, safety, and utility of the supplementary medicinal substance must be sought by the notified entity if the ancillary substance: • Is made from human blood or plasma • Has undergone prior EMA evaluation • Does not fall inside the centralized procedure's required scope.
3.	Companion diagnostics	If the medication falls under the purview of the centralized procedure, the notified authority is required to get the scientific opinion of the EMA about the acceptability of the companion diagnosis.
4.	Medical equipment that contains a supplemental drug	A competent authority's scientific opinion must be sought by the notified entity; the European Medicines Agency (EMA) offers scientific opinion on the substantive compliance with the requirements in Annex I of Directive 2001/83/EC.
5.	Risky medical equipment	The European Medicines Agency (EMA) supports medical device expert panels that advise notified entities on the scientific evaluation of specific high-risk medical devices and in vitro diagnostics.

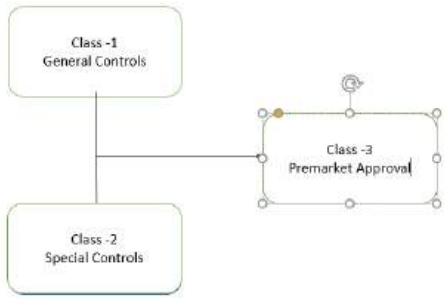


Figure-1 it shows that medical devices classification

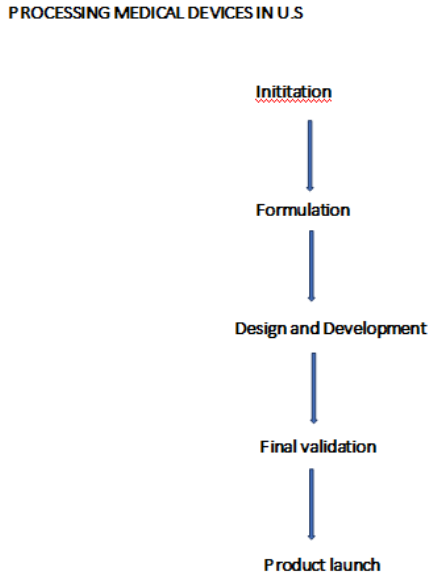


Figure-2 It shows that processing of medical devices[7]

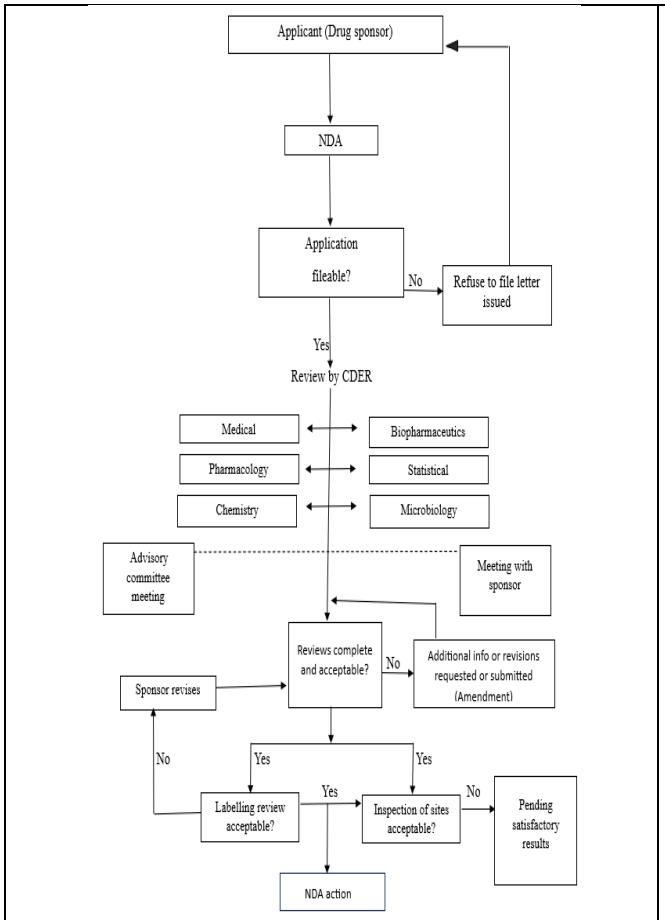


Figure:3 New drug application process in (USA) [8]

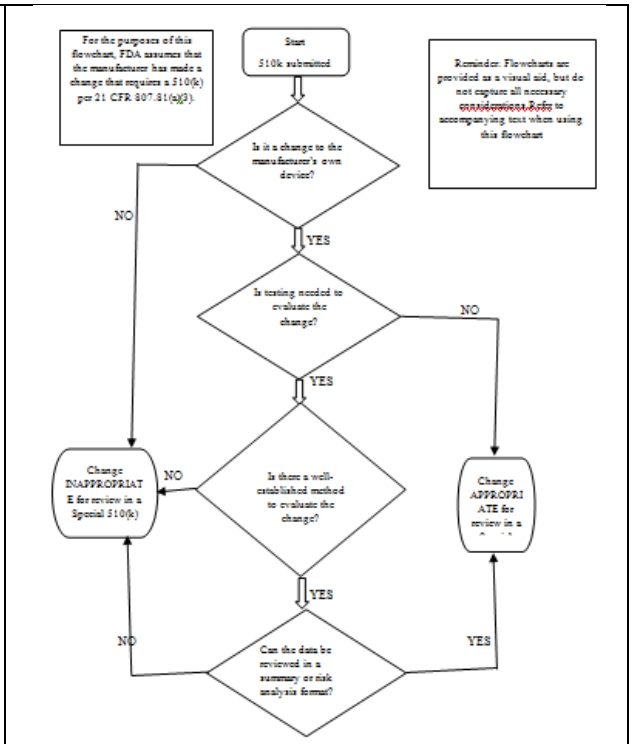


Figure:4 510K flow chart

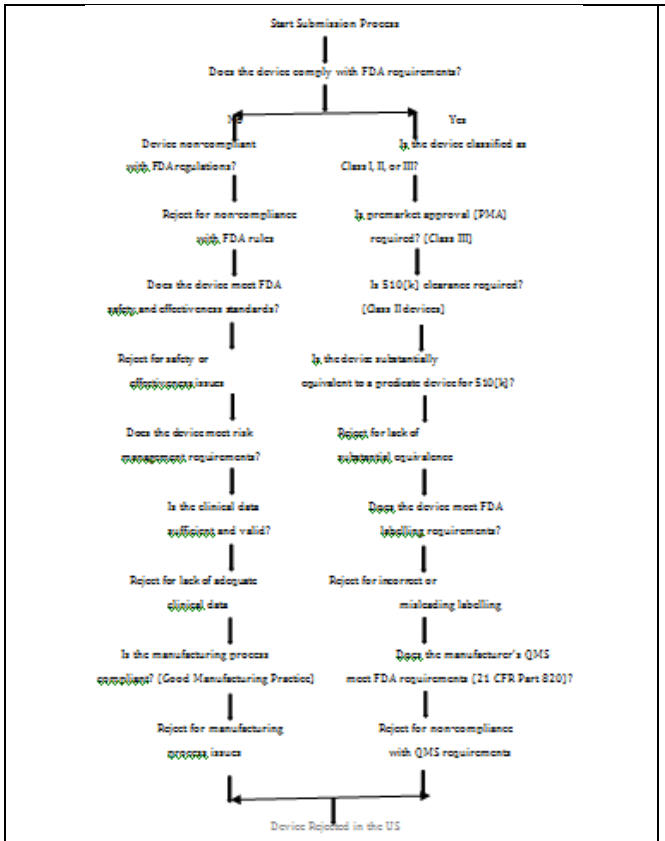


Figure: 5 US Medical device Rejected process

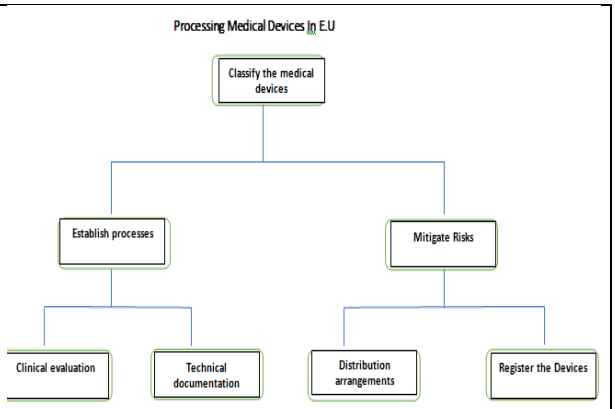


Figure-6 It shows that processing of Medical devices in EU [10]

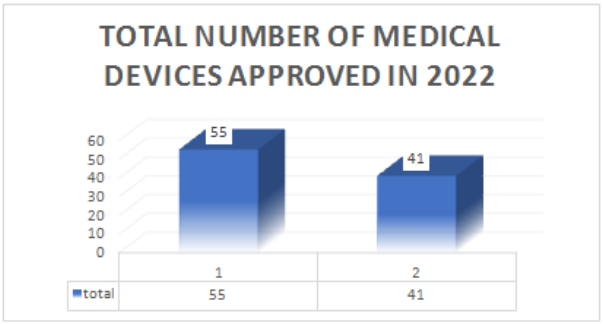


Figure 7: Total number of medical devices approved in the year of 2022[11]

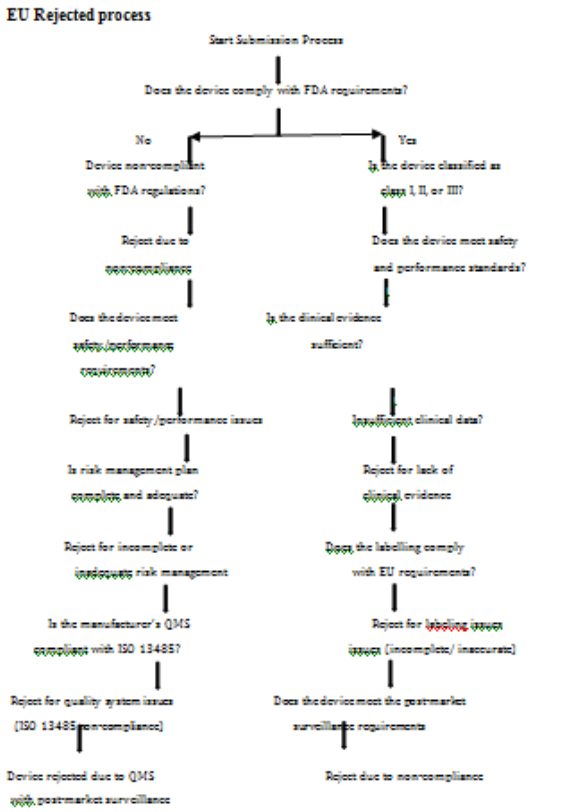


Figure:8 EU Medical device Rejected process

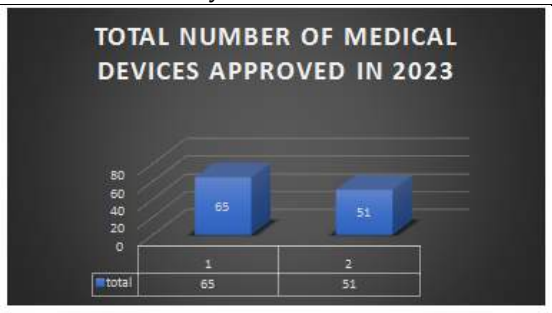


Figure 9: Total number of Medical devices approved in the year of 2023[12]

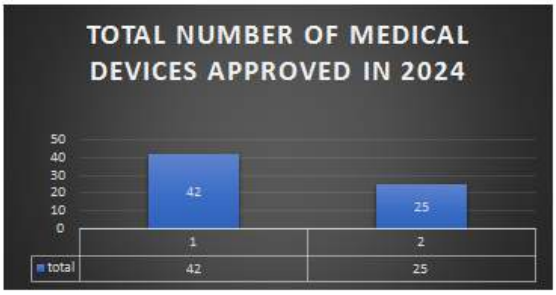


Figure 10: Total number of medical devices approved in the year of 2024 [13]

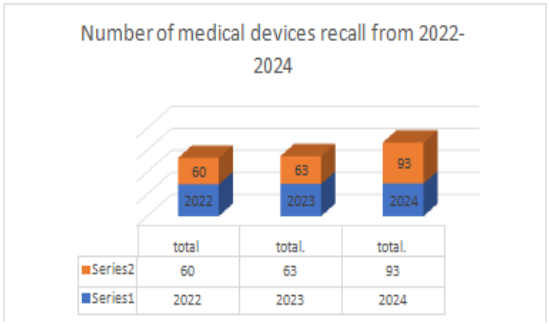


Figure 11: Total number of medical devices are recalled in the year of 2022-2024[14]

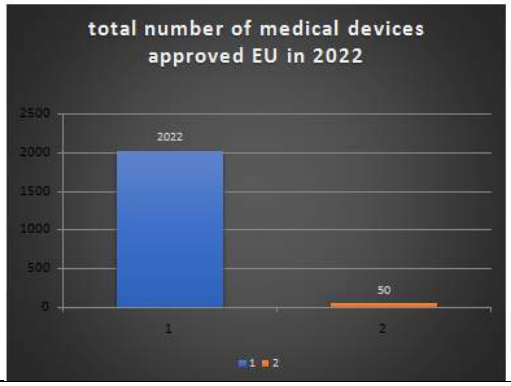


Figure12:Total number of medical devices approved in EU in the year 2022[16]

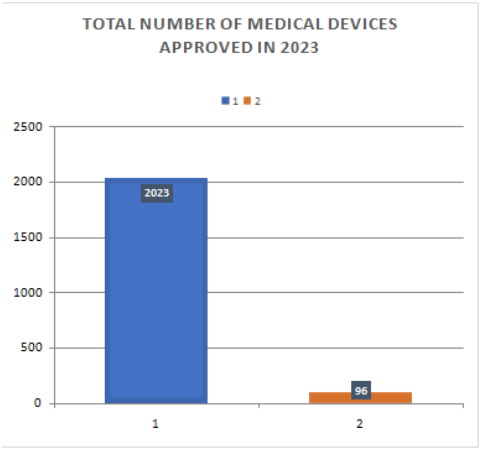


Figure 13:Total number of medical devices approved in EU in the year 2023[17]

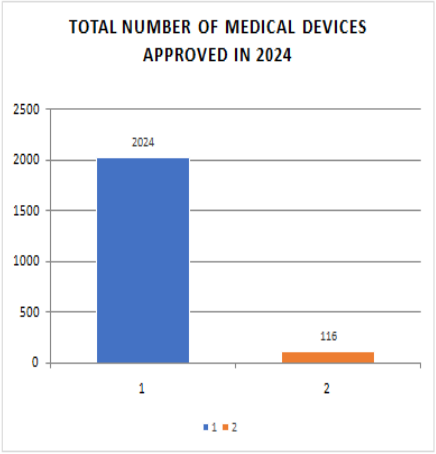


Figure 14:Total number of medical devices approved in EU in the year 2024[18]

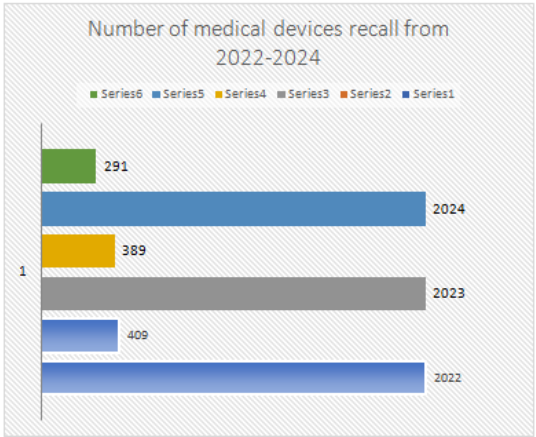


Figure 15: Total number of medical devices are recalled in the year of 2022-2024 [19]

REVIEW ARTICLE

Review Paper on Natural Language Analysis and Processing for Recognition and Sentiment Extraction

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ABSTRACT

This review paper reviews the natural language analysis and processing progresses made so far, based on recognition and sentiment extraction. Along with the increasing importance of user experience and human-computer interaction, being able to understand and then respond well to natural language has now become a necessity that has urged the development of diversified techniques and algorithms, namely syntactic and semantic analysis, machine learning, and deep learning. These approaches enable tasks such as entity recognition, sentiment and emotion extraction from text, and interpreting user intent. The paper also explores the challenges and constraints of natural language processing, including handling ambiguity and maintaining context sensitivity. In addition, it outlines the vast applications of natural language processing in sectors such as healthcare, finance, and social media. It briefly represents the state of natural language processing in terms of recognition and sentiment extraction and also touches the current challenges along with promising lines of research.

Keywords: Sentiment, Opinion, Data Analysis, Natural Language processing

INTRODUCTION

The growing significance of human-computer interaction has elevated natural language processing (NLP) to a prominent position in information technology. Natural Language Processing (NLP) is the computational modelling and analysis of human language, with various applications in machine translation, email spam detection, information extraction, summarization, medical uses, and question answering. This review paper focuses on NLP for recognition and sentiment extraction, which has captured the attention of academics, businesses, and governments. The paper examines the different phases and levels of NLP and its components, the development and history of NLP, and its current applications, including sentiment analysis. The technologies of machine translation and text summarization provide opportunities for people from different cultures and socioeconomic backgrounds to have access to education and information. NLP techniques are used in information extraction to help users find the information they need within the vast amount of data available on the internet. The paper also discusses the potential of opinion mining and sentiment analysis for businesses and governments to understand public opinion on products, government activities, and public discussions. The main objective of "Natural Language Processing (NLP)," a subfield of both linguistics and artificial intelligence, is to teach machines how to understand human-written language. The development of "natural language processing (NLP)" has as its major focus the simplification of the user experience and the fulfilment of a long-held desire of users to be able to communicate naturally to their computers. "NLP" was developed to assist those who do not have the time to become skilled in machine-specific language. This is due to the fact that not all users are fluent in this language. One way to look at a language is as a collection of symbols, while another way to look at it is as a set of rules. When information is sent by transmission or broadcast, frequently a mix of symbols is involved. The oppressive nature of norms has a negative impact on symbols. The two subfields of "Natural Language Processing," "Natural Language Comprehension" and "Natural Language Generation," each add to the creation of novel approaches to understanding and producing text. (Fig. 1). Phonology is the way sounds are produced; morphology, the formation of words; and semantics, meaning and use.

Pragmatics is the most important role in interpreting the syntax and meaning of sentences. Noam Chomsky is the most influential theoretical linguist, especially with respect to syntax. Syntax is broadly categorized into two main levels: speech recognition is at the top level, and natural language is at the bottom. Natural Language Processing includes co-reference resolution, discourse analysis, machine translation, morphological segmentation, named entity recognition, optical character recognition, and part-of-speech tagging among other tasks in the area of automated summarization. These tasks are for summarizing large volumes of text, named entities identification, grammatical element identification, and translating text from one language to another. The objective of natural language processing (NLP) is to modify a language model to suit the requirements of a particular program or system. NLP is a field that studies the algorithmic structure that enables the integration of language interpretation and output. Additionally, it has several applications in multilingual event detection [1]. To extract cross-lingual events from texts written in Gujarati, Hindi, English, Dutch, and Italian, a new modular technique is recommended. Separate pipelines for each language would be developed in this approach. The system incorporates some of the most advanced multilingual NLP features currently available, and each feature may be enabled or disabled independently. The pipeline combines fundamental NLP processing components with those for more complex tasks, such as connecting named entities across languages, labelling semantic roles, and normalizing time passage. These are some of the pipeline's responsibilities. Since the pipeline's design supports several languages, it can translate not just names but also dates, locations, and times, as well as the links between them. The output from each pipeline's processing is fed into a larger system designed to generate event-centric knowledge graphs. Each module in the pipeline works like a UNIX pipe: it takes data from the standard input, applies annotations to it, and then passes the annotated data to the standard output. Pipelines are created using a data-centric design that employs replaceable component parts. The architecture is modular, allowing it to be adaptable and flexible to a range of different configurations and distribution strategies. Researchers in the fields of computer science, linguistics, psychology, and philosophy have all expressed interest in "Natural Language Processing"; nevertheless, computer scientists are responsible for the majority of the work in this field. The contribution that "NLP" makes to our capability to grasp language is one of the most

intriguing aspects of this field. The difficult task of teaching computers to understand human language is the focus of the branch of computer science known as natural language processing. One of the primary obstacles that natural language presents is ambiguity. This issue is often resolved at the syntactic level, with additional subtasks involving the investigation of existing words from a lexical and morphological perspective, as well as the creation of new terms. Reading the entire text is required in order to interpret any ambiguities, [2] regardless of whether they are contextual, semantic, or formal. In an effort to provide clarity to the situation, techniques including "Reducing Ambiguity," "Preserving Ambiguity," "Interactive Disambiguation," and "Weighing Ambiguity" may be used [2,3,4] Preserving ambiguity is one approach of reducing ambiguity that has been the subject of substantial research and is utilised by researchers. The objectives are analogous to the ones from the previous one; they span a wide range of ambiguity, and the technique for achieving them includes a statistical component implicitly.

NLP LEVELS

One of the most straightforward ways to explain natural language processing is by referring to its 'language levels.' Through the processes of content planning, sentence planning, and surface realisation, these stages help with text generation. The second illustration in Figure: The study of the meaning of language, the context of language, and the many different kinds of language is known as linguistics. The following are examples of words that are included in Natural Language Processing terminology:

Phonology

The classification of phonemes is the main subject of the branch of linguistics known as phonology. Phonology is the study of sound and language; the prefix phono- relates to the human voice, and the suffix -logy means “-logy” or “-logy.” Lass (1998) argued that the term “phonology” should be used to refer more generally to the sounds of language, rather than just to the sub-field of language study; alternatively, “Phonetics is the branch of linguistics that studies how sounds work and how they are structured within a language.” Phonology was defined in 1993 by Nikolai Trubetzkoy as “the study of sound as it relates to the language system.” However, Lass (1998) argued that the term “phon”, it covers the manner in which the sounds of each language are used to communicate meaning [5].

Lexical

The individual words that make up Lexical may be comprehended by both humans and machines that do natural language processing. One type of processing that enhances comprehension at the word level is the act of assigning a part-of-speech tag to each individual word. According to the setting in which they are located, words that are capable of being interpreted in a variety of ways are classified as belonging to particular parts of speech. Words with a single meaning can sometimes be used in the lexicon in place of more complicated semantic representations. The representation of an NLP system takes on a different form depending on the semantic theory that is used by the system.

Semantic

The widespread misconception that only the semantic level can convey meaning is incorrect; meaning may be communicated on all levels. Semantic processing is able to discern the many different meanings that may be attributed to a phrase by analysing the links that exist between the various words that make up the phrase. Words that may be understood in more than one way can profit from the semantic disambiguation that occurs during this level of processing, just as they do from the syntactic disambiguation that occurs during the syntactic level of processing. The word "file" has many diverse meanings, such as a binder for storing papers, a nail file for shaping fingernails, or a queue of individuals waiting in line. The dictionary report and the sentence context report both use the semantic level of the terms from the survey. [47] The majority of words have many accounts, but by analysing the context in which they are used, we may figure out which one is most suitable[6].

Morphology

One is able to dissect the meaning of a word into ever-more-granular components, which are known as morphemes. Morphemes are the driving force behind the field of morphology, also known as the study of how words function.

The word "precancellation," which consists of the prefix "pre," the root "cancella," and the ending "-tion," is an illustration of a morpheme. Because the term "morpheme" has a broad definition, it is feasible to break down any given word into the various morphemes that make it up in order to have a deeper understanding of the meaning of the word. The addition of the -ed ending to a verb gives the impression that the action it describes occurred at some point in the past. In the lexicon, morphemes are words that continue to have their own meaning even when they are not combined (e.g.: table, chair). Words that end in a grammatical morpheme (such as -ed, -ing, -est, -ly, and -ful) and words with specific suffixes are examples of lexical morphemes (eg. Worked, Consulting, Smallest, Likely, Use). Grammarians refer to the combination of these two morphemes as a "bound morpheme" (eg. -ed, -ing). Moreover, morphemes can be further separated into two other classes: bound morphemes and derivational morphemes.

Syntactic

To determine the syntax of a statement, we analyse it by breaking down this word by word. And now, at this step, a grammar and a parser become essential elements for the process. In general, this produces an annotated representation of the statement of structural relationships between the words as that has been processed so far; however, grammars have a limit. Some NLP applications do not need the parsing of full phrases. While prepositional phrase attachment and conjunction analysis are problems that remain unsolved, requests involving clausal and phrasal dependencies are now better processed. Syntax is crucial to convey meaning because it is an order- and dependency-sensitive. Meaning in most language families is structured through syntax. Consider, for example the phrases "The cat chased the mouse" and "The mouse chased the cat." Their linguistic structures differ only slightly, yet they mean completely opposite things.

Pragmatic

Pragmatics examines the use of language in context to comprehend a document's goal and elucidate how implicit meanings are derived from texts. It was vital to have a comprehensive comprehension of the global backdrop, as well as an awareness of the objectives, intents, and tactics that people had. The anaphoric “they” in the next two lines have both set very ambitious [17] objectives for themselves, but in order to accomplish those goals, the speakers will need to have a comprehensive knowledge of both local and international issues.

Discourse

Discourse-level natural language processing relies on units at the paragraph and essay level rather than the sentence-level units employed by syntax and semantics. These higher-level units are necessary for the processing system to function properly. This would suggest that it does not recognise texts with several sentences as a group of independent sentences. In contrast, the focus of attention in discourse is on the entire piece of writing, with the meaning being conveyed through the links that are made between the phrases. Resolution of anaphora and resolution of entities are two of the most common processes in the process. When a term is employed in a setting where it does not have a direct semantic counterpart, anaphora resolution includes replacing the term with the noun to which it refers [17]. Study of the Text and Recognition of the Conversation - Once the text and discourse's organisational structure are recognised, the text's sentence functions are rearranged to better accurately reflect the text.

NLP: HISTORY

Although while work on machine translation (also known as MT) had started in the late 1940s, the phrase “machine translation” didn't become common usage until much later. The research that was done at this time wasn't carried out in a vacuum. Although other languages, such Chinese, were employed, the two most common languages used for MT were Russian and English (Booth, 1967) [8]. According to a study published by ALPAC in 1966, the academic subfield of MT/NLP studies appeared to be in its latter stages of existence. Nonetheless, customers eventually received the finished product that was produced using some MT production systems [9]. At this point in time, research projects examining the possibilities offered by computers in the fields of linguistics and literature were already under progress. As early as 1960, artificial intelligence began to have a discernible impact on the Q-A systems [11] used in baseball. It was generally agreed upon that LUNAR [10] and Winograd SHRDLU, with their more

sophisticated capacities to handle language and tasks, were the inevitable successors to these systems. It was widely considered that advancement was only conceivable in two domains: the Other significant system development projects that created database front ends include the ARPA Speech Understanding Research (SUR) project. The overall goal of these front-end [12] initiatives was to outperform LUNAR in terms of how large datasets were handled. Research on computational grammar theory blossomed in the early 1980s, along with research on logics for meaning and the capacity of knowledge to fit the user's ideas and intents, and other related fields of study. Towards the end of the decade, robust general-purpose sentence processors, including SRI's Core Language Engine [13] and Discourse Representation Theory [14], offered a way to deal with longer speeches within the parameters of grammatico-logical analysis. There were more residents there over the course of this time. A number of other beneficial materials, grammars, tools, and parsers are also made available, in addition to the Alvey Natural Language Tools 15. In addition to the issues discussed, the DARPA voice recognition and message understanding information extraction conferences were distinguished by their focus on rigorous evaluation, a practice that became prevalent in the 1990s. [16, 17] In addition to their work on discourse structure serving, [19] the team also did some research on user modeling, [18] which was one of the topics of the study piece. Concurrently, as McKeown [19] has shown, there are rhetorical schemas that can be utilised to generate material that is logically sound and successfully delivers its point. These schemas may be used to create content that is logically sound and effectively conveys its message. Other NLP research has brought to light a number of important challenges, two of which are word sense disambiguation [20] and statistically coloured probabilistic networks. These are only two instances of the pressing issues that have been brought to light. Both studies on natural language processing and lexicography pointed in this general direction. When statistical language processing first gained popularity in the 1990s, its practitioners consisted of a much wider range of individuals than only those who worked in the field of statistics. In addition to that, information extraction and automated summarization [21] were major focuses. The majority of current research has been on semi-supervised and unsupervised learning approaches.

TASKS THAT MATTER

Many academics made major contributions to the development of NLP by establishing a wide variety of approaches and tools pertaining to the field. NLP research has been productive due to the availability of useful techniques like as emotion detection, sentiment analysis, named entity recognition (NER), chunking, and POS tagging. Named entity recognition (NER), semantic role labelling, and named entity recognition are other strategies (NER). The sentiment analyser's [21] main duty is to solicit opinions from users about a particular topic. Sentiment analysis is the act of gathering words that are relevant to a particular topic, identifying general sentiments, and creating linkages between concepts. The two linguistic resources that are used in the sentiment analysis process are the sentiment lexicon and the sentiment pattern database. It accomplishes this by searching the articles for both positive and negative terms before attempting to calculate a score that is between -5 and +5. In addition to European languages, research is being done to create parts of speech taggers for Arabic, Sanskrit, [22] Hindi, [23], and other languages. It is very amazing how precisely words can be labelled and arranged into categories like nouns, adjectives, verbs, and so on. While most part-of-speech approaches work rather well in European languages, they are entirely useless in Asian and Middle Eastern languages. Those who tag Sanskrit parts of speech favour the treebank method in particular. Arabic basic phrases are automatically tokenized, part-of-speech tagged, and annotated using the Support Vector Machine (SVM) [24] technique. By identifying phrases that are syntactically linked, such as "Noun Phrase" and "Verb Phrase," shadow parsing is a sort of sentence segmentation that locates sentence pieces. The term "chunking" is also frequently used to describe this form of text fragmentation (NP or VP). To indicate whether a word is at the start of the chunk or in the middle, it is given either a Begin Chunk (B-NP) tag or an Inside Chunk (I-NP) tag. The CoNLL 2000 shared task is used frequently to evaluate chunking. The data required to assess Chunking may be obtained in CoNLL 2000. As a direct consequence of this, a few novel approaches have surfaced in the intervening time [25,26,27] and an F1 score of around 94.3 percent Words, point-of-sale labels, and many other identifiers are all features of these systems. When applied outside of an academic setting, where individuals are less likely to speak Standard English, Named Entity Recognition (NER) might be challenging to implement successfully. As a direct consequence of this, the performance of traditional NLP tools is substantially worse than usual. We are able to annotate words or tweets by constructing systems that have been trained on unlabeled data from inside the domain as well as data from outside the domain. It



displays a considerable improvement when compared to natural language processing systems that are considered to be industry standard. With the exception of its ability to identify emotions in postings that have been written in a mix of two languages—in this case, English and any other language spoken in India—Emotion Detection [28] conducts operations that are analogous to those of sentiment analysis. By using emotional states, it is possible to group utterances into these six categories. They first ascertained the native tongue of the speaker in order to achieve this. This allowed them to identify the lexical category or sections of speech written in mixed script and to distinguish between terms with comparable implications in Hindi and English. SRL will assign a sentence a semantic function to aid in analysis. The Prop Bank [29] formalisation assigns a specific role to each word that acts as a verb's argument. A statement with several verbs may have many tags since the verb frame defines the specific arguments. State-of-the-art A system must first construct a parse tree, then decide which nodes correspond to the arguments of a specific verb, and then classify the nodes in the parse tree. The approach in Discovery: Events in social media 30 is graphical to analyse the social media feeds for real-world events, including the references to individuals, locations, and timestamps. Even with irrelevant noisy messages and highly inconsistent language in the posts, the model was able to accurately extract event records from these noisy data streams through a multi-message aggregation strategy. Yet a much wider scope of feature components could help make the results even more effective.

NLP: CURRENT SCENARIO

In the following paragraphs, we will talk about some of the most recent advancements in NLP projects that have been carried out by various companies:

[31] The Role that Natural Language Processing will have in the Future of Business Intelligence

Numerous companies in the business intelligence (BI) industry are working hard to catch up with the times by exerting significant efforts to make data analysis simpler and more user-friendly. Having said that, there is still a long way to go, one won't even require a graphical user interface in order to access the data when you're using BI. Mainly because the majority of inquiries asked on mobile devices these days are posed in the form of text or voice commands. You can get the forecast for tomorrow's weather on Google, for example, right now. We will soon be able to ask our own personal data, which will be portrayed by a chatbot, about current consumer sentiment as well as our evaluation of the company's brand in a week while we are out and about. Natural language processing, often known as NLP, is primarily concerned with converting human speech into computer code at this point in time. Yet as time passes, technology will improve to the point where the computer becomes better at "understanding" the request, at which point it will start giving answers rather than search results, especially with reference to the AI component. You should expect the data chatbot to ask you a question like, "How have revenues changed over the last three quarters?" at first. before handing you reams of information to read. But rather than just giving you numerical data, once it comprehends the semantic connections and implications of the question, it will be capable of executing the requisite filtering and formulation to provide an answer that is comprehensible to you. Link:http://www.smartdatacollective.com/eran-levy/489410/here-s-why-natural-language-processing-future-bi

The Pilot, the first earbuds that translate between languages, has finally arrived

Soon, people speaking 15 distinct languages will be able to place orders for Pilot, the first smart earpiece to be sold everywhere in the world [32]. Waverly Labs' Pilot, according to Spring Smart, can now transliterate seven written appended languages in addition to the five spoken languages it previously supported (English, French, Italian, Portuguese, and Spanish). The Pilot's included earpiece uses Bluetooth to connect to the speech translation application. This programme translates spoken language using a number of different technologies, including [33] voice synthesis, [34] automatic speech recognition, [35] machine translation, language learning based on artificial intelligence, and machine translation. The user's second earpiece will provide them with the ability to hear a simultaneous translation of the speech. It is not even necessary for the users to communicate with one another; rather, they are free to carry on private chats with one another. Users may encounter a delay of a few seconds between speaking and having their words translated. Waverly Labs is working to eliminate this delay so that users do not have to wait as long. Pre-orders for the Pilot earpiece, which costs $249 and will be fulfilled in September, are being accepted right now. In addition to these functions, earbuds may play music, answer phone calls, and offer

warnings. Link:https://www.indiegogo.com/projects/meet-the-pilot-smart-earpiece-language-translator-headphones-travel#/

Introduced by RAVN Systems, the GDPR Robot Facilitated by ACE

A software robot driven by RAVN ("Applied Cognitive Engine") has been released, according to the pros at RAVN Systems, a supplier of AI-based search and knowledge management solutions, and it is intended to make compliance with the [36] General Data Protection Regulation (GDPR) simpler. This software robot was created to simplify the GDPR-compliant data collection and processing of personal information. The Robot use artificial intelligence (AI) techniques to carry out thorough, automated analysis of data and documents contained in any corporate system subject to the General Data Protection Regulation (GDPR). Users may find, access, mark, classify, and report on data that complies with the GDPR's definition of highly sensitive information with ease. Users can search for personal information within documents, get updates of latest personal data that require attention, and generate reports of information recommended for destruction or protection. Users can also view feeds that highlight personal information that requires urgent attention. Data Subject Access Requests (DSARs) can be handled quickly and simply with the help of RAVN's GDPR Robot. Due of this, it is no longer necessary to employ a manual technique, which is frequently a time-consuming and unsuccessful strategy. "GDPR compliance is of universal paramountcy as it will exploit to any organisation that retain and handle data impacting EU individuals," claims Peter Wallqvist, chief security officer at RAVN Systems. "GDPR compliance is of utmost importance as it will exploit any organisation that owns and processes data pertaining to EU individuals," says the author. Link:http://markets.financialcontent.com/stocks/news/read/33888795/RAVN_Systems_Launch_the_ACE_Powered_GDPR_Robot

The Application of Natural Language Processing and Network Analysis to the Investigation of Medication Management and Therapy

An Introduction to Network Analysis and Natural Language Processing with a Focus on the Management of Pharmaceutical Treatment Creating a conceptual framework to analyse the impacts of various pharmaceutical treatment management procedures is what we mean when we use the word "research" (MTM). Both the MTM service model and the chronic care model were selected to serve as the parent theories for their respective models. The predominant subject of discussion in the abstracts of publications identified in Ovid Medline reviews is the administration of drugs for the treatment of chronic disorders (2000-2016). Using a Meta Map, we can draw out certain concepts from the abstracts, and then we can analyse the pair-wise co-occurrence of those concepts. The data is then used to create a graph of interconnected concepts, which is analysed to draw out important details for the developing conceptual framework. The framework is then developed. We examined the abstracts of 142 distinct publications [37]. Medication adherence, the component of pharmacological therapy that has drawn the most attention, has been related to the idea of patient-centered therapies with a focus on self-management. The revised model contains 65 concepts organised into 14 distinct structures. More research is required to modify and analyse the paradigm in order to ascertain whether it may be useful for a wide range of people and situations, especially those with low resources. Link: https://www.ncbi.nlm.nih.gov/pubmed/28269895?dopt=Abstract

Capital One has launched a chatbot called Eno, which is capable of understanding human language

Eno, a brand-new chatbot, has recently been made available by Capital One. Users are able to speak with one another through text using natural language thanks to Eno, which is a chatbot. According to Capital One, Eno is the first SMS chatbot developed by an American bank to assist natural language inquiries made by customers. Clients have the ability to connect with Eno through a text interface, during which they may ask inquiries regarding their money and other topics. By altering the environment, Eno gives the feeling that someone is communicating to you personally. According to Capital One's Vice President of Digital Product Development, Ken Dodelin, the business "kind of constructed a chatbot and didn't recognise it." To put it another way, this paves the door for a separate setting from which to launch chatbots in direct rivalry with those of other corporations. They feared that Facebook's access to user data would breach privacy rules in the United States, which are used to regulate financial firms. Each Facebook Page administrator can view all conversations with the bot, including word-for-word transcripts. False: If that were true,

administrators would have unlimited access to their clients' financial data. Link:https://www.macobserver.com/analysis/capital-one-natural-language-chatbot-eno/

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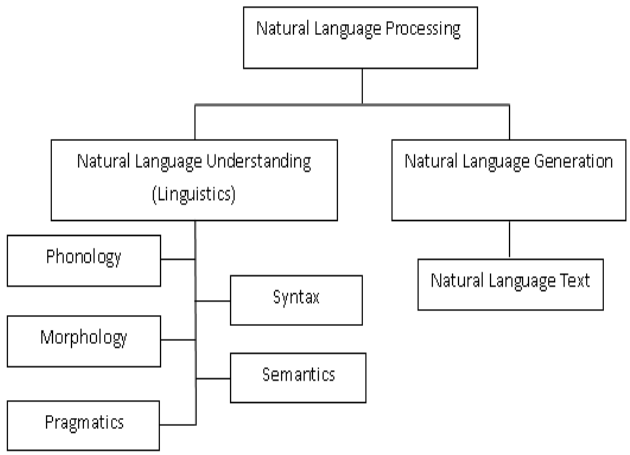


Figure 1: High-level categorization of natural language

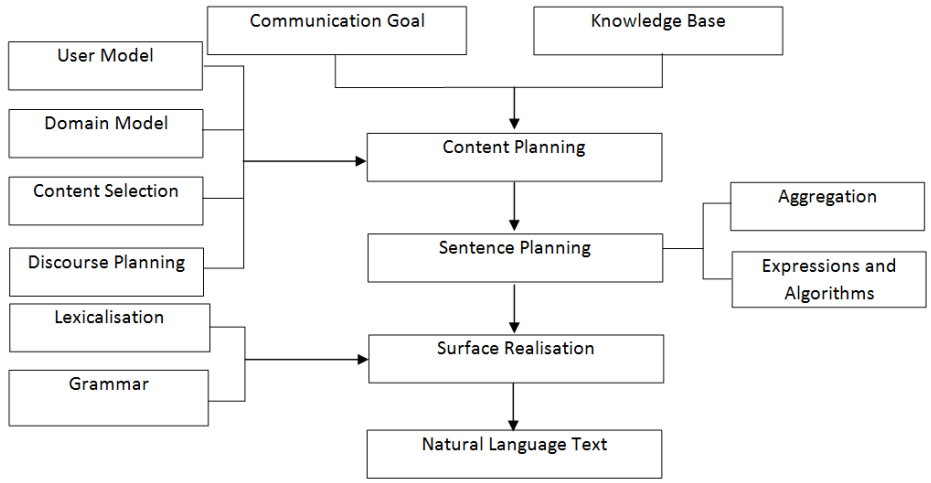


Figure 2: NLP architecture phases

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RESEARCH ARTICLE

Artificial Intelligence in Autism Care: Leveraging MRI, EEG, and Machine Learning for Early Detection and Personalized Treatment

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ABSTRACT

Autism Spectrum Disorder (ASD) is a condition with rising prevalence, impacting individuals socially, emotionally, and academically. The growing number of cases, coupled with limited access to diagnosis and treatment, highlights the need for more efficient and widely available services. Many individuals with ASD face challenges in receiving proper care due to factors such as high costs, long wait times, and complex diagnostic processes. Recent advancements in artificial intelligence (AI) and machine learning (ML) offer promising solutions to these accessibility barriers. Research has demonstrated progress in utilizing MRI and EEG datasets to develop ML models for ASD diagnosis and the potential identification of biomarkers through supervised and unsupervised techniques. Additionally, AI algorithms capable of analyzing body language and physical behaviors may help assess ASD characteristics despite the disorder's heterogeneity. Beyond diagnosis, AI's adaptability holds potential for creating supportive tools to aid students with ASD in learning, emotional regulation, social communication, and adaptability. While further research is needed to confirm the effectiveness of these applications, many studies indicate significant promise in improving outcomes for children with ASD.

Keywords: Artificial Intelligence, Deep Learning, Machine Learning, ASD Diagnosis, ASD Treatment

INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition that encompasses a wide range of challenges, including difficulties with social skills, communication impairments, and rigid or restrictive behaviors [1]. These challenges often manifest in repetitive behaviors, difficulties in modulating speech volume, maintaining appropriate physical distance, and interpreting nonverbal cues such as gestures and facial expressions [2]. According to the Centers for Disease Control and Prevention (CDC), as of 2023, approximately 1 in 36 children (2.8%) aged 3–17 years in the United States have been diagnosed with ASD [2]. The symptoms of ASD vary depending on age, but in children, the disorder commonly leads to delayed development, affecting academic performance and social interactions compared to their neurotypical peers [3]. Furthermore, children with ASD frequently experience co-occurring developmental and psychiatric conditions, including a heightened risk of Attention-Deficit/Hyperactivity Disorder (ADHD), anxiety, depression, epilepsy, gastrointestinal issues, and sleep disorders [4]. The financial burden associated with ASD is significant, with the estimated lifetime costs averaging $1.4 million for individuals without intellectual disabilities and up to $2.4 million for those with intellectual disabilities [5,7]. Due to the wide range of symptoms and behaviors associated with Autism Spectrum Disorder (ASD), diagnosing the condition can be challenging, particularly in milder cases or when co-occurring conditions are present [6]. The heterogeneous nature of ASD further complicates diagnosis, as it encompasses a broad spectrum of individuals with varying presentations [6]. ASD diagnosis is often a costly and time-consuming process, with families frequently facing long waitlists before being evaluated by a professional [10]. As a result, many individuals remain undiagnosed until adulthood. Additionally, early misdiagnoses are common, with ASD sometimes being mistaken for conditions such as Attention-Deficit/Hyperactivity Disorder (ADHD), Obsessive-Compulsive Disorder (OCD), or Social Anxiety Disorder (SAD). Early diagnosis is critical, as it enables timely intervention and support for both the child and their family. In contrast, delayed diagnosis is associated with increased mental health challenges [8]. Research indicates that individuals diagnosed with ASD in adulthood are nearly three times more likely to report psychiatric conditions compared to those diagnosed in childhood [9]

Following an autism diagnosis, interventions are essential to enhance an individual's functioning and overall well-being. While no medications have been proven effective in addressing the core characteristics of Autism Spectrum Disorder (ASD), psychological and behavioral interventions, such as cognitive behavioral therapy (CBT) and behavioral modification strategies, have shown positive effects in improving symptoms and overall quality of life [1]. However, these interventions are often costly and not accessible to all individuals. In educational settings, children with ASD frequently lack access to specialized support, placing them at risk of falling behind academically. Data indicates that autistic students have lower high school graduation rates, with 26.4% failing to earn a diploma compared to 14% of their neurotypical peers. Additionally, a shortage of trained professionals limits the availability of critical services, and financial constraints may further prevent families from accessing necessary care [10]. Artificial Intelligence (AI) encompasses computer systems engineered to execute tasks that traditionally require human intelligence. A key subset of AI, Machine Learning (ML), focuses on developing algorithms and models capable of making predictions or decisions based on data, either with or without human intervention, and continuously improving through computational experience. AI and ML have been widely utilized in the diagnosis and management of various neurological and psychiatric conditions, including Alzheimer's disease, dementia, schizophrenia, multiple sclerosis, cancer, and other infectious and degenerative diseases. These technologies leverage unstructured data, such as medical imaging and genomic information, to predict, study, treat, and manage these conditions [11]. Deep Learning (DL), a specialized subset of ML, enables computers to process information similarly to the human brain, enhancing their ability to recognize complex patterns. In recent years, the application of AI, ML, and DL in the identification and assessment of mental health disorders has expanded significantly, demonstrating promising potential in improving diagnosis and treatment outcomes. This review explores the applications of artificial intelligence in diagnosing and treating Autism Spectrum Disorder in children.

Diagnosis

Magnetic Resonance Imaging (MRI) is a non-invasive imaging technique used to study brain activity and structure. Functional MRI (fMRI) measures brain activity by detecting changes in blood flow, while structural MRI (sMRI) maps brain structures and captures contrast variations in brain tissue. Since the 1990s, MRI has been widely utilized for data collection and analysis in patients with mental disorders [12]. Machine Learning (ML) methods have shown efficacy in analyzing MRI datasets. By processing raw imaging data, ML and Deep Learning (DL) models can classify images, reducing the subjectivity inherent in traditional diagnostic assessments and identifying patterns that support clinical diagnosis [13]. Supervised learning, a key ML approach, trains models using labeled data with predefined outputs, whereas unsupervised learning analyzes unlabeled data to detect hidden patterns without predefined guidance [14]. Among supervised learning techniques, Support Vector Machines (SVMs) and Random Forests are commonly employed for classification, regression, and outlier detection tasks [18]. Structural MRI (sMRI) provides detailed information about brain structure and function, including cortical thickness, the volume of specific brain regions, and functional connectivity between different areas. In contrast, functional MRI (fMRI) captures correlation coefficients between the time courses of various brain regions, offering insights into brain activity patterns [15].

Using data from the National Database for Autism Research (NDAR), Dekhil et al. reported classification accuracies of 75% with fMRI data alone, 79% with sMRI data alone, and 81% when combining both features [15]. When utilizing both sMRI and fMRI data, the Random Forest algorithm achieved an 81% classification accuracy, while Support Vector Machines (SVM) attained a 71% accuracy rate [15]. Other applications of SVM on sMRI datasets have demonstrated varying accuracy levels, ranging from 45% to 94% across different ASD datasets [20]. Similarly, Liu et al. found that classification accuracies using different machine learning methods and fMRI data from multiple sources ranged between 48.3% and 97% [21]. Potential physical markers of Autism Spectrum Disorder (ASD) have been observed in the frontal, parietal, and limbic regions, as well as the basal ganglia and cerebellum. However, due to the heterogeneous nature of the disorder, these differences are highly variable and often unreliable as definitive diagnostic indicators [16]. Research suggests that subtle variations in brain anatomy exist, but ASD-related structural differences are not limited to a single morphological parameter; rather, they impact multiple cortical features [17].

Ecker et al. developed a model utilizing volumetric and geometric features at various spatial locations on the cortical surface to distinguish individuals with and without ASD. Their model incorporated features such as the average convexity or concavity of cortical folding patterns, mean radial curvature, metric distortion reflecting cortical folding degrees, cortical thickness, and pial area for measuring brain volume. By applying a Support Vector Machine (SVM) classifier, this study achieved an accuracy rate of 85% in differentiating ASD patients from control groups [17]. Resting-state functional connectivity (FC) has also been explored as a potential diagnostic biomarker for ASD. Zhao et al. proposed that high-order FC differs in individuals with ASD compared to traditional FC, suggesting its effectiveness as a diagnostic marker [22]. However, research on identifying reliable ASD biomarkers remains ongoing [21]. The establishment of the Autism Brain Imaging Data Exchange (ABIDE) database has significantly contributed to the advancement of machine learning models for the automated diagnosis of Autism Spectrum Disorder (ASD). Parikh et al. utilized personal characteristic data (PCD) from the ABIDE database, including age, sex, handedness, and three IQ measures, to develop predictive models. Among the various machine learning algorithms tested—such as decision trees, majority models, random forests, linear and nonlinear Support Vector Machines (SVMs), confidence models, logistic regression, k-nearest neighbors, and neural networks—both linear and nonlinear SVMs demonstrated the highest efficacy in terms of accuracy, sensitivity, specificity, and cost-effectiveness. The study highlighted the predictive power of PCD, achieving an accuracy of 61% [19]. Electroencephalography (EEG), a non-invasive and cost-effective method for recording brain activity, has also been explored for ASD diagnosis [23]. Although EEG readings can be unreliable when assessed solely by humans, various machine learning techniques have been applied to improve diagnostic accuracy. Tawhid et al. demonstrated that deep learning (DL) models could identify critical biomarkers for ASD diagnosis, achieving an impressive accuracy of 99.15% [24]. Similarly, Bosl et al. found that digital biomarkers extracted from EEG data could accurately predict ASD diagnostic outcomes in infants as young as three months and even estimate symptom severity, facilitating early detection with high accuracy [25]. However, many EEG-based studies are limited by small sample sizes and an overrepresentation of male subjects, which raises concerns about the validity and generalizability of their findings, particularly for female individuals

with ASD [26]. Additionally, researchers at the University of Geneva developed an artificial intelligence-based algorithm to analyze children's movements and identify potential ASD characteristics. Their model, trained on data from 68 typically developing children and 68 children with autism, achieved an accuracy of 80.9%, with prediction probabilities correlating positively with the severity of autism symptoms. The study assessed 27 behavioral traits, including gestures, immediate echolalia, vocal intonation, stereotyped language, spontaneous vocalizations, facial expressions, response to name, quality of social interactions, joint attention, and unusual sensory interests. Despite its promising results, the study faced limitations due to the broad nature of autistic traits. ASD cannot be diagnosed solely based on isolated behavioral acts, as it also involves impairments that may not manifest in physical traits [27]. The study introduces a novel medical diagnosis system leveraging Explainable Artificial Intelligence (XAI) for Autism Spectrum Disorder (ASD). The authors emphasize the importance of AI-driven decision-making that is not only accurate but also interpretable for clinicians, caregivers, and researchers. It utilizes decision tree and support vector machine (SVM) models, achieving 85% and 86% accuracy, respectively. Explainable AI techniques enhance transparency, aiding clinicians in understanding diagnostic decisions. The dataset includes 704 instances with 21 attributes related to behavioral and medical history. The study highlights the importance of interpretable AI in ASD diagnosis. Limitations include the need for diverse datasets and additional biomarkers. Future improvements involve expanding data sources and refining AI models. The research contributes to early ASD detection, improving patient outcomes [34]. AI technologies, particularly machine learning algorithms, are being utilized to analyze diverse data sources—such as behavioral patterns, neuroimaging, genetic information, and electronic health records—to enable early detection and personalized assessment of ASD. These algorithms have demonstrated high accuracy in distinguishing ASD from neurotypical development and other developmental disorders, facilitating timely interventions [35].

Treatment

AI and machine learning (ML) applications in Autism Spectrum Disorder (ASD) treatment primarily serve as supportive systems that enhance proven intervention methods, such as emotional regulation, individualized education services, and behavioral therapies [1]. Researchers have made advancements in emotion recognition and adaptive learning systems to help children with ASD navigate social conflicts [29]. Children with ASD frequently experience significant emotional difficulties and impaired cognitive flexibility, leading to heightened frustration that can hinder learning. Approximately 74% of children with ASD exhibit substantial emotional challenges, compared to just 18% of neurotypical children [30]. E-learning systems designed for emotional assistance rely on automatic emotion recognition and adaptive emotional regulation [29]. Various machine learning techniques, particularly support vector machines (SVMs) and artificial neural networks, are commonly employed for emotion detection. Observable indicators of emotional shifts include changes in facial expression, body posture, eye gaze, gestures, heart activity, muscle tension, perspiration, and brain activity [28]. These adaptive emotion recognition techniques can be leveraged to detect and respond to negative emotions, such as frustration, anxiety, and distress, thereby improving learning outcomes for children with ASD. Chu *et al*. proposed an AI-based adaptive learning model in which new students complete a pre-test to assess their learning styles, followed by an AI-driven learning path tailored to each individual. The model ensures that students remain engaged without experiencing excessive frustration. During the learning process, students' emotional states are monitored, and negative emotions are managed using regulation strategies based on James Gross' emotional regulation framework, which consists of five steps: situation selection, situation modification, attentional deployment, cognitive change, and response modulation [31]. The proposed emotional regulation strategies are categorized into three main areas:

- Response Modulation – A computer-aided program guides students in managing stress responses through techniques such as muscle relaxation, deep breathing, and positive imagery.
- Cognitive Change – The system suggests adaptive strategies, including social stories, self-instruction, and self-management, supported by video and audio instructions.
- Attentional Deployment – Educational games and graphic animations help redirect students' focus toward positive aspects of a situation while minimizing attention to negative stimuli.
- The emotion recognition component of this model was constructed using SVMs and achieved an overall recognition accuracy of 93.34%. Preliminary results indicate that the model significantly enhances learning

efficiency, student performance, and emotional regulation. However, larger-scale trials are needed to further validate its effectiveness [29].

Augmented reality (AR) has also emerged as a promising intervention method for ASD treatment. AR-based therapy has shown positive results, particularly when combined with cognitive behavioral therapy (CBT) for managing mental health conditions. The use of AR glasses and headsets in classroom-assisted learning has been effective in reducing irritability and rigid behaviors in children with ASD [32]. Unlike traditional interventions, AR offers an immersive and adaptable learning environment that can accommodate the diverse needs of children with ASD. Studies suggest that both children and parents respond positively to AR-assisted learning, as it enhances social interactions and improves the recognition of verbal and nonverbal cues. AR-based interventions hold great potential as a supplementary tool to traditional cognitive and behavioral therapies for children with ASD [33]. Beyond diagnostics, AI is also enhancing therapeutic interventions for individuals with ASD. Innovations include augmentative communication systems, virtual reality-based training, and robot-assisted therapies, all showing potential in improving social interactions and communication skills. For instance, AI-powered virtual reality (VR) therapy creates realistic social scenarios, allowing individuals with autism to practice social skills in a safe environment [35].

CONCLUSION

ASD is a complex and heterogeneous disorder with no singular approach to diagnosis or treatment. As a result, effective detection methods must account for the variability of the condition. AI and ML techniques show significant promise in enhancing ASD diagnosis and treatment. Research on ML and DL models demonstrates high accuracy and specificity in identifying ASD; however, many studies are constrained by small sample sizes, necessitating further validation to confirm their practical applicability. Despite these limitations, AI-driven advancements hold potential for refining diagnostic methods, identifying an ASD biomarker, and improving the accessibility and efficiency of diagnosis. Similarly, AI-based interventions, including adaptive learning, emotional regulation techniques, augmented reality and Virtual reality, offer innovative avenues for ASD treatment but require further exploration. Given the relatively recent integration of AI into ASD research, ongoing studies are crucial to strengthening these models and ensuring their effectiveness across the diverse ASD population.

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Table 1. Demographic Profile of Our Sub-Sample from the ABIDE Database.

Group	ASD (*N* = 421)	Control (*N* = 430)	*P*
Age	16.8 ± 7.7	16.7 ± 6.9	0.858
Full-Scale IQ	105.2 ± 16.8	110.9 ± 12.6	<0.001
Verbal IQ	104.4 ± 17.8	111.3 ± 13.3	<0.001
Performance IQ	105.0 ± 17.2	108.2 ± 13.3	0.003
Sex (%)			0.017
Male	88	82	
Female	12	18	
Handedness (%)			0.018
Left	13	6	
Right	85	92	
Ambidextrous	2	1	

All data are mean ± SD unless otherwise specified.

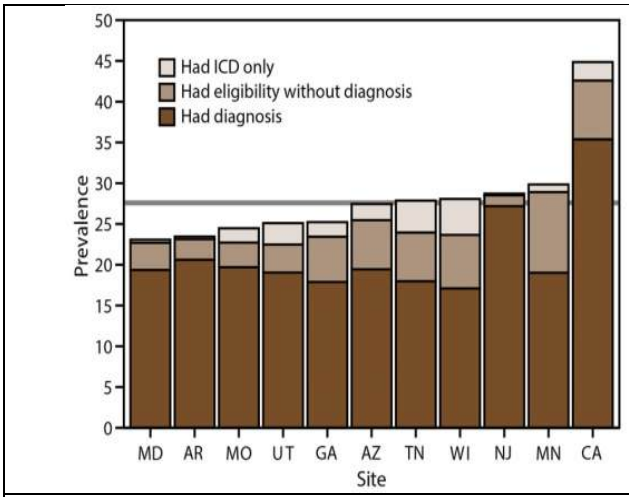


Figure 1. Prevalence of Autism Spectrum Disorder in 8-Year-Old Children by Identification Type and Location

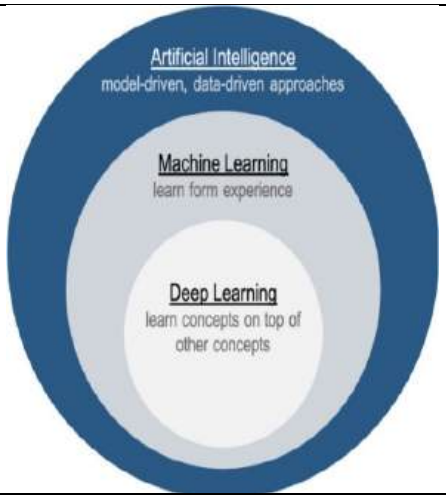


Figure 2.The interconnections between artificial intelligence, machine learning, and deep learning.

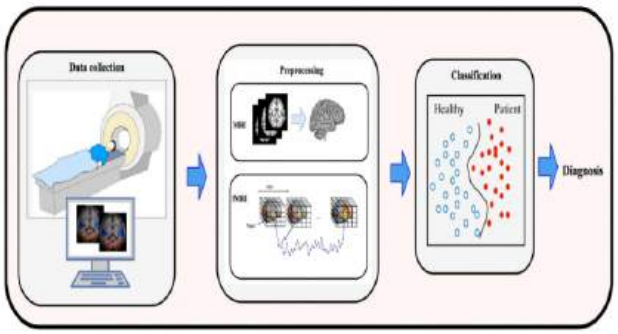


Figure 3.Brain Imaging-Based Classification Using Machine Learning.

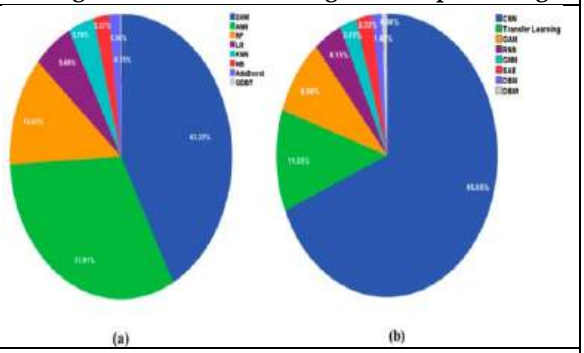


Figure 4.Utilization of Various AI Models for MRI Data Analysis.

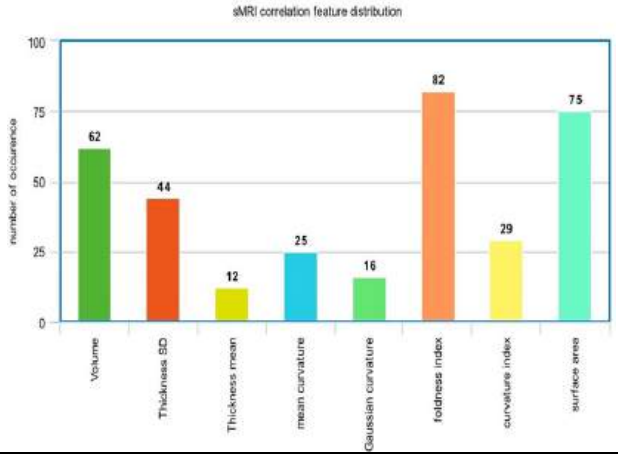


Figure 5. The occurrence frequency of each sMRI feature in the list of significantly correlated features with the ADOS overall score.

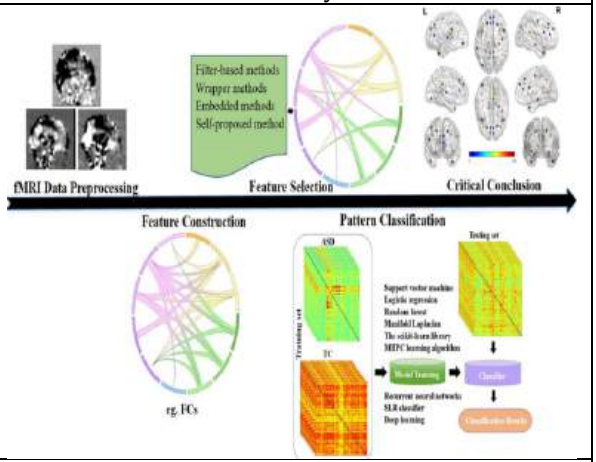


Figure 6.Standard Procedure for ASD Studies Using fMRI Data and Machine Learning.

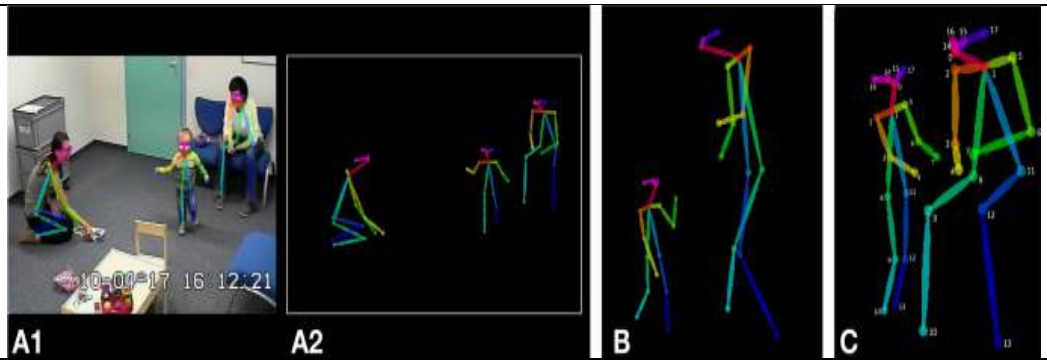


Figure 7. Demonstration of 2D Pose Estimation with OpenPose on ADOS Video Frames: (A1) OpenPosekeypoints applied to an ADOS assessment video, (A2) Skeletal keypoints displayed against a neutral background, (B) Visualization of requesting behavior with skeletal markers, and (C) Depiction of showing behavior with numbered keypoints.

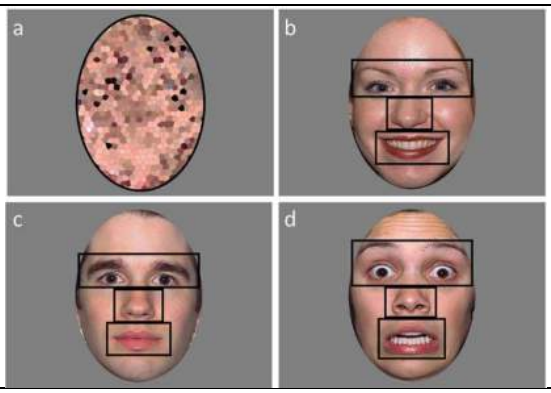


Figure 8.facial expression

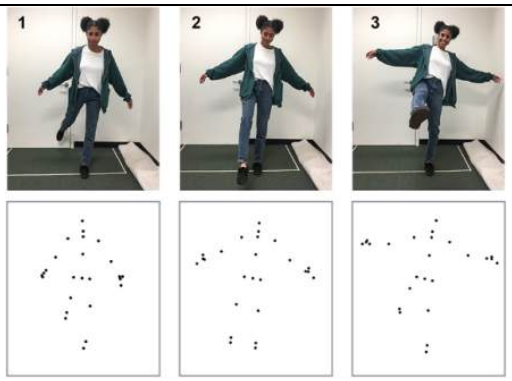


Figure 9.body posture

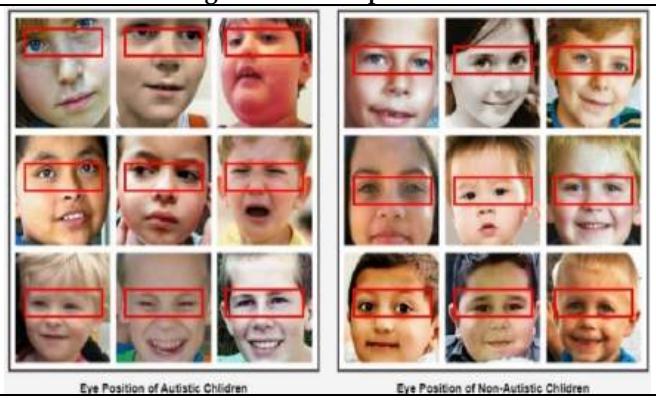


Figure 10. eye gaze

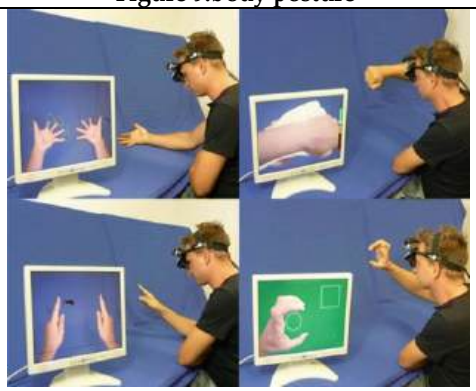


Figure 11. Virtual reality-based training

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RESEARCH ARTICLE

Retrospective Analysis of Congenital Ocular Disorders in a Tertiary Eye Care Center

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ABSTRACT

Congenital ocular anomalies are a significant cause of childhood blindness and visual impairment worldwide. These conditions include a variety of disorders such as congenital cataracts, glaucoma, retinopathy of prematurity, and others that can lead to lifelong disability if not addressed early. Understanding the prevalence, causes, and management strategies for these anomalies is crucial for developing effective prevention and treatment programs. In most of the cases the cause of blindness in children is due to not getting proper treatment on time. This study aims to retrospectively analyze the prevalence and clinical presentations in pediatric populations. The study also seeks to identify gaps in current healthcare practices and propose measures to improve early detection and management of these conditions. A retrospective analysis was conducted by review of patients records from tertiary eye hospital. Data on demographic information, clinical presentations, diagnostic procedures, treatments, and outcomes were collected and analyzed. The study population include all anterior and posterior congenital anomalies of patient within the age group of 0-16 year. Patients with acquired ocular conditions and those without complete medical records were excluded from the study. Data were collected from the hospital's electronic medical records (EMR) system. A total of 592 patients in the age group of 0-16 years attended the ophthalmology outpatient department during the study period. Out of these, 100 patients were found to have congenital ocular disorders. As per the present study, the incidence rate of congenital ocular anomalies was found to be 16.89%.A prevalence of congenital anomalies can vary from region to region. In our study the most common congenital ocular anomaly was Naso-lacrimal duct obstruction (48.1%). Nystagmus was the second most common congenital ocular anomalies (12.96%) and cataract was the third most common congenital ocular anomalies (12.04%).

Congenital ocular anomalies continue to pose a major public health challenge. This study highlights the need for improved prenatal care, early screening, and timely intervention to reduce the burden of these conditions. Public health strategies should focus on raising awareness, enhancing healthcare infrastructure, and training healthcare professionals to manage congenital ocular anomalies effectively. Further research is needed to explore genetic and environmental factors contributing to these disorders and to develop targeted preventive measures.

Keywords: Congenital, Ocular Anomalies, Early intervention, Congenital cataract, Congenital glaucoma

INTRODUCTION

Congenital ocular anomalies refer to eye defects that are present at birth, affecting vision and overall ocular health. These anomalies can range from structural abnormalities to functional defects. The impact of these conditions can be profound, often leading to significant vision impairment or blindness if not promptly diagnosed and treated.

The prevalence of congenital ocular anomalies varies globally due to differences in genetic factors, maternal health, and access to prenatal care. According to the World Health Organization (WHO), congenital anomalies are a significant cause of infant mortality and childhood blindness worldwide. Approximately 3 and 14 per 100,000 population live births globally are affected by severe ocular anomalies like anophthalmia and microphthalmia (WHO, 2020)(Verma *et al*., 2007). In high-income countries, congenital cataracts occur in 1 to 6 per 10,000 live births, whereas in low- and middle-income countries, the prevalence is higher due to factors such as maternal infections, malnutrition, and inadequate prenatal care (Wu *et al*., 2017). India, with its vast population and varying socioeconomic conditions, faces a considerable burden of congenital ocular anomalies (Murthy *et al*., 2002). According to recent studies, the prevalence of congenital cataracts in India is estimated to be around 1 to 3 per 10,000 live births. Additionally, congenital glaucoma affects about 1 in 10,000 infants (Gogate *et al*., 2011). The incidence of retinopathy of prematurity (ROP) is also rising due to increased survival rates of preterm infants, with estimates suggesting that around 20% of preterm infants are at risk of developing ROP (Vinekar *et al*., 2007).Congenital ocular anomalies represent a significant cause of childhood vision impairment and blindness worldwide. These anomalies, which include a spectrum of structural and functional eye disorders present at birth, pose substantial challenges not only to affected individuals but also to their families and the broader healthcare system (Gilbert *et al*., 2003). The early detection and management of these conditions are crucial in mitigating their impact and improving the quality of life for those affected.

Common Congenital Ocular Anomalies are

Nasolacrimal Duct Obstruction (NLDO)

Nasolacrimal duct obstruction is a condition where the tear duct fails to open properly, leading to tear overflow and recurrent eye infections (Vagge *et al*., 2018).

Nystagmus

Nystagmus is characterized by involuntary, rapid eye movements, which can be congenital or acquired. Congenital nystagmus typically manifests within the first few months of life and can be associated with other visual impairments (Self *et al*., 2020).

Congenital Cataract

Congenital cataract is the clouding of the eye's lens present at birth, which can lead to significant visual impairment if not treated promptly. It is a major cause of childhood blindness worldwide, with an incidence of 1-6 per 10,000 live births (Haargaard *et al*., 2004).

Ptosis

Ptosis refers to the drooping of the upper eyelid and can be congenital or acquired. Congenital ptosis can obstruct vision and lead to amblyopia if not corrected early (Marenco *et al*., 2017).

Coloboma

Coloboma is a defect in the structure of the eye, such as the iris, retina, choroid, or optic disc. It occurs due to incomplete closure of the embryonic fissure during development and can result in vision impairment (Gregory-Evans *et al*., 2004).

Retinopathy of Prematurity (ROP)

ROP is a potentially blinding disorder affecting premature newborns that isdistinguished by abnormal blood vessel formation in the retina. The occurrence varies, with higher rates in countries with advanced neonatal care due to the improved survival rates for very preterm infants (Quinn *et al*., 2010).

Microcornea

Microcornea is an abnormality where the cornea is smaller than normal, which can affect vision. It is often associated with other ocular anomalies such as microphthalmos or coloboma (Lingam *et al*., 2021).

Microphthalmos

Microphthalmos is a condition where one or both eyes are abnormally small. It can be isolated or part of a syndrome and often leads to significant visual impairment (Harding *et* al., 2019).

Persistent Hyperplastic Primary Vitreous (PHPV)

PHPV is a developmental anomaly where the primary vitreous fails to regress and can cause cataracts, glaucoma, and retinal detachment. It requires early intervention to preserve vision (Pollard *et* al., 1997).

Retinitis Pigmentosa (RP)

RP is a group of genetic disorders causing retinal degeneration and progressive vision loss. Symptoms typically start in childhood with night blindness, followed by peripheral vision loss (Hartong *et* al., 2007).

Haemangioma

Ocular haemangiomas are benign vascular tumors that can affect the eyelid, orbit, or conjunctiva. They can cause astigmatism, amblyopia, or cosmetic concerns and may require treatment depending on the severity (Kowalska*et al*., 2021).

Congenital Glaucoma

Congenital glaucoma is characterized by increased intraocular pressure present at birth, leading to optic nerve damage and vision loss. Early diagnosis and surgical intervention are crucial for preserving vision (Papadopoulos *etal*., 2020). The early detection and management of these conditions are crucial in mitigating their impact and improving the quality of life for those affected. This study will acknowledge What are the common congenital ocular disorders observed in a tertiary eye care Centre, and what is their demographic and clinical profile? The purpose of this study is to raise awareness among healthcare practitioners, professionals, and patients about the critical importance of early detection and management of congenital ocular anomalies. Our findings will serve as a reference guide for the community, emphasizing the need for prompt and proactive measures in preventing childhood blindness. Additionally, this study aims to encourage community engagement and action towards reducing the burden of vision impairment in children. By examining the records of patients with congenital ocular anomalies, this study seeks to contribute to the body of knowledge in this field and provide evidence-based recommendations for improving early detection and management practices. Through increased awareness and education, we hope to empower healthcare professionals and the community to take decisive steps in combating childhood blindness, ultimately enhancing the lives of affected individuals and their families.

MATERIALS & METHODS

A retrospective analysis was conducted by review of patients records from tertiary eye hospital. Data on demographic information, clinical presentations, diagnostic procedures, treatments, and outcomes were collected and analyzed. The study population include all anterior and posterior congenital anomalies of patient within the age group of 0-16 year. Patients with acquired ocular conditions and those without complete medical records were excluded from the study. Data were collected from the hospital's electronic medical records (EMR) system. The collected data were entered into Microsoft Excel for analysis. A total of 592 patients in the age group of 0-16 years attended the ophthalmology outpatient department in a tertiary eye care hospital between January 2022 to December 2022.

RESULTS AND DISCUSSION

A total of 592 patients in the age group of 0-16 years attended the ophthalmology outpatient department during the study period. Out of these, 100 patients were found to have congenital ocular disorders. As per the present study, the incidence rate of congenital ocular anomalies was found to be 16.89%. There were 68 (68%) males and 32 (32%) females(Fig.1). Unilateral and bilateral involvement was seen in 60 (60%) and 40 (40%) cases. Bilateral involvement found in 28 males and 12 females and unilaterally, 40 males and 20 females were found with congenital ocular disorder(Fig.2)(Fig.3). Total 63 cases were in the 0-3 years age group, 13 cases in 4-7 years age group, 11 cases were in 8-12year age group and 13 cases were in 13-16year age group(Fig.4)(Table.1). Total 12 congenital ocular disorders were found. Out of these, NLDO in 52 cases (48.14%), congenital nystagmus in 14 cases (12.96%), congenital cataract in 13 cases (12.04%), congenital ptosis in 10 cases (9.26%), congenital coloboma in 6 cases (5.55%), ROP in 3 cases (2.78%), microphthalmos in 2 cases (1.85%), microcornea in 2 cases (1.85%), RP in 2 cases (1.85%), PHPV in 2 cases (1.85%), congenital glaucoma in 1 case (0.92%) and haemangioma in 1 case (0.92%)(Table.2). In 0-3 age group most, common congenital ocular disorder is NLDO, in 4-7 age group cataract in a greater number of cases, in 8-12 age group nystagmus were found is more cases, in 13-16 age group nystagmus were found in more cases(Fig.5). In this study, the associated ocular complications that occur in most of the cases are refractive error and squint(Table.3). Refractive error occurs in association with congenital cataract, nystagmus, retinopathy of prematurity and coloboma(Fig.6). Most cases of squint occur in association with congenital cataract and Nystagmus cases (Fig.7). Childhood blindness remains a significant global health problem. In order to develop control programs to prevent childhood blindness, it is necessary to identify important avoidable causes of visual impairment and blindness, and monitor changing pattern from time to time. Congenital eye disorders are important causes of childhood blindness (Garg*et al*.,2016). The incidence rate of congenital ocular disorders in the study was 16.89%. Most of the patients in the present study (63%) were in the 0-3 age group. Parag N Tupe and Sagar V Chaudhari in their study on the prevalence of congenital ocular anomalies have reported most of the patients in the 0-2 year's age group (Tupe *et al*., 2015). In the present study, the proportion of males (68%) affected was significantly higher than females (32%). The male to female ratio was 2.12:1. Pooja Dash et al.have reported a male to female ratio of 1.12:1 in their studyand unilateral and bilateral involvement in 71.4% and 28.6% of their cases (Dash et al., 2022). In our study unilateral involvement was noted in 60% cases, which was higher than bilateral cases (40%). In our study, 12 types of congenital anomalies were studies; congenital cataract, Coloboma, congenital glaucoma, haemangioma, microphthalmos, microcornea, nystagmus, NLDO, congenital ptosis, retinopathy of prematurity, retinitis pigmentosa, PHPV. Commonest congenital disorder in our study was found to be Naso-lacrimal duct obstruction (48.14%). In agreement Rakhi Jain et al. found Naso-lacrimal duct obstruction was most common congenital anomaly (65%) (Jain *et al*., 2022). In our study most cases of Naso-lacrimal duct obstruction were found in 0-3 year's age group (94.23%). Limitations of the present study include small sample size and absence of genetic studies. Genetic study could not be done because of its nonavailability in our setting.

CONCLUSION

A prevalence of congenital anomalies can vary from region to region. In our study the most common congenital ocular anomaly was Naso-lacrimal duct obstruction (48.1%). Nystagmus was the second most common congenital ocular anomalies (12.96%) and cataract was the third most common congenital ocular anomalies (12.04%). All cases with ocular abnormalities must need a proper clinical examination, proper knowledge of developmental pathogenesis of congenital ocular anomalies is important to diagnosed and treat them on time as early diagnosis is essential to ensure adequate management and preserve visual function. Some of the congenital disorders can be prevented by proper history taking during evaluation of the patients and just spreading awareness among community. The study's key conclusions underline the importance of: Early Detection and Intervention: Early diagnosis and timely treatment are critical in managing congenital ocular disorders and preventing irreversible vision loss. Routine neonatal and infant eye screenings should be implemented to identify and address these conditions promptly. Improved Prenatal Care: Enhancing prenatal care can reduce the incidence of congenital ocular anomalies. Maternal health education, nutrition, and management of infections during pregnancy are essential preventive measures. Genetic Counselling: Families with a history of ocular anomalies should seek genetic counselling to understand the risks and implications for future pregnancies. Newborn Screening: Implementing routine eye examinations for newborns can facilitate early detection and treatment of congenital anomalies. Access to Specialized Eye Care: Increasing access to specialized paediatric ophthalmology services, especially in low- and middle-income regions, is vital. Training healthcare providers in early detection and management techniques can significantly improve outcomes for affected children. Public Awareness and Education: Raising awareness about congenital ocular disorders among parents, caregivers, and healthcare professionals can lead to earlier recognition and intervention. Public health campaigns and community-based programs can play a significant role in educating the populace. Further Research: Continued research is necessary to understand the genetic and environmental factors contributing to these anomalies. Collaborative efforts between researchers, clinicians, and policymakers can help develop targeted strategies for prevention and treatment. Congenital ocular anomalies pose a significant challenge to paediatric vision health worldwide. Through awareness, early detection, and appropriate interventions, many of these conditions can be managed effectively, reducing the burden of childhood blindness and visual impairment. Findings of this study will help as a reference to the health care workers and clinicians to council and aware the people surrounding them.

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Table.1 Number of cases occur different age group

AGE GROUP	N0. OF CASES
0-3	63
4-7	13
8-12	11
13-16	13

Table.2 Number of cases occur in different ocular congenital disorder

CONGENITAL OCULAR DISORDER	NO. OF CASES	PERCENTAGE (%)
NLDO	52	48.14%
Nystagmus	14	12.96%
Cataract	13	12.04%
Ptosis	10	9.26%
Coloboma	6	5.55%

Retinopathy of Prematurity	3	2.78%
Microcornea	2	1.85%
Microphthalmos	2	1.85%
PHPV	2	1.85%
Retinitis Pigmentosa	2	1.85%
Haemangioma	1	0.92%
Glaucoma	1	0.92%

Table.3 Number of Congenital ocular disease associated with Refractive error and Squint

DISEASE	NO. OF REFRACTIVE ERROR ASSOCIATION	NO. OF SQUINT ASSOCIATION
NLDO	0	0
NYSTAGMUS	4	4
CATARACT	7	5
PTOSIS	2	0
COLOBOMA	2	1
ROP	2	0
MICROCORNEA	2	1
MICROPHTHALMOS	0	0
PHPV	0	0
RP	1	0
HAEMANGIOMA	0	0
GLAUCOMA	0	0

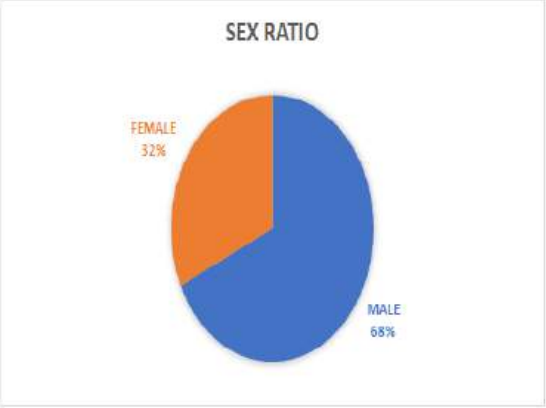


Figure 1: Sex ratio of the patient with congenital ocular disorder presented to OPD during study duration

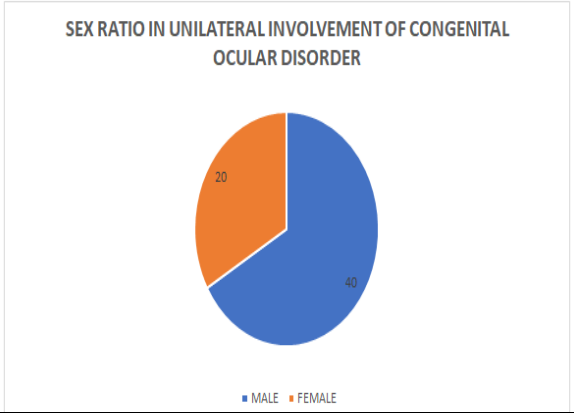


Figure 2: Sex ratio in patients with unilateral involvement of congenital ocular disorders

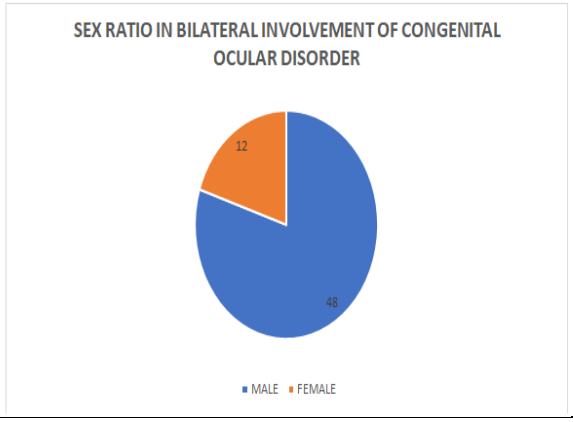


Figure 3: Sex ratio in patients with bilateral involvement of congenital ocular disorders

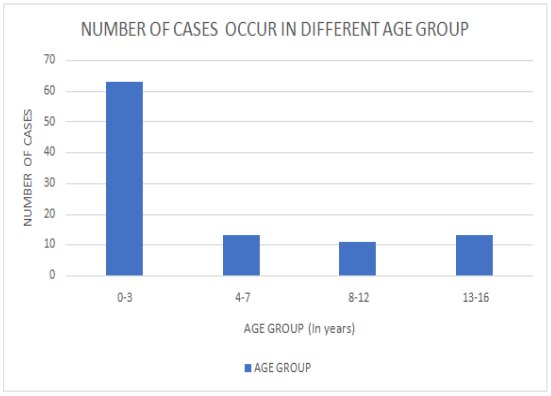


Figure 4: this represents the number of cases occur in different age group

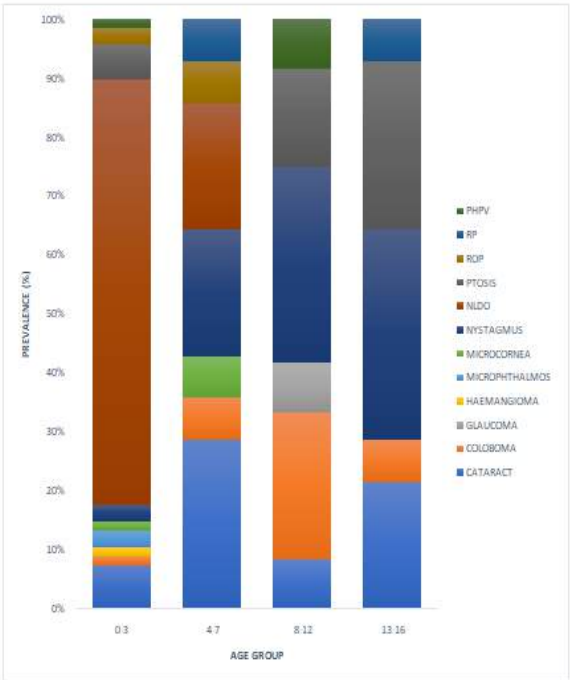


Figure 5: This represents the number of each congenital ocular disorders occur in different age group

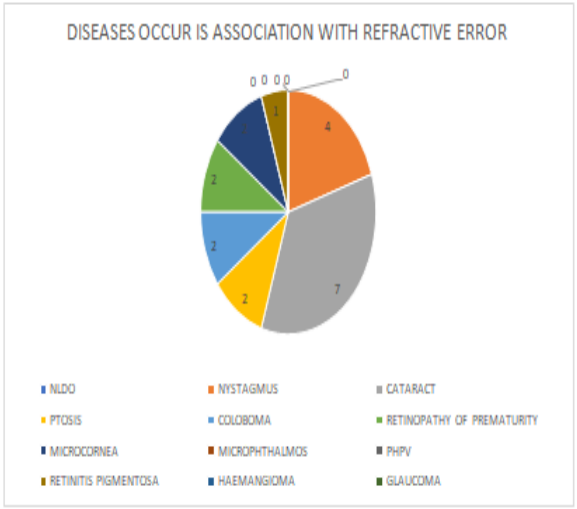


Figure 6: This represents the number of Congenital ocular disease associated with Refractive Error

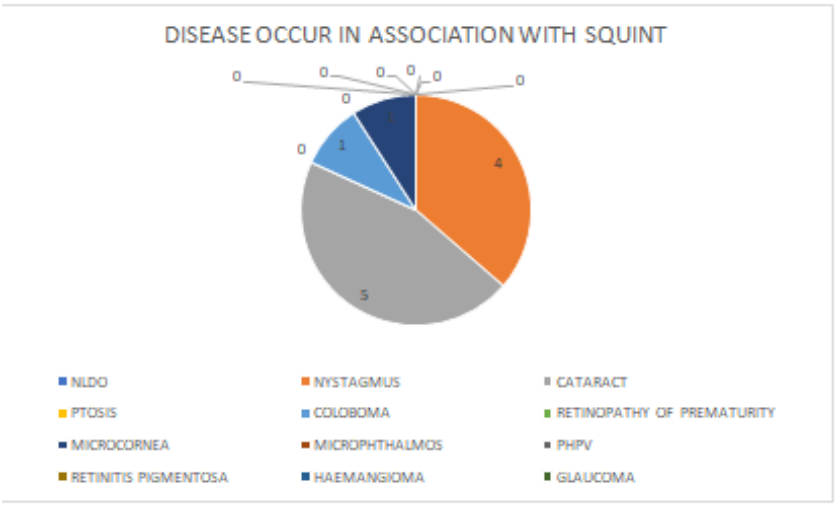


Figure 7: This represents the number of Congenital ocular disease associated with Refractive Error

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RESEARCH ARTICLE

Statistical Analysis of Milk Production for Future Planning with Special Reference to Sangli District

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ABSTRACT

In this paper we study the relation between amount of milk and fat of buffaloes as well as for cows. We carried out our survey in two compile center Ganesh Dudhsangh & Siddhnath Dudhsangh in village Erandoli and Aawalai respectively of sangli district. The main aim of paper is to study a relation between amount of milk and fat of buffaloes and cows. Secondary aim is to see which Edibles are more used and to check more efficiency of Edibles by using statistical analysis.

Keywords: Milk Fat, Efficiency of edibles, cow milk, buffalo milk, statistical analysis.

INTRODUCTION

Animal milk is used first as human food during the secondary Products revolution. India is bestowed with a largest livestock population in the world having a total bovine population of 304 million compared to the world's total bovine population of 1400 million. It accounts for 57.3% of the world's buffalo population and 14.7% of cow population [2]. India continues to be the largest producer of milk in the world and produces 13.1% of total milk produced in the world Hence, India has attained first in milk production in the world [8].This is not only placed country on the top in the world, but also represents sustained growth in the availability of milk & milk products for growing population of the country [6]. Dairy farming has been recognized as an important source of income and is more beneficial in comparison to crop production in India [5]. Milk production is predominantly the domain of small farmers in mixed farming system [4].The importance of dairy farming in lies not only in products but also it brings about significant changes in socio-economic structure of rural economy [7]. In India more than 90% farmers have

milk production business as a side-business. Almost everybody has at least one pet-animal in their house. so analysis of the problem is important of topic "Statistical study of milk production". Here we study the relation between amount of milk and fat of buffaloes as well as for cows [1].We carried outour survey in two compile center Ganesh Dudhsangh & Siddhnath Dudhsangh in village Erandoli and Aawalai respectively. The main aim of our project is to study a relation between amount of milk and fat of buffaloes and cows. Secondary aim is to see which Edibles are more used and to check more efficiency of Edibles.

OBJECTIVES

i. To check relationship between milk and fat.
ii. To study on an average milk of buffalo & cow are same or not.
iii. To check variation between amount of milk and its fat.
iv. To study effect of edibles on milk production.

METHOD OF DATA COLLECTION

The aim of our paper is to study relation between amount of milk & fat of cow and bedfellow. We decide to collect all primary data from the farmers in the Erandoli & Aawalai village whose sub-business is milk production. We made questionaries' to collect all the necessary information. The related data & information is collected from farmers at the milk compile center in village Erandoli & Aawalai by using convenient sampling. In this survey we collect the information about an amount of milk and its fat & which edible are used for animals.

STATISTICAL ANALYSIS:

- Graphical representation
- karl pearsons Correlation coefficient
- Test of Significance for difference of two means
- The tests based on F- distribution

DIAGRAMMATIC REPRESENTATION

In village Erandoli, Pandharpuri and Desi Buffalo species are more preferred and Jarashi &Videsi Cow species are equally preferred.In village Aawalai, Desi Buffalo species are more preferred and Jarashi Cow species are more preferred. In village Erandoli, Cotton is 38% and Atta is 34% used as edibles to cow and buffalo.Also in Erandoli village the dry food and wet food are nearly equally used. In village Aawalai Cotton is 54% and Globule is 29% used as edibles to cow and buffalo.Also in Aawalai village the dry food and wet food are equally use

STATISTICAL TOOLS

TEST OF CORRELATION

Suppose (xi,yi), i=1,2,3,.....n. be n pairs of observation on variable X and Y then the Karl Pearson's Correlation Coefficient between X and Y is denoted by r and is defined as, the ratio of covariance between X and Y to the product of the standard deviation of X and standard deviation of Y. Hence, Karl Pearson's Correlation Coefficient between X and Y is given by,

$$r = \frac{cov(x,y)}{\sqrt{var(x) * var(y)}}$$

TEST SIGNIFICANCE FOR DIFFERENCE OF TWO POPULATION MEANS

Let $\bar{X}_1$ be mean of sample size n_1 from a population with mean μ_1 and variance σ_1^2(known) and $\bar{X}_2$ be mean of sample size n_2 from a population with mean μ_2 and varianceσ_2^2(known). Sample size n_1 and n_2 are large therefore sample mean $\bar{X}_1$ has asymptotically normal with mean μ_1 and variance $\frac{\sigma_1^2}{n_1}$.And sample mean $\bar{X}_2$has asymptotically normal with mean μ_2 and variance $\frac{\sigma_2^2}{n_2}$ i.e. $\{\bar{X}_1 \sim N(\mu_1, \frac{\sigma_1^2}{n_1})$ and $\bar{X}_2 \sim N(\mu_2, \frac{\sigma_2^2}{n_2})\}$ Let us suppose sample means $\bar{X}_1$ and $\bar{X}_2$ are independently normally distributed. Therefore, the difference of sample means, $(\bar{X}_1 - \bar{X}_2) \sim N(\mu_1 - \mu_2, \frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2})$. Therefore, corresponding standard normal variate is

$Z = \frac{(\bar{X}_1 - \bar{X}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \sim N(0, 1)$

Here we have to test the hypothesis,

H_0: $\mu_1 = \mu_2$(i.e. there is no significant difference between the population means)

Against,

H_1 :$\mu_1 \neq \mu_2$ (two tailed alternative)

Under H_0, the test statistic is given by,

$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \sim N(0,1)$

TEST BASED ON F –DISTRIBUTION

Let $x_1, x_2, \ldots\ldots\ldots, x_{n1}$ and $y_1, y_2, \ldots\ldots\ldots y_{n2}$ be two independent random samples of sizes n_1 and n_2 drawn from the parent normal populations N (μ_1, σ_1^2) and N(μ_2, σ_2^2) respectively. We have to test the null hypothesis, H_0: $\sigma_1^2 = \sigma_2^2 = \sigma^2$(say) (i.e. Both the sample are drawn from the normal populations with the same variance σ^2). Against, The alternative hypothesis, H_1: $\sigma_1^2 > \sigma_2^2$ (right tailed alternative). Under the null hypothesis H_0, the test statistic is,

$F = \frac{S_x^2}{S_y^2} \sim F_{(n1-1, n2-1)d.f.}$

Where, $S^2_x = \frac{1}{n1-1}\sum_{i=1}^{n1}(x_i - \bar{x})^2$ $S^2_y = \frac{1}{n2-1}\sum_{j=1}^{n2}(y_i - \overline{y})^2$

STATISTICAL ANALYSIS

Correlation

Village:-Erandoli

Cow

The correlation between amount of milk and fat = - 0.191935

The correlation between amount of milk and fat are negatively correlated.

i.e. Hence the increases milk then decreases its fat.

Buffaloes

The correlation between amount of milk and fat = -0.02954

The correlation between amount of milk and fat are negatively correlated.

i.e. Hence the increases milk then decrease it's fat.

Village:-Aawalai

Cow

The correlation between amount of milk and fat = 0.3932

The correlation between amount of milk and fat are positively correlated.

i.e. Hence the increases milk then increases its fat.

Buffaloes

The correlation between amount of milk and fat = - 0.3369

The correlation between amount of milk and fat are negatively correlated.

i.e. Hence the increases milk then decrease its fat.

TO TEST SIGNIFICANCE FOR DIFFERENCE OF TWO POPULATION MEANS

Village:-Erandoli

To check significant difference between Milk of buffalo & cow.

We have to test hypothesis,

H_0: There is no significant difference between the Milk of buffalo & cow.

Vs

H_1: There is significant difference between the Milk of buffalo & cow.

Calculation:

$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$ ~ N(0,1)Z = 7.5324 Tab. Z = 1.96

Conclusion: Cal Z > tab Z Reject H_0, at 5% level of significance.

Then there is significant difference between the Milk of buffalo & cow.

To check significant difference between Buffaloes fat and Cow fat.

We have to test hypothesis

H_0: There is no significant difference between the Buffaloes fat and cow fat.

Vs

H_1: There is significant difference between the Buffaloes fat and cow fat.

Calculation:-

$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$ ~ N(0,1) Cal. lZl = 12.6066 Tab. Z = 1.96

Conclusion

Cal Z > Tab Z Reject H_0, at 5% level of significance.

Then there is significant difference between the Buffaloes fat and Cow fat.

Village:-Aawalai

To check significant difference between Milk of buffalo & cow.

We have to test hypothesis

H_0: There is no significant difference between the Milk of buffalo & cow.

Vs

H_1: There is significant difference between the Milk of buffalo & cow.

Calculation

$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$ ~ N(0,1) Cal lZl = 9.5163 Tab Z = 1.96

Conclusion

Cal Z > Tab Z Reject Ho, at 5% level of significance. Then there is significant difference between the Milk of buffalo & cow.

To check significant difference between Buffaloes fat and Cow fat.

We have to test hypothesis

H_0: There is no significant difference between the Buffaloes fat and cow fat.

Vs

H_1: There is significant difference between the Buffaloes fat and cow fat.

Calculation:

$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$ ~ N(0,1) Cal lZl = 17.5646 Tab Z = 1.96

Conclusion

Cal Z > tab ZReject Ho, at 5% level of significance

Then there is significant difference between the Milk of buffalo & cow.

Village:-Erandoli
Edibles (Cotton and Globule)
We have to test hypothesis,
H_0: There is no significant difference between the effect of Cotton and Globule on milk production.
Vs
H_1: There is significant difference between the effect of Cotton and Globule on milk production.
Calculation:

$$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \sim N(0,1)$$ Cal Z =1.9084 Tab Z = 1.96

Conclusion
cal Z < tab Z Accept H0, at 5% level of significance.
Then there is no significant difference between the effect of cotton and Globule on milk production.

Village:-Aawalai
Edibles (Cotton and Globule)
We have to test hypothesis
H_0: There is no significant difference between the effect of cotton and Globule.
Vs
H_1: There is significant difference between the effect of cotton and Globule.
Calculation:

$$Z = \frac{(\bar{X}_1 - \bar{X}_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}} \sim N(0,1)$$ Cal Z =3.0463 Tab Z = 1.96

Conclusion
cal Z < tab Z Reject H0, at 5% level of significance.
Then there is significant difference between the effect of cotton and Globule on milk production.

TO CHECK HOMOGENEITY OFCOW MILK AND BUFFALOES MILK.
Village:-Erandoli
We have to test hypothesis,
H_0 : Milk of buffalo & cow are homogeneous Vs
H_1 : Milk of buffalo & cow are not homogeneous
Calculation: $F = \frac{S_x^2}{S_y^2} \sim F_{(n1-1,n2-1)d.f.}$

Fcal =	4.062291731
Ftab =	1.766115123

Conclusion
Fcal>Ftab
Reject H_0, then Milk of buffalo & cow are not homogeneous.

We have to test hypothesis,
H_0: Fat of buffalo & cow milk are homogeneous. Vs
H_1: Fat of buffalo & cow milk are not homogeneous.

Calculation: F = $\frac{S_x^2}{S_y^2} \sim F_{(n1-1,n2-1)d.f.}$

Fcal =	1.511991988
Ftab =	1.766115123

Conclusion

Fcal<Ftab

Accept H_0, then Fat of buffalo & cow milk are homogeneous

Village:-Aawalai

We have to test hypothesis,

H_0: Milk of buffalo & cow are homogeneous.Vs

H_1: Milk of buffalo & cow are not homogeneous.

Calculation: F = $\frac{S_x^2}{S_y^2} \sim F_{(n1-1,n2-1)d.f.}$

Fcal=	10.71689765
Ftab=	1.907087695

Conclusion

Fcal>Ftab

Reject H_0: then Milk of buffalo & cow are not homogeneous.

We have to test hypothesis,

H_0: Fat of buffalo & cow milk are homogeneous.Vs

H_1: Fat of buffalo & cow milk are not homogeneous.

Calculation: F = $\frac{S_x^2}{S_y^2} \sim F_{(n1-1,n2-1)d.f.}$

Fcal =	2.118176303
Ftab =	1.907087695

Conclusion:-Fcal>Ftab

Reject H_0, then Fat of buffalo & cow milk are not homogeneous.

MAJOR FINDING

- The Edibles cotton is mostly use.
- There is variability in milk production of Cow and Buffalo.
- On an average the milk production of Cow and Buffalo are not equal.
- There is variability between fat of buffalo's milk & fat of cow's milk.
- In village Erandoli the average effect of cotton & globule is same & for village Aawalai the average effect of cotton & globule is different.

SCOPE AND LIMITATIONS

Scope

This type of analysis also use for other villages as well as districts and state level. This type of analysis used for to suggest farmers which food or edibles are used for increase in milk production.

Limitations

We consider only two villages Erandoli and Aawalai. For the time limit we study only effect of food & edibles on milk production.

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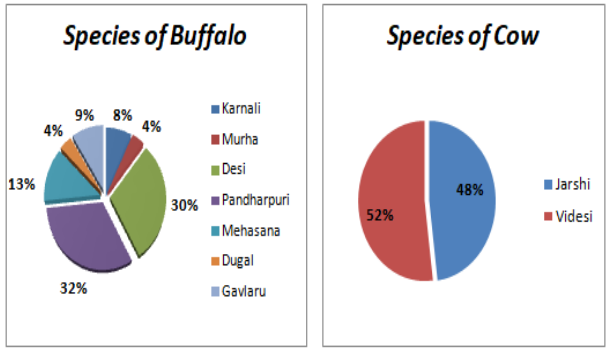


Fig: 1

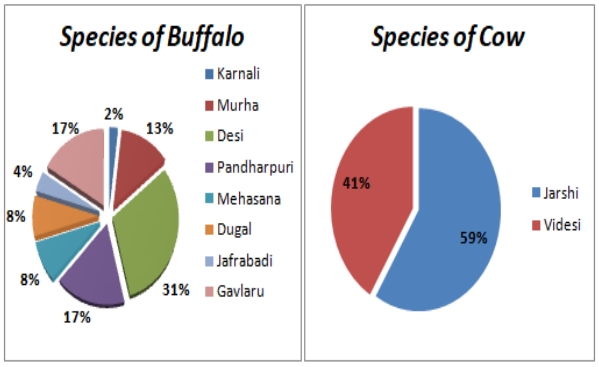


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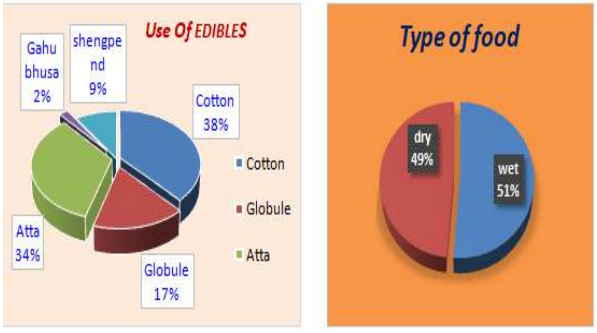


Fig:3

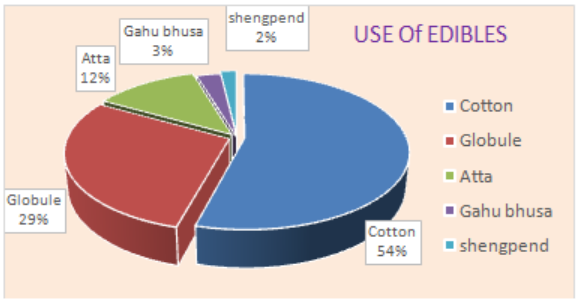


Fig:4

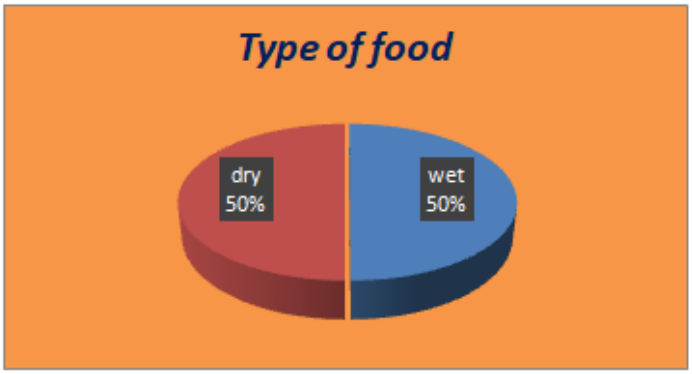


Fig:5

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RESEARCH ARTICLE

Leveraging Machine Learning for the Early Prediction of Rheumatoid Arthritis

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ABSTRACT

Rheumatoid arthritis (RA) is a chronic systemic illness that can lead to destructive polyarthritis, joint damage, and disability if not managed effectively. Diagnosis of RA typically involves a combination of laboratory tests and clinical evaluation of symptoms. However, overlapping features with other forms of arthritis can make early diagnosis challenging. Early detection and identification of RA are critical for improving patient care and outcomes. To improve the accuracy of RA diagnosis and analyze the influence of various clinical factors, the researcher utilized a hybrid approach combining k-means clustering and a genetic algorithm (KMGT). The methodology collected data on six key characteristics for each sample: age, sex, rheumatoid factor (RF), and anti-citrullinated peptide antibody (ACPA).

Keywords: To improve the accuracy of RA diagnosis and analyze the influence of various clinical factors, the researcher utilized a hybrid approach combining k-means clustering and a genetic algorithm (KMGT).

INTRODUCTION

Chronic inflammatory synovitis and consequent joint structure degradation are the causes of rheumatoid arthritis (RA), an multisystem autoimmune illness. Both environmental and genetic risk factors contribute to the genesis of this complicated illness [1]. Two laboratory markers—anti-cyclic citrullinated peptide (CCP) antibody and rheumatoid factor (RF)—are often used to diagnose RA. However, a patient might continue to get RA even if these indications are absent. However, the person may not have RA if one of the indications is positive. In a prior work, we shown that anti-CarP plus 14-3-3η protein are useful markers of RA the northern part of China, and that the detection

efficiency is increased when coupled with RF and anti-CCP [2]. However, other criteria including gender and age are overlooked throughout the diagnosing procedure in beside either of the markers mentioned above. Furthermore, some RA patients do not fit the 2010 United States College of Rheumatology (ACR)/European Union of Rheumatology (EULAR, which stands) diagnostic criteria, which rheumatologists frequently utilize for diagnosis [3]. In order to increase the precision of RA diagnosis, we are thus actively searching for more efficient methods and other clinical markers. Artificial intelligence (also known as AI has advanced significantly in several scientific fields in the past few decades. In clinical contexts, computer programs analyze medical pictures more precisely than people [4]. The use of deep learning, a kind of computational intelligence, to interpret medical images has steadily grown. AI is commonly used to interpret MR imaging data and forecast early RA, for example. It is well recognized that in some sectors, computer analysis is more efficient than human researchers [5]. In the field of vision, deep learning has various uses and is crucial for evaluating imaging data from a variety of illnesses, including retinopathy, metastatic breast cancer, and melanoma. The latest tool available for longitudinal forecasting and application of data from electronic health records is recurrent neural networks, which are a subclass of deep learning [6]. Using various patient records to create AI-based models has demonstrated significant promise in raising diagnostic accuracy and producing positive therapeutic outcomes[7]. To determine whether a patient has RA, Fukae and colleagues converted lots of clinical data from patients into two-dimensional pictures and then fine-tuned convolutional neural networks (CNNs). The groundwork for using deep learning to diagnose RA has been established by this study [3]. Here, we integrated a deep learning ANN under our RA diagnosis, taking into account that our prior study omitted several generic variables (such age and gender) [2]. By re-training the network, we assessed the impact of various clinical parameters on the result. Due to historically unfavorable social and economic conditions in several regions of northern India, leading to an increase in rheumatic diseases as the population ages.

Diseases are more likely to occur as people age, which lowers their quality of life (QOL). There are substantial social and financial expenses associated with treating RA. The idea of health places emphasis on both general life happiness and the absence of sickness. According to the World Health Organization (WHO), quality of life (QOL) is a reflection of people's recognition of their social and cultural surroundings., reflects individuals' acknowledgment of their cultural and social contexts. Rheumatoid and osteoarthritis, particularly related to aging, rank second in the analysis of long-term diseases. Environmental and genetic variables are thought to interact in a complicated way, even if the precise origin of RA is yet unknown. Multiple joints are impacted by the chronic condition known as RA. Normally, the immune system creates antibodies to combat infections, but in RA sufferers, it unintentionally targets the joint tissues. Inflammation and the production of chemicals that break down bone structure, cartilage, ligaments, and muscles are the results of this immunological reaction. Joints are structures that may lose their natural alignment and form if therapy is delayed. Early detection and treatment of RA can significantly improve outcomes. Several clinical parameters, including Anti-CCP, RF, erythrocyte sedimentation rate (ESR), and swollen joint count (SJC), are crucial for identifying RA. In this paper, clustering techniques were used to analyze patient data and predict potential RA cases at an early stage, contributing to improved diagnostic accuracy and patient outcomes. Joint pain is the primary symptom of rheumatoid arthritis (RA), often accompanied by swelling and stiffness. This condition can also lead to general symptoms and inflammation in different parts of the body, which may develop gradually over several weeks or progress rapidly within a few days. Patients may experience flare-ups when symptoms worsen significantly. RA typically affects the smaller joints in the hands, fingers, feet, and toes, especially in the early stages. More than two-thirds of patients report fatigue, muscle weakness, and a loss of appetite. Other common symptoms include excessive sweating, weight loss, lethargy, low energy, and fever. These signs can make diagnosing rheumatic diseases challenging. Physicians rely on laboratory tests, physical examinations, and imaging to diagnose RA. The diagnostic process involves several steps and procedures, underscoring the importance of early detection help enhance standard of life as they age.

1. Before there is a noticeable improvement, stiffness around and within the joints lasts for at least an hour.
2. There are 14 potential joint regions that might be affected by arthritis, comprising either the left or the right PIP, wrist, ankle, elbow, knee, MTP, and MCP joints.
3. The MCP or PIP joints have to possess a minimum of one swollen joint.

4. Symmetric arthritis is defined by constant discomfort in the same joint sites on the two sides of the body. Even if congruence is not perfect, bilateral participation by MCPs, PIPs, or MTPs is appropriate.
5. Subcutaneous nodules located in the extensor regions, over bony prominences, or near joint areas are indicative of rheumatoid nodules.
6. Another requirement is the existence of aberrant serum rheumatoid factor levels, which can be found using any trustworthy technique. Just under five percent in standard control groups show positive results.
7. It is necessary to have radiographic proof of RA in the hand or wrist (posterior-anterior view) that clearly shows bone decalcification in the afflicted joints. Classification of osteoarthritis cannot be done only based on radiographic findings.

Subcutaneous nodules located in the extensor regions, over bony prominences, or near joint areas are indicative of rheumatoid nodules.

1. The presence of abnormal levels of serum rheumatoid factor, detected by any reliable method, is another criterion. Positive results are found in fewer than 5% of normal control groups.
2. Radiographic evidence of RA in the wrist or hand (posterior-anterior view), showing clear bony decalcification in the affected joints, is required. Radiographic features of osteoarthritis alone are insufficient for classification.

METHODOLOGY

In the proposed KMGT method, the initial values for the k-means algorithm are chosen through the use of a genetic algorithm. When predicting rheumatoid arthritis, it is vital to identify the most relevant features, as not all of them are necessary for diagnosing the disease. The genetic algorithm is applied to select the most significant factors for predicting rheumatoid arthritis. Once these key features are identified, they are input into the k-means algorithm for further analysis and prediction.

CLUSTERING

One machine learning method that is classified as unsupervised learning is clustering. Data points are grouped into clusters for this purpose. In contrast to supervised learning, which involves a teacher guiding the training procedure, unsupervised learning concentrates on grouping data according to the dataset's innate patterns. Finding logical categories where observations within an identical group are more comparable to one another than those that appear in other groups is the aim of clustering. Clusters are created by dividing the population into several groups according to similar and dissimilar the data points. Three primary clustering techniques exist. In order to minimize the variation between each cluster, the K-means clustering method separates the data set into 'k' clusters. Data is arranged into 'N' component factors in hierarchical clustering, which are then further divided into 'M' clusters, eventually producing nested clusters. Clustering is beneficial in a variety of domains and has varying degrees of usefulness. According to their similarities and differences, we divide data into various variables in cluster analysis. One of the most popular unsupervised learning methods is K-means clustering. Centroids are chosen, data points are categorized according to their location with these centroids, as well as the centroids are then recalculated to improve classification outcomes. The clustering method improves accuracy by decreasing the distance among the data points with the centroids, for example, by applying Euclidean distance.

K-Means Clustering Algorithm

Starting with process initialization, the K-Means algorithm chooses the total amount of clusters, represented by 'K'. 'K' centroids are subsequently picked at random; they do not have to be chosen from the dataset. The initial clusters are then formed by assigning each data point to the closest center. To provide more precise results, the centroids are computed again using the current clusters. Until there is no more reassignment, indicating that the clustering is stable, the procedure of redirecting data points to the nearby centroids along with recalculating centroids is repeated. After the clusters are completely built, the procedure comes to an end.

Genetic Algorithm

A search method used to address challenging optimization issues, the evolutionary algorithm is founded on the ideas of natural selection. The following elements are involved: A number of essential components make up the genetic algorithm. The first is a collection of chromosomes, each of which stands for a potential fix for the issue. Fitness-based selection follows, with those with greater fitness scores having a larger chance of being selected for reproduction. The crossover method, which aims to provide superior solutions by combining the genetic material of two chosen individuals to create children, comes next. Finally, to ensure genetic diversity and aid in the investigation of novel potential solutions, random mutation is used to create tiny, random alterations in the chromosomes. The algorithm starts out with an ensemble of "individuals," each of whom stands for a possible fix for an issue. The "chromosomes," which are gene sequences that are given a "fitness" value due to a fitness function, are programmed with these solutions. Crossover is the process of combining the genetic material of two individuals to create children, while individuals are chosen for procreation based on their fitness. The process keeps going until the best solution is discovered, and these children should be more fit even their parents.

RESULTS AND DISCUSSION

In this experiment, data from 140 rheumatoid arthritis patients were used. A total of 30 features were used to predict rheumatoid arthritis. Through the application of the genetic algorithm, only four features ESR, Anti-CCP, RF factor, and HLA were selected as the optimal features for predicting rheumatoid arthritis at an early stage. The last row represent the proposed method and shows good accuracy rate with 88.3%.

CONCLUSION

In this paper, the researcher presents a novel algorithm, KMGT, aimed at improving the accuracy of early detection of rheumatoid arthritis. The KMGT algorithm delivers better results than K-Means, particularly when managing noisy data. It reveals that rheumatoid arthritis can be predicted with only four essential features: ESR, Anti-CCP, HLA, and Rh factor. By enabling early diagnosis through these indicators, doctors can help save many lives and significantly enhance the quality of life for individuals affected by the disease.

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Table-I: Accuracy comparison

Images	Features	Patient with RA	Patient Without RA	Accuracy
140	30	65	35	75.4
140	6	77	23	86.3
140	4	80	20	87.9
140	4	82	19	88.3

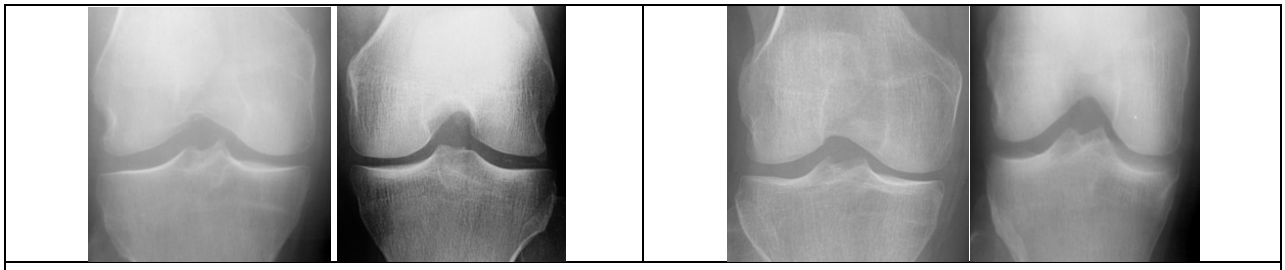


Fig 1. Training images on osteoarthritis

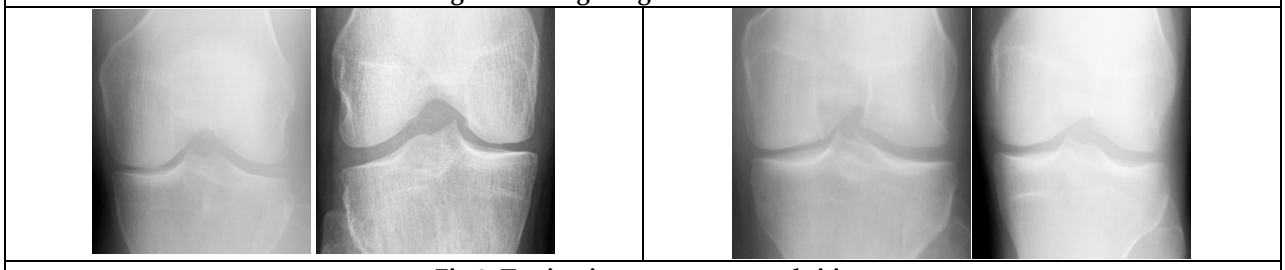


Fig 2. Testing images on osteoarthritis

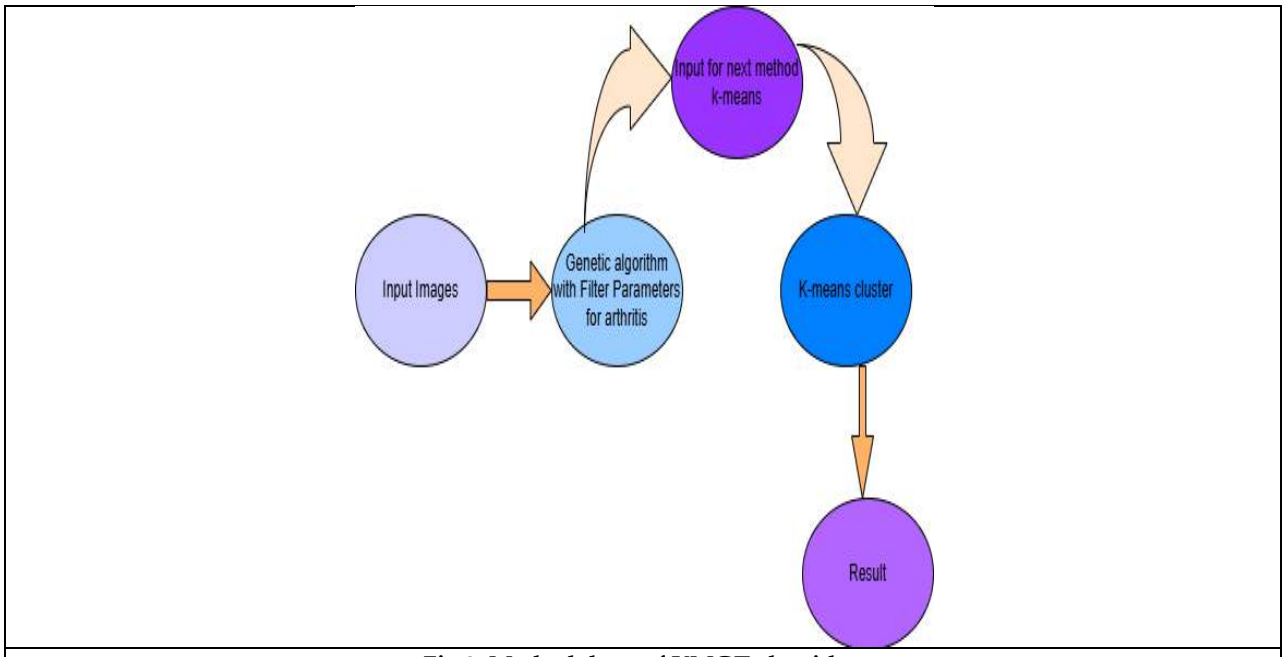


Fig 3: Methodology of KMGT algorithm

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RESEARCH ARTICLE

Hybrid Graphene - Metal Composites: Synthesis and Characterization for Gas Sensor Technologies

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ABSTRACT

Graphene-based metal composites have emerged as promising materials for gas sensor applications due to their unique combination of high electrical conductivity, large surface area, and enhanced catalytic properties. In this study, we synthesized and characterized graphene-metal composites, including pure graphene, graphene-copper (G-Cu), graphene-silver (G-Ag), and graphene-aluminium (G-Al), to evaluate their potential for gas sensing applications. The composites were prepared using a modified chemical reduction method and characterized through X-ray diffraction (XRD), scanning electron microscopy (SEM), and energy-dispersive X-ray spectroscopy (EDS), Fourier Transform Infrared Spectroscopy (FTIR), Raman spectroscopy and electrical characterisation. The structural and morphological analysis confirmed the successful mixture of metal nanoparticles within the graphene, resulting in improved surface activity and charge transfer properties. The electrical conductivity studies demonstrated that metal-doped graphene composites exhibit enhanced conductivity compared to pristine graphene, with G-Cu and G-Ag showing superior performance due to their high electron mobility. The results indicate that these composites have significant potential for developing high-performance gas sensors for environmental monitoring and industrial applications.

Keywords: Graphene, Composites, Graphene –Silver, Graphene –Copper, graphene-Aluminium

INTRODUCTION

Graphene, a single layer of carbon atoms arranged in a two-dimensional honeycomb lattice, has captured significant attention in material science due to its exceptional mechanical strength, high electrical conductivity, and remarkable thermal stability [1]. To further enhance its functional properties, researchers have developed graphene-based composites by integrating it with metals, such as copper, silver, and aluminium. These composites exhibit unique synergistic properties, making them promising candidates for applications in energy storage, catalysis, electronics, and structural materials [2]. Graphene oxide (GO), a precursor for graphene, plays a pivotal role in composite preparation due to its functionalized surface containing oxygen-rich groups. These groups facilitate chemical interactions with metal ions, enabling effective composite formation [3]. The preparation of graphene-metal composites typically involves processes like in situ chemical reduction, thermal methods, and electrochemical deposition, which ensure homogeneous dispersion of graphene within the metal matrix [4]. Graphene-copper composites are widely studied for their excellent thermal and electrical conductivity, along with enhanced mechanical properties, making them suitable for electronic components and heat dissipation systems.[5,6]. similarly, graphene-silver composites exhibit superior antibacterial properties and enhanced electrical performance, finding applications in sensors, conductive inks, and biomedical devices.[7,8] Graphene-aluminium composites[9] on the other hand, offer improved strength-to-weight ratios and corrosion resistance, making them ideal for aerospace and automotive applications. This report explores the preparation methodologies of graphene, graphene-copper, graphene-silver, and graphene-aluminium composites, along with their characterization. So far to our knowledge preparation of graphene metal oxide composites were reported on literature survey but graphene metal composites and the comparison studies are not reported so far with these combination. By investigating the structural, thermal, and mechanical properties of these materials, the study aims to provide insights into their potential applications and the optimization of fabrication techniques.

MATERIALS AND METHODS

Preparation of Graphene

The graphene precursor, the solid Solvothermal product, is usually made by heating 5 millilitres of ethanol and 2 grams of sodium in a 1:1 molar ratio in a sealed reactor tank at 220℃ for 72 hours. Following a rapid pyrolysis of this material, 100 millilitres of deionized water are used to clear the residue. The suspended solid is then vacuum-filtered and dried in a vacuum oven set at 100°C for 24 hours. With a final yield of 0.1 g per 1 ml of ethanol, graphene typically yields ~0.5 g per Solvothermal process [10]

Synthesis of Metal nanoparticles

Copper Nanoparticles

Copper nanoparticles are formed via a chemical reduction process using copper (II) sulfate pentahydrate as the precursor salt and starch as the capping agent. Initially, 120 mL of a 1.2% starch solution and a 0.1 M solution of copper (II) sulfate pentahydrate were mixed together and rapidly stirred for half an hour. Then, 50 mL of a 0.2 M ascorbic acid solution was added, always stirring quickly. Then, for two hours at 80°C, 30 mL of a 1 M sodium hydroxide solution was added gradually while being continuously agitated. Throughout the process, the solution changed from yellow to ocher. During the process. After the reaction was complete, the solution was removed from the heat and let to settle overnight. To get rid of extra starch, the precipitates were filtered and rinsed three times with ethanol and deionized water after the supernatant was carefully disposed of. After drying at room temperature, the resulting ocher-colored precipitates were placed in a glass vial for additional examination [11].

Silver Nanoparticles

Using 1% trisodium citrate as a reducing agent, silver nanoparticles were created by heating an aqueous 0.01 M silver nitrate solution to a boiling point. Throughout this procedure, the solution was heated and well mixed. When exposed to 1% trisodium citrate, aqueous silver ions were decreased and changed colour from yellowish to pale

brown, signifying the creation of silver nanoparticles. Using a magnetic stirrer, the nanoparticle solution was agitated at 90°C for 20 minutes. The reaction mixture was centrifuged at 6000 rpm for 15 min. After being gathered, the pellet was rinsed three times with triple-distilled water and dried at 80°C in a hot air oven [12].

Aluminium nanoparticles

In the deionized water, citric acid was used to dissolve aluminum nitrate. The citrate/nitrate (C/N) molar ratio was 0.5. At 60°C, the mixture was constantly swirled for several hours until it became a yellowish sol. After that, the solution was heated to 80°C while being continuously stirred to form the translucent gel. The gel was baked for 12 hours at 90°C to dry it out. At 600°C, the dry gel was crushed and sintered [13].

Composite preparation

Graphene metal composite were prepared by the following way, prepared graphene and metals such as copper, silver and Aluminum nanoparticles were mixed by 1:1 weight ratio and used for further analysis.

RESULTS AND DISCUSSION

X-Ray Diffraction Analysis for Prepared composites

Figure 1 presents the XRD patterns of (a) graphene, (b) graphene-copper composite, (c) graphene-silver composite, and (d) graphene-aluminum composite. In Graphene (Figure 1a) shows the XRD pattern of graphene exhibits two characteristic peaks at approximately 26.5° (002) and 42.8° (100), corresponding to the interlayer spacing of graphitic carbon. The broad nature of the (002) peak suggests the presence of disordered or few-layered graphene, indicating a partially exfoliated structure[14]. Graphene-Copper Composite (Figure 1b) shows the XRD pattern of the graphene-copper composite reveals distinct peaks at 43.3° (111), 50.4° (200), and 74.1° (220), which correspond to the face-centered cubic (FCC) structure of copper. The absence of a strong graphene peak suggests effective dispersion of graphene within the copper matrix. [15] Graphene-Silver Composite (Figure 1c) shows the XRD spectrum of the graphene-silver composite shows peaks at 38.1° (111), 44.3° (200), 64.5° (220), and 77.4° (311), which correspond to the FCC structure of silver. The peak intensities indicate good crystallinity of silver nanoparticles in the composite. The broadening of peaks suggests a nanoscale particle size[16]. Graphene-Aluminum Composite (Figure 1d) shows the XRD pattern of the graphene-aluminum composite displays peaks at 38.4° (111), 44.7° (200), 65.2° (220), and 78.3° (311), characteristic of aluminum's FCC structure. The well-defined peaks indicate high crystallinity, while the absence of distinct graphene peaks suggests strong interaction between graphene and aluminium [17] The XRD analysis confirms the successful incorporation of graphene into copper, silver, and aluminum matrices. The characteristic metal peaks dominate the composite patterns, indicating a well-dispersed graphene phase within the metal matrix. The absence or broadening of the graphene peak suggests possible exfoliation or integration at the nanoscale, which can enhance mechanical, electrical, and thermal properties of the composites.

Scanning Electron micrograph (SEM) analysis

Figure 2 presents SEM images at low and high magnifications for (a, b) graphene, (c, d) graphene-copper composite, (e, f) graphene-silver composite, and (g, h) graphene-aluminium composite. The morphological characteristics of each sample are analysed as follows: Graphene (Figure 2a, 2b) shows the SEM images of graphene reveal a typical layered and wrinkled sheet-like morphology. The graphene layers appear loosely stacked with a high degree of exfoliation, indicating few-layered or multi-layered graphene. The crumpled structure enhances the surface area, which is beneficial for composite formation. Figure 2 shows the SEM images of low and high magnification of (a,b) Graphene (c,d) Graphene copper composite (e,f) graphene silver composite (g,h) graphene aluminum composite Graphene-Copper Composite (Figure 2c, 2d) shows in the graphene-copper composite, the graphene sheets are decorated with copper nanoparticles. The copper particles are dispersed along the graphene surface, with some areas exhibiting agglomeration. The uniform dispersion suggests strong interfacial interaction between graphene and copper, which could improve electrical and mechanical properties.

Graphene-Silver Composite (Figure 2e, 2f) shows the SEM images of the graphene-silver composite show a similar morphology to the copper composite, with silver nanoparticles attached to the graphene sheets. The particles appear more uniformly distributed across the graphene layers, likely due to strong nucleation sites on the graphene surface. The presence of silver nanoparticles enhances electrical conductivity and antimicrobial properties. Graphene-Aluminium Composite (Figure 2g, 2h) shows the graphene-aluminium composite exhibits a structure where aluminium nanoparticles are distributed along the graphene sheets. The aluminium particles tend to form spherical clusters, suggesting possible aggregation. However, the interaction with graphene is still evident, which can contribute to improved mechanical reinforcement in composite materials.

Energy Dispersive X-Ray Analysis (EDAX)

Figure 3 shows the EDAX images of (a) Graphene (b) Graphene copper composite (c) graphene silver composite (d) graphene aluminum composite Figure 3 presents the EDX spectra and elemental composition of (a) graphene, (b) graphene-copper composite, (c) graphene-silver composite, and (d) graphene-aluminum composite. The elemental distribution confirms the successful integration of metal nanoparticles into the graphene matrix. Graphene (Figure 3a) reveals that the EDX spectrum of graphene shows dominant peaks for carbon (C) and oxygen (O), with weight percentages of 75.43% and 24.09%, respectively. The presence of oxygen indicates partial oxidation, suggesting the material could be reduced graphene oxide (rGO). Small traces of silicon (Si) and chlorine (Cl) may be due to contamination from the synthesis or processing environment.Graphene-Copper Composite (Figure 3b) reveals that The EDX analysis of the graphene-copper composite shows peaks for carbon (C), oxygen (O), and copper (Cu). The copper content is significantly high (68.04% by weight), confirming the successful incorporation of copper into the graphene matrix. The reduction in carbon content (16.63%) compared to pure graphene suggests metal deposition on graphene sheets. Graphene-Silver Composite (Figure 3c) reveals that The EDX spectrum of the graphene-silver composite exhibits strong peaks for silver (Ag), carbon (C), and oxygen (O). The presence of 7.66% Ag by weight confirms the successful integration of silver nanoparticles onto the graphene surface. The high atomic percentage of silver (28.64%) suggests good dispersion of Ag particles within the composite, which can enhance electrical and antibacterial properties. Graphene-Aluminum Composite (Figure 3d) reveals that The EDX spectrum of the graphene-aluminum composite shows peaks corresponding to carbon (C), oxygen (O), and aluminum (Al). The aluminum content is 17.57% by weight, confirming the presence of aluminum particles in the composite. The relatively high oxygen percentage (18.06%) suggests possible oxidation of aluminum, forming aluminum oxide (Al_2O_3), which may influence the composite's mechanical and thermal properties. The EDX analysis confirms the successful incorporation of copper, silver, and aluminum into the graphene matrix.

Raman spectrum for prepared graphene and the composite

Figure 4 shows the Raman spectrum of (a) Graphene (b) Graphene copper composite (c) graphene silver composite (d) graphene aluminum composite The spectra in Figure 4 appear to be Raman spectra of various graphene-based materials, specifically graphene and graphene composites with different metals (copper, silver, and aluminum). D and G Bands: Fig (a) shows the Graphene raman spectrumThis spectrum likely represents pristine graphene or graphene with minimal defects. The G band(1583 cm-1) is prominent, and the D band(**1350 cm-1)** is relatively weak, suggesting a high degree of structural order. The "D" band is associated with defects or disorder in the graphene lattice. A more intense D band generally indicates higher levels of disorder. The "G" band is related to the in-plane vibrations of sp2-hybridized carbon atoms in the graphene sheet. Its position and intensity can provide information about the quality and structure of the graphene. 2D Band: There might be a weak "2D" band present in the spectra, typically around 2700 cm-1. This band is a second-order overtone of the D band and is sensitive to the number of graphene layers[18]. Fig(b) reveals the Graphene Copper Composite spectrum of Raman. The presence of a more intense D band compared to (a) indicates that the introduction of copper might have introduced some disorder into the graphene lattice. The G band is still visible, suggesting that the overall graphene structure remains intact. Graphene Silver Composite was shown in Fig (c) Similar to (b), the D band is more prominent in this spectrum compared to pristine graphene. This suggests that the interaction with silver might have induced some defects in the graphene structure. Graphene Aluminum Composite is shown in Fig(d) In this spectrum, the D band is even more

intense than in (b) and (c), suggesting a higher level of disorder in the graphene structure when combined with aluminum[19].

Electrical Characterization of graphene and graphene composite

Figure 5 shows the Electrical characterization of (a) Graphene (b) Graphene copper composite (c) graphene silver composite (d) graphene aluminum composite Figure 5 presents the variation of electrical resistance with applied voltage for (a) pure graphene, (b) graphene-copper composite, (c) graphene-silver composite, and (d) graphene-aluminium composite. The observed trends provide valuable insights into the electrical characteristics of these materials. Pure Graphene shown in (a) exhibits the highest resistance (1.3 to 8.2 micro ohm) among the tested samples. This increased resistance can be attributed to several factors, including grain boundaries, defects, and inter-layer contact resistance in the material. These structural imperfections hinder efficient electron transport, leading to relatively higher resistivity. Graphene-Silver Composite shown in (c) (2.1 to 23.7 micro ohm) among the composites, the graphene-silver composite demonstrates the lowest resistance, confirming the superior electrical conductivity of silver. The high conductivity of silver enhances charge carrier mobility within the graphene matrix, significantly reducing overall resistance. This suggests that silver integration effectively improves the electrical transport properties of the composite, making it a promising material for electronic applications requiring low resistance pathways. Graphene-Copper Composite (2.8 to 41.2 micro ohm) shown as fig (b) and Graphene-Aluminium Composite (3.1 to 53.5 micro ohm) shown in (d) the resistance of the graphene-copper composite is lower than that of the graphene-aluminium composite. Copper is known for its excellent electrical conductivity, second only to silver among commonly used metals. The improved conductivity in the graphene-copper composite indicates strong electron transport properties and reduced interfacial resistance. Conversely, aluminium, despite being a good conductor, exhibits relatively higher resistance, likely due to increased scattering of charge carriers and possible oxide layer formation at the interfaces.

CONCLUSION

In this study, we successfully synthesized and characterized graphene-metal composites, including pure graphene, graphene-copper (G-Cu), graphene-silver (G-Ag), and graphene-aluminium (G-Al), to evaluate their electrical properties and potential for gas sensing applications. The electrical characterization results demonstrated a significant enhancement in conductivity with metal incorporation. Among the composites, G-Ag exhibited the lowest resistance, indicating superior electrical conductivity due to the high charge carrier mobility of silver. The G-Cu composite also showed improved conductivity compared to pure graphene, confirming copper's effectiveness in enhancing electron transport. Conversely, the G-Al composite displayed relatively higher resistance than G-Ag and G-Cu, though still lower than pure graphene, suggesting moderate electrical enhancement. These findings suggest that metal integration effectively reduces interfacial resistance and improves charge carrier mobility in graphene-based materials. The structural and spectroscopic analyses confirmed the successful incorporation of metal elements into the graphene matrix. XRD patterns revealed the presence of characteristic peaks corresponding to graphene and metal phases, while SEM and EDS analyses provided insight into the morphology and elemental distribution. FTIR and Raman spectroscopy further validated the structural integrity of the composites, indicating minimal defects and strong interactions between graphene and metal particles. Overall, our findings suggest that graphene-metal composites, particularly G-Ag and G-Cu, exhibit promising electrical properties that could be leveraged for gas sensing applications. Future work will focus on optimizing synthesis parameters, exploring the gas sensing performance of these composites under different environmental conditions, and investigating their long-term stability and sensitivity toward various target gases.

Declaration of Conflict of Interest

The authors declares no conflicts of interest

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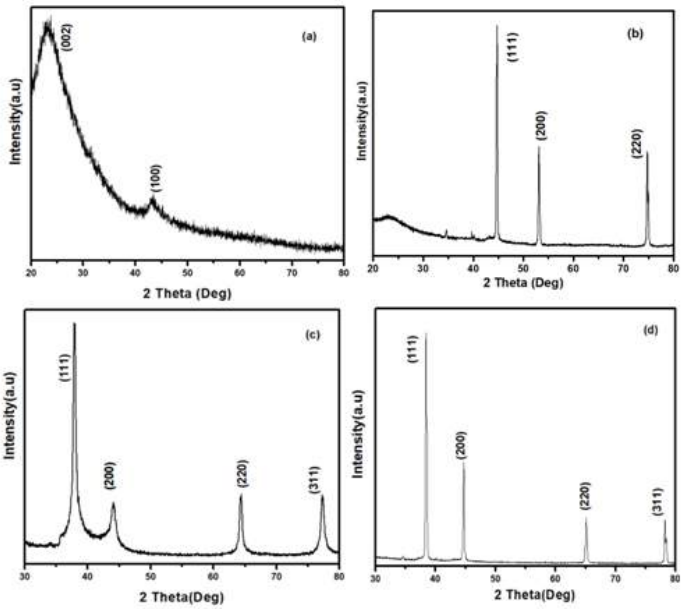


Figure: 1 shows the XRD pattern of (a) Graphene (b) Graphene copper composite (c) graphene silver composite (d) graphene aluminum composite

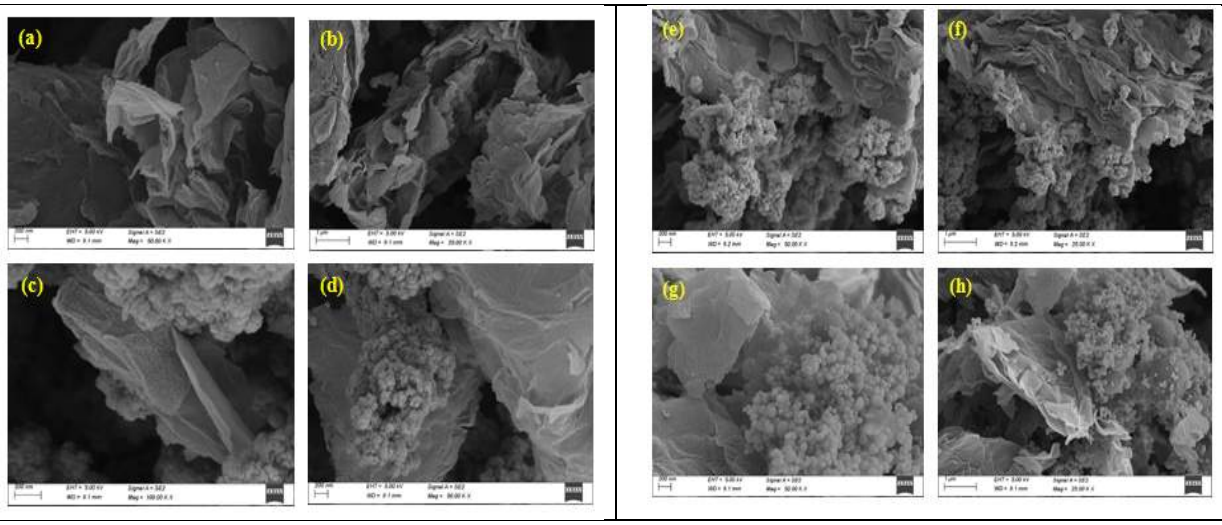


Figure 2 shows the SEM images of low and high magnification of (a,b) Graphene (c,d) Graphene copper composite (e,f) graphene silver composite (g,h) graphene aluminum composite

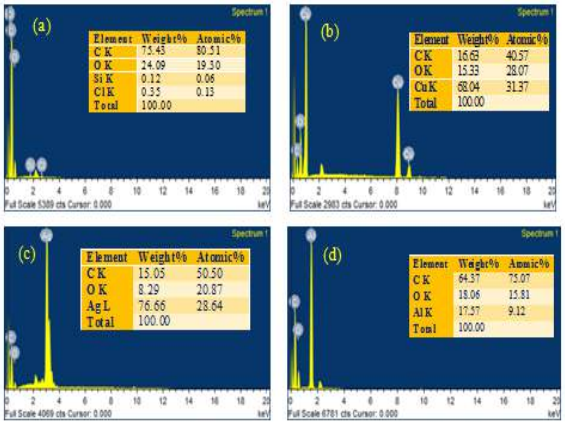


Figure 3 shows the EDAX images of (a) Graphene (b) Graphene copper composite (c) graphene silver composite (d) graphene aluminum composite

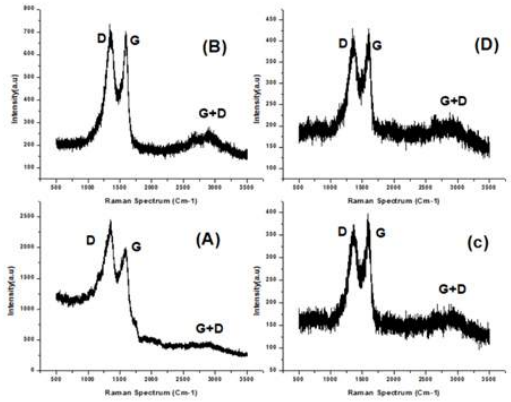


Figure 4 shows the Raman spectrum of (a) Graphene (b) Graphene copper composite (c) graphene silver composite (d) graphene aluminum composite

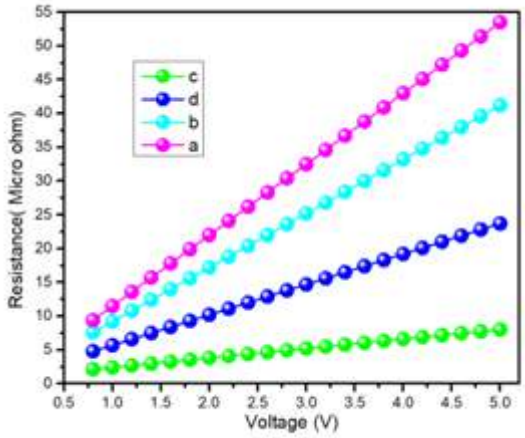


Figure 5 shows the Electrical characterization of (a) Graphene (b) Graphene copper composite (c) graphene silver composite (d) graphene aluminum composite

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RESEARCH ARTICLE

To Compare the Effectiveness of Active Release Technique Combined with Prescribed Exercise Versus Prescribed Exercise Alone in Computer Professionals with Upper Cross Syndrome

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ABSTRACT

Each year, millions of people suffer from a condition known as Upper Crossed Syndrome (UCS). Sedentary lifestyles, excessive hours working at a desk or computer, frequent texting, postural changes, and improper weightlifting techniques are common contributors to UCS. As we age, posture tends to decline: shoulders become more rounded, the head shifts forward (protracted), and the thoracic spine (upper back) becomes excessively curved. Over time, poor alignment and posture can result in abnormal tissue stress, leading to degenerative joint changes and chronic pain. Primary Objective: To compare the effectiveness of Active Release Technique (ART) combined with prescribed exercise versus prescribed exercise alone in improving range of motion (ROM) and muscular strength. Secondary Objective: To evaluate the independent effect of prescribed exercise on UCS. Participants who met the inclusion criteria provided informed consent after being thoroughly briefed on the procedure. Two intervention groups were established: Group A: Received prescribed exercise alone. Group B: Received ART in combination with prescribed exercise. The Student's t-test and paired t-test were used for statistical analysis. The following outcome measures were evaluated both before and after the interventions: Manual Muscle Testing (MMT), Neck Disability Index (NDI) Significant differences were observed for all dependent variables across both groups. However, Group B (ART combined with prescribed exercise) demonstrated statistically greater improvements compared to Group A. The findings suggest that Upper Crossed Syndrome can be effectively managed with a combination of Active Release Techniques and prescribed exercises, yielding maximum improvement in patients' conditions.

Keywords: Upper Crossed Syndrome, Neck muscles, Manual Muscle Testing, Neck Disability Index, Prescribed exercise.

INTRODUCTION

Posture is the way a person moves, sits, and walks and is individually unique. It is also defined as the spine being in a neutral position, with good posture being imperative for improved health. (1) Posture is an important function because it is involved in movements of daily life, such as standing, sitting, bending, and lying. Maintenance of posture involves muscles to contract, which enables the body to remain in both seated and standing positions. However, prolonged sitting or standing can have a detrimental effect on an individual's posture and lead to many postural abnormalities. (2) Each year, millions of people suffer from a condition known as Upper Crossed Syndrome. Sedentary lifestyles, excessive hours working at a desk or computer, texting, postural changes, and even improper weight lifting can lead to Upper cross syndrome. (3) As we grow older, our posture tends to decline: not only do the shoulders become more rounded, but the head becomes protracted forward and the thoracic spine (or upper back), is more curved. In time, faulty alignment and poor posture can add abnormal tissue stress, leading to degenerative joint changes and pain. Bad posture has also been linked to poor balance, as well as to decreases in gait and functional performance. (4) Upper Cross Syndrome is a condition that arises from a cyclical pattern of poor body mechanics. It is a problem that many people suffer from, but often don't identify. (5) Upper Crossed Syndrome occurs when there is a muscular imbalance in the neck, shoulder region, and upper to mid thoracic spine. (6) It can lead to more serious problems such as early degenerative (arthritic) changes. Here shoulders become rounded, your head starts jutting forward, and all the muscles that hold you up against gravity get weak. This C-Posture is the result of this Upper Crossed Syndrome. These are common signs of Upper Crossed Syndrome. A posture that is prevalent with most people and leads to issues such as neck pain, muscle spasms, headaches, and may even cause numbness and tingling in the arms or hands. (7) Upper cross syndrome is defined as "tightness of the upper trapezius, pectoralis major, and levator scapulae and weakness of the rhomboids, serratus anterior, middle and lower trapezius, and the deep neck flexors, especially the scalene muscles." (7) A lengthened muscle loses its ability to generate tension at a given length, resulting in weakness, and a shortened muscle loses its elasticity and becomes tight.(8) This syndrome can cause a multitude of dysfunctions within the body including headaches, early degeneration of the cervical spine, and loss of the cervical curve. In 5 addition, Upper cross syndrome can cause an abnormal kyphotic thoracic spine and altered biomechanics of the glenohumeral joint. (9) If Upper Crossed Syndrome is not dealt with, it can lead to a variety of pains and problems. They range from temporomandibular stress, neck pain, shoulder dysfunction, thoracic outlet syndrome, and inability to use the thorax normally in breathing. (10) Active Release Techniques are used to treat inflammation of muscle (myofascitis), tendon (tendinosis), and ligament secondary to repetitive stress or frank injury. Over-used muscles (and other soft tissues) change in three important ways: acute conditions (pulls, tears, collisions, etc), accumulation of small tears (microtrauma), and lack of adequate oxygen (hypoxia). Active Release Technique is also used to evaluate the texture, tightness, and movement of muscles, fascia, tendons, and ligaments in your problem area. This method softens and stretches the scar tissue, resulting in an increased range of motion, increased strength, and improved circulation. Treatment of the involved muscle(s) also addresses neuritis/neuralgia which occurs when nerves become trapped or compressed by the affected muscles.(11)

METHODOLOGY

Study Design
This study employed a comparative design.

Source of Data
The participants were individuals recruited from the City Hospital Charitable Trust, Mangalore.

Definition of Study Subjects
The study included individuals aged between 20 to 50 years who were diagnosed with Upper Cross Syndrome.

Inclusion Criteria

1. Male and female subjects aged between 20 to 50 years.
2. Diagnosed with acute pain associated with Upper Cross Syndrome.
3. Willingness to participate in the study.
4. No participation in any formal physical rehabilitation program.
5. Experience of mechanical neck pain.

Exclusion Criteria

1. History of surgeries in the cervical area.
2. Current use of analgesics and/or muscle relaxants.
3. Diagnosed thoracic scoliosis.
4. Known rotator cuff tear.
5. Pregnancy.
6. Unwillingness to participate in the study.

Study Sampling Design, Method, and Size

- Sampling Design: Probability convenience sampling.
- Method of Data Collection: Participants meeting the inclusion and exclusion criteria were recruited.
- Sample Size: A total of 30 subjects were included in the study.

Follow-Up and Assessments

1. Pre-Test Assessment: Pain and disability were evaluated on the first day before the intervention using manual muscle testing (MMT) and the Neck Disability Index (NDI). Range of motion (ROM) was assessed using goniometry.
2. Post-Test Assessment: Pain, disability, and range of motion were reevaluated on the last day of the treatment using the same tools (MMT, NDI, and goniometry).

Duration of Study

The study was conducted over a period of six months.

Intervention Procedures

Participant Selection and Screening

All participants were screened based on the inclusion and exclusion criteria. Participants were briefed on the purpose, nature, and intervention procedures of the study, and informed consent was obtained.

Group Allocation

Participants were randomly assigned to one of two groups

Group A (Control Group)

- Received prescribed exercises for 45 minutes per day, three times a week, for four weeks.
- The exercises included:
  - Manual stretching of the upper trapezius, pectoralis major, and levator scapulae.
  - Strengthening of the serratus anterior, rhomboids, middle and lower trapezius, and deep neck flexors.
- Each exercise was performed in 3 sets of 10 repetitions.

Group B (Experimental Group)

- Received the same prescribed exercises as Group A for 45 minutes per day, three times a week, for four weeks.
- In addition, participants underwent the Active Release Technique (ART) for 30 minutes on alternate weeks over the same four-week period.

- ART targeted the pectoralis major, levator scapulae, and upper trapezius bilaterally. After completing the four-week intervention, all participants were reevaluated for pain, range of motion (ROM), and disability using MMT, ROM, and the NDI.

RESULTS

Average improvement of neck disability index in control group is 8.46 and t value is 10.69 Average improvement of manual muscle testing in the experimental group is 12.33 and t value is 13.57

DISCUSSION

In the present study age group that participated was between 20-50 years who had been evaluated with upper cross syndrome. Recent studies have shown the use of the active release technique in improving neck muscle strength and pain when used for a short duration. A lack of research is present to demonstrate the beneficial effects of the active release technique for a longer duration of time to achieve long-term effects of flexibility and range of motion of neck muscle. Hence this study shall be concentrated for a longer duration of time to achieve long-term effects of flexibility of neck muscle and improving posture. Results of these studies were directed toward active release technique with prescribed exercise to improve their upper cross syndrome in the present study

CONCLUSION

The treatment of upper cross syndrome with active release technique and prescribed exercises demonstrated the most significant improvements in patients' conditions. This study offers valuable insights into the most effective management approach for upper cross syndrome among computer professionals, with potential implications for optimizing the quality of care and enhancing the well-being of this occupational group. Active release technique with prescribed neck exercises can be promoted as a form of rehabilitation and daily training as a performance-enhancing program for various musculoskeletal neck injuries. Further studies can be done to find out the efficacy of these exercises in preventing recurrence rate.

LIMITATION OF THE STUDY

1. Age groups were selected 20 to 50 years.
2. Sample size was limited to 15 in each group.
3. Absence of an objective assessment scale.

CLINICAL IMPLICATIONS

The result of this study shows that Active release technique with prescribed neck exercises is effective than prescribed exercise alone in upper cross syndrome

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Table 1: Comparison of Age in years of Control Group and Experimental Group

AGE IN YEARS	CONTROL	EXPERIENTAL
20-30	5	5
30-40	6	5
40-50	3	4
50	1	1
TOTAL	15	15

Table 2: Comparison of Gender in Control and Experimntal Group

GENDER	CONTROL	EXPERIMENT
FEMALE	8	7
MALE	7	8
RESULT	15	15

Table 3: Comparison of Pre and Post Control and Experimental in Manual Muscle Testing

	MMT	MEAN	S.DEVIATION
CONTROL GROUP	pre	2.6	0.50
	post	3.2	0.67
EXPERIMENTAL GROUP	pre	2.6	0.5
	post	4.06	0.79

Table 4: Comparison of Pre Post Mmt between Groups

	MMT	Average Improvement	t-value	p value	Result
CONTROL GROUP	pre -post	3.15	0.007	0	p<0.05 SIG
EXPERIMENTAL GROUP	pre -post	0.05	11	0	p<0.05 SIG

Table 5: Comparison of Pre and Post Control and Experimental in Neck Disability Index

	NDI	MEAN	S.DEVIATION
CONTROL GROUP	pre	21.93	2.98
	post	13.46	1.59
EXPERIMENTAL GROUP	pre	21.86	3.09
	post	9.53	1.95

Table 6: Comparison of Pre and Post between Groups

	MMT	Average Improvement	t-value
CONTROL GROUP	pre -post	8.46	10.69
EXPERIMENTAL GROUP	pre -post	12.33	13.57



Figure:1



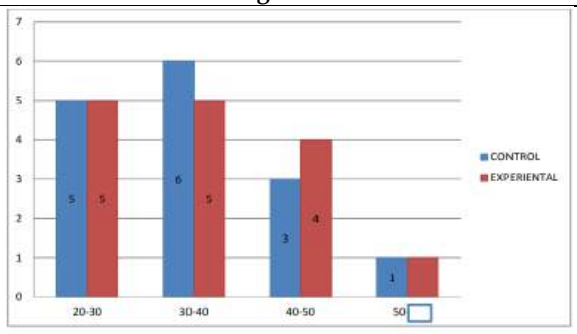
Figure:2



Figure:3

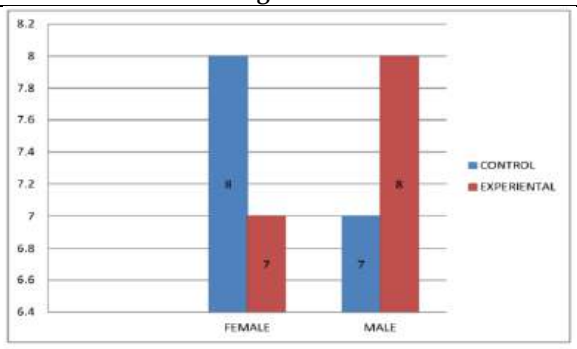


Figure:4

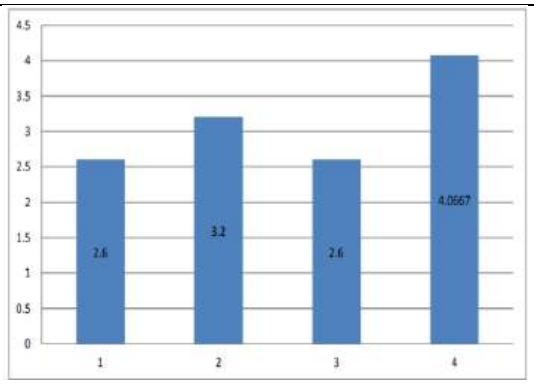


GRAPH 1: COMPARISON OF AGE IN YEARS OF CONTROL GROUP AND EXPERIMENTAL GROUP

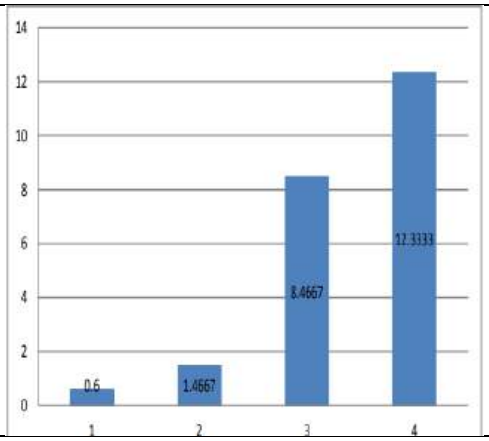
Graph 1: Comparison of Age in years of Control Group and Experimental Group



Graph 2: Comparison of Gender in Control and Experimental Group



Graph: 3 Comparison of Pre and Post Control and Experimental in Manual Muscle Testing



Graph 4: Comparison of Pre and Post between Groups

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RESEARCH ARTICLE

Susceptible-Exposed – Infected - Treatment Model with Disease Infection in Prey Population Recovered by Treatment

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ABSTRACT

This study presents a Susceptible-Exposed-Infected-Treatment (SEIT) model to describe the dynamics of disease transmission in a prey population by incorporation of treatment. The model includes compartments for susceptible, exposed, infected, and treated individuals. Differential equations are derived to capture the transitions between these states. The analysis focuses on finding equilibrium points and determining their stability. Numerical simulations are conducted to explore the impact of various parameters on disease dynamics and the effectiveness of treatment strategies. The results provide insights into disease control and management in ecological systems.

Keywords: SEIT model, Disease dynamics, Prey population, treatment and recovery, Epidemic modeling, Differential equations, Stability analysis, Numerical simulation, Ecological epidemiology, global stability, Hopf bifurcation, Harvesting.

INTRODUCTION

In the study of infectious diseases within ecological systems, the interaction between disease dynamics and population biology is of paramount importance. This paper focuses on the development and analysis of a Susceptible-Exposed-Infected-Treatment (SEIT) model to describe the spread of disease in a prey population, incorporating the effects of treatment on disease recovery. In natural ecosystems, prey populations are susceptible to

infectious diseases that can significantly impact their dynamics and survival. Understanding the mechanisms of disease transmission and recovery is crucial for managing and conserving these populations. Traditional epidemiological models, such as the Susceptible-Infected-Recovered (SIR) and Susceptible-Exposed-Infected (SEI) models, provide foundational frameworks for studying disease dynamics. However, these models often overlook the impact of treatment and its role in disease management. The SEIT model introduced in this study extends the SEI framework by including a treatment compartment, where infected individuals can recover through medical intervention. This model divides the prey population into four compartments: susceptible (S), exposed (E), infected (I), and treated (T). Susceptible individuals can become exposed upon contact with infected individuals. Exposed individuals progress to the infected stage, during which they can either recover naturally, succumb to the disease, or receive treatment that leads to recovery. Treated individuals are considered recovered and are assumed to gain immunity, preventing them from returning to the susceptible state. The primary objectives of this study are to derive the differential equations governing the SEIT model, analyze the stability of equilibrium points, and conduct numerical simulations to investigate the impact of key parameters on disease dynamics. By understanding the interplay between disease transmission, progression, and treatment, we aim to provide insights into effective disease control strategies and their implications for the long-term sustainability of prey populations. This paper is structured as follows: Section 2 outlines the mathematical formulation of the SEIT model. Section 3 presents the equilibrium analysis and stability criteria. Section 4 discusses the results of numerical simulations, highlighting the effects of various parameters on the disease dynamics. Finally, Section 5 concludes with a summary of findings and potential directions for future research.

MATHEMATICAL MODEL FORMATION

$$\frac{ds}{dt} = as(t)\left(1 - \frac{s(t)}{k}\right) - \frac{cN(t)s(t)}{1 + N(t)} - \beta p(t)s(t) - \beta s(t)N(t)$$

$$\frac{dE}{dt} = \beta s(t)N(t) - \sigma E(t) - \delta E(t)$$

$$\frac{dN}{dt} = \frac{cN(t)s(t)}{1 + N(t)} - jN(t)p(t) - \delta N(t) - eN(t) + \sigma E(t)$$

$$\frac{dT}{dt} = vT(t) - fT(t) + \delta N(t) + \delta E(t)$$

$$\frac{dP}{dt} = \psi N(t)p(t) + \phi s(t)p(t) - hP(t)$$

With initial condition

S (0)>0, E (0)>0, N (0)>0, T (0)>0, P (0)>0.

we make the following assumptions to formulate the mathematical model assumption

S(t)→ Susceptible prey

E(t)→ Exposed prey

N(t)→ Infected prey

T(t)→ Treatment

P(t)→ predator

A → growth rate of susceptible prey

K → carrying capacity of susceptible prey

c→ interference coefficient of three prey species with type II functional response.

β, j→ force of infection of prey from predator

e→ natural death rate of infected prey.

δ→ recovered rate of infected prey

σ→ rate at which exposed individuals progress to infectious rate

f→ relates death of infected prey under treatment

v→ growth rate of prey under treatment

ϕ, ψ→ conversion coefficient of predators from Susceptible, Exposed, and Infected prey populations

h→ harvest effort of a predator.

This model has some assumptions which consist of the following

1. The Susceptible, Exposed, and Infected prey interaction occurs with Holling type II functional response.
2. We identify the number of Infected prey and give treatment for them.
3. The probability of an infected individual receiving treatment per unit of time does not change over time or with the size of the infected population.
4. Infected individual receives treatment, they are instantly moved to the treated (recovered) compartment.
5. Treated individuals are assumed to gain complete immunity to the disease. Therefore, individuals in the treated compartment do not revert to the susceptible, exposed, or infected states.
6. Treated individuals are considered non-infectious. They do not contribute to the transmission of the disease after receiving treatment.
7. Natural birth and death rates, as well as the rates of disease progression and natural recovery, are assumed to be constant over time.
8. It assumes that all infected individuals can receive treatment if they require it.

POSITIVITY AND BOUNDEDNESS OF THEOREM

In this section, we establish the conditions to get positive as well as bounded solutions of the system.

Positivity

Theorem 1

Every solution of system (1) with initial condition always exists in the interval $[0,\infty)$ and S (0)>0, E (0)>0, N (0)>0, T (0)>0, P (0)>0, for all t≥ 0.

Proof

In the right-hand side of equation (1) is completely continuous and relates to local Lipschitzian on C, the condition (2) exists and is unique on $[0,\zeta), where\ 0 < \zeta \leq +\infty$. from equation (1) and (2) we have

S(t)= S (0) exp $[\int_0^t \left\{a\left(1-\frac{s}{k}\right)-\frac{cN}{1+N}-\beta p-\beta N\right\}dt] > 0$

E(t)= E (0) exp $[\int_0^t \{\beta SN\}dt] > 0$

N(t)= N (0) exp $[\int_0^t \left\{\frac{cs}{1+N}-jp-\delta-e+\sigma E\right\}dt] > 0$

T(t)= T(0) exp$[\int_0^t \left\{v-f+\frac{\delta N}{T}\right\}dt] > 0$

P(t)= P(0) exp $[\int_0^t \{\psi N+\phi S-h\}dt] > 0$

Hence, we proved.

Boundedness

Theorem 2

Susceptible prey is always bounded above for a>0, K>0.

Proof

If S(0) =0 then the result is obvious, if S (0)>0, then S(t)>0 for all t on adding equation(1) we obtain

$\frac{ds}{dt} \leq a\left(1-\frac{s}{k}\right)\lim_{t\to\infty}(Sup\ s(t) \leq k)$

Theorem 3

Exposed prey, Infected prey, Treatment, and predator are bounded above.

Proof

If E(0)> 0, the results are obvious. We obtain the equation (1)

If E(0)> 0, then $\frac{dE}{dt} < 0\ if\ d_1E > 1, \frac{dN}{dt} < 0\ if\ d_2N > 1, \frac{dT}{dt} < 0\ if\ d_3T > 1, \frac{dp}{dt} < 0\ if\ d_4P > 1.$

Where $d_1 = \beta SN$, $d_2 = \delta + e, d_3 = v + f, and\ d_4 = h.$

$\Rightarrow \lim_{t\to\infty}\left(Sup\, E(t) \le \frac{1}{d_1}\right),\ \lim_{t\to\infty}\left(Sup\, N(t) \le \frac{1}{d_2}\right),\ \lim_{t\to\infty}\left(Sup\, T(t) \le \frac{1}{d_3}\right),\ \lim_{t\to\infty}\left(Sup\, s(t) \le \frac{1}{d_4}\right)$

Theorem 4

The path of the equation (1) is bounded.

Proof

Define the function $\Omega = S + E + N + T + P\ and$ take its time derivative along the solution of (1) $\frac{d\Omega}{dt} = \frac{ds}{dt} + \frac{dE}{dt} + \frac{dN}{dt} + \frac{dT}{dt} + \frac{dP}{dt}$ since the parameters are non-negative and solutions initiating in R_+^4 remain in the non-negative quadrant, then.

$\frac{d\Omega}{dt} + \rho\Omega \le as\left(1 - \frac{s}{K}\right) - \beta SN - eN + vT - fT - hP + \rho S + \rho E + \rho N + \rho T + \rho P$

$=(\rho + a)S + (\rho + \beta)E + (\rho - e)N + \left(\frac{\rho+v}{f}\right)T + (\rho - h)P - \frac{as^2}{k}$

Where ρ is a non-negative constant for $\rho > e\ or\ \rho > h\ given\ \varepsilon > 0\ there\ exists\ to\ such\ that\ t\ 0n\ t \ge t_0.$

$\frac{d\Omega}{dt} + \rho\Omega \le m+\varepsilon = min\{=(\rho + a), (\rho + \beta), (\rho - e), \left(\frac{\rho+v}{f}\right), (\rho - h)\}$

Lemma.

Let φ be acontinuous function satisfying the differential inequality

$\frac{d\varphi(t)}{dt} + \alpha_1\varphi(t) \le \alpha_2, t \ge 0\ where(\alpha_1, \alpha_2)\epsilon R_+^3\ \alpha_1 \ne 0$ then $\forall t \ge T \ge 0, \phi(t) \le \frac{\alpha_2}{\alpha_1} - \left(\frac{\alpha_2}{\alpha_1}\emptyset(t)\right)e^{\alpha_1(t-T)}$

From the above lemma $\Omega(t) \le \Omega(t_0)e^{-\rho(t-t_0)} + (\frac{m+\varepsilon}{\rho})(1 - e^{-\rho(t-t_0)})$

Letting t→∞ *then letting* $\varepsilon \to 0$ $\lim_{t\to\infty}(\sup\Omega(t)) \le \frac{m}{\rho}$

On the initial condition, the system (1) is bounded.

NONLINEAR SYSTEM AND STABILITY ANALYSIS

Equilibrium points:

The equilibrium points of the parametric model(1) are given by steady-state equation $\frac{ds}{dt} = \frac{dE}{dt} = \frac{dN}{dt} = \frac{dT}{dt} = \frac{dP}{dt}$.

The system has equilibrium points and after some algebraic calculations we get the trivial,axial, and non-trivial equilibrium points(table 1)

Analysis Stability and the existence of equilibrium point

The Jacobian matrix of the system (1) at equilibrium point E=(s(t), E(t), N(t), T(t), P(t)) is given by

$$J=\begin{bmatrix} a\left(1-\frac{2s}{k}\right) - \frac{cN}{1+N} - \beta P - \beta N & 0 & \frac{-cs}{(1+2)^2} & 0 & -\beta S \\ \beta N & -(\sigma+\delta) & \beta S & 0 & 0 \\ \frac{cN}{1+N} & \sigma & \frac{CS}{1+N} - \frac{CNS}{(1+N)^2} - jp - \delta - e & 0 & -jN \\ 0 & \delta & \delta & v - f & 0 \\ P\emptyset & 0 & P\psi & 0 & \Psi N + \Phi S - h \end{bmatrix}$$

Based on the condition of eigenvalues, the dynamical system (1) gets stable if all eigenvalues are non-positive in the case of real roots or non-positive real parts in the case of complex roots of the characteristic equation for the above Jacobian matrix. Otherwise, the system is unstable.

Theorem 5

Given the linearized system of equation (1) is trivial equilibrium point E1{S=0, E=0, N=0, T=0, P=0} is called a saddle point.

Proof

The Jacobian matrix is

$$J_1=\begin{bmatrix} a & 0 & 0 & 0 & 0 \\ 0 & -(\sigma+\delta) & 0 & 0 & 0 \\ 0 & \sigma & -\delta-e & 0 & 0 \\ 0 & \delta & \delta & v-f & 0 \\ 0 & 0 & 0 & 0 & -h \end{bmatrix}$$

The eigen Values are $\lambda_1 = a, \lambda_2 = -(\sigma+\delta), \lambda_3 = -\delta - e, \lambda_4 = v - f, \lambda_5 = -h$

Hence the equilibrium point (1) is locally stable if $\lambda_1 = a > 0, \lambda_2 = -(\sigma+\delta) < 0, \lambda_3 = -\delta - e < 0, \lambda_4 = v - f < 0, \lambda_5 = -h$<0 is called a saddle point.

Theorem 6

Given the linearized system of equation (1) is exposed prey, infected prey, treatment and predator-free equilibrium point E2{S=K, E=0, N=0, T=0, P=0} is locally asymptotically stable.

Proof

The Jacobian matrix is

$$J_2=\begin{bmatrix} -a & 0 & 0 & 0 & -\beta k \\ 0 & -(\sigma+\delta) & \beta k & 0 & 0 \\ 0 & \sigma & -\delta-e & 0 & 0 \\ 0 & \delta & \delta & v-f & 0 \\ 0 & 0 & 0 & 0 & K\Phi - h \end{bmatrix}$$

The eigen Values are $\lambda_1 = -a, \lambda_2 = -(\sigma+\delta), \lambda_3 = -\delta - e, \lambda_4 = v - f, \lambda_5 = K\phi - h$

Hence the equilibrium point(1) is locally stable if $\lambda_1 = -a < 0, \lambda_2 = -(\sigma+\delta) < 0, \lambda_3 = -\delta - e < 0, \lambda_4 = v - f < 0, \lambda_5 = K\phi - h$<0 with the condition $-(\sigma+\delta) > 0, = -\delta - e > 0, v > f \; and \; h > K\phi$.

Theorem 7

Given the linearized system of equation (1) is exposed prey, infected prey, and treatment- free equilibrium point E3 {S=$\frac{h}{\phi}$,E=0, N=0, T=0, P= ($\frac{-a(k\phi-h)}{k\beta\phi}$) } is locally asymptotically stable.

Proof:

The Jacobian matrix is

$$J_3=\begin{bmatrix} a\left(1-\frac{2h}{K\phi}\right)-\beta\left(\frac{-a(k\phi-h)}{k\beta\phi}\right) & 0 & 0 & 0 & -\beta\frac{h}{\phi} \\ 0 & -(\sigma+\delta) & \beta\frac{h}{\phi} & 0 & 0 \\ 0 & \sigma & -j\left(\frac{-a(k\phi-h)}{k\beta\phi}\right)-\delta-e & 0 & 0 \\ 0 & \delta & \delta & v-f & 0 \\ \left(\frac{-a(k\phi-h)}{k\beta}\right) & 0 & 0 & 0 & 0 \end{bmatrix}$$

The eigen Values are $\lambda_1 = a\left(1-\frac{2h}{K\phi}\right)-\beta\left(\frac{-a(k\phi-h)}{k\beta\phi}\right), \lambda_2 = -(\sigma+\delta), \lambda_3 = -j\left(\frac{-a(k\phi-h)}{k\beta\phi}\right)-\delta-e, \lambda_4 = v-f, \lambda_5 = 0$

Hence the equilibrium point(1) is locally stable if $\lambda_1 = a\left(1-\frac{2h}{K\phi}\right)-\beta\left(\frac{-a(k\phi-h)}{k\beta\phi}\right) > 0, \lambda_2 = -(\sigma+\delta) < 0, \lambda_3 = -j\left(\frac{-a(k\phi-h)}{k\beta\phi}\right)-\delta-e > 0, \lambda_4 = v-f > 0, \lambda_5 = 0.$

Theorem 8

Given the linearized system of equation (1) is exposed prey, and treatment-free equilibrium point E4{S=K, E=0, N=$\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}$, T=0, P= ($\frac{-a(k\phi-h)}{k\beta\phi}$) } is locally asymptotically stable.

Proof

The Jacobian matrix is

$$J_3=\begin{bmatrix} m_{11} & 0 & \frac{cK}{\left(1+\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)^2} & 0 & -\beta K \\ \beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) & m_{22} & \beta K & 0 & 0 \\ \frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)} & \sigma & m_{33} & 0 & -j\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) \\ 0 & \delta & \delta & m_{44} & 0 \\ \left(\frac{-a(k\phi-h)}{k\beta}\right) & 0 & \psi(\frac{-a(k\phi-h)}{k\beta\phi}) & 0 & m_{55} \end{bmatrix}$$

Were

$m_{11}=-a-\frac{\left(C\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{\left(1+\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}-\beta\left(\frac{-a(k\phi-h)}{k\beta\phi}\right)-\beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right),\ m_{22}=-(\sigma+\delta)$

$m_{33}=\frac{cK}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}+\frac{cK}{\left(1+\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)^2}-j\left(\frac{-a(k\phi-h)}{k\beta\phi}\right)-\delta-e,\ m_{44}=v-f$

$m_{55}=\psi\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)+K\phi-h.$

The eigen values are

$$\lambda_1=-a-\frac{\left(C\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{\left(1+\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}-\beta\left(\frac{-a(k\phi-h)}{k\beta\phi}\right)-\beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)<0,\lambda_2=-(\sigma+\delta)<0,\lambda_3$$

$$=\frac{cK}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}+\frac{cK}{\left(1+\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)^2}-j\left(\frac{-a(k\phi-h)}{k\beta\phi}\right)-\delta-e<0,\lambda_4=v-f<0,$$

$\lambda_5=\psi\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)+K\phi-h<0$

Hence the equilibrium point (1) is locally asymptotically stable if
$\lambda_1<0,\lambda_2<0$ *with the condition* λ_3,λ_4 *and* λ_5 *have negative real parts.*

Theorem 9

Given the linearized system of equation (1) is exposed prey, infected prey, treatment and predator-free equilibrium point E5{S=$\frac{h}{\phi},E=\frac{h}{\phi}(\frac{-a(k\phi-h)}{\phi(ck-\beta k)})$, N=$\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)},T=0,P=0$}
is locally asymptotically stable.

Proof

The Jacobian matrix is

$$J_5=\begin{bmatrix} m_{11} & 0 & \frac{c\frac{h}{\phi}}{\left(1+\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)^2} & 0 & -\beta\frac{h}{\phi} \\ \beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) & m_{22} & \beta\frac{h}{\phi} & 0 & 0 \\ \frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)} & \sigma & m_{33} & 0 & -j\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) \\ 0 & \delta & \delta & m_{44} & 0 \\ 0 & 0 & 0 & 0 & m_{55} \end{bmatrix}$$

Were,

$m_{11} = a\left(1-\frac{2h}{\phi}\right)-\left(\frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right)-\beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)$

$m_{22} = -(\sigma+\delta)$

$m_{33} = \left(\frac{c\frac{h}{\phi}}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right)-\left(\frac{c\frac{h}{\phi}}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)^2}\right)-\delta-e$

$m_{44} = v-f$

$m_{55} = \psi\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)$

The eigenvalues are

$\lambda_1 = a\left(1-\frac{2h}{\phi}\right)-\left(\frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right)-\beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)<0, \lambda_2 = -(\sigma+\delta)<0, \lambda_3$

$= \left(\frac{c\frac{h}{\phi}}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right)-\left(\frac{c\frac{h}{\phi}}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)^2}\right)-\delta-e<0, \lambda_4 = v-f<0,$

$\lambda_5 = \psi\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)<0$

Hence the equilibrium point (1) is locally asymptotically stable if
$\lambda_1<0, \lambda_2<0$ *with the condition* λ_3, λ_4 *and* λ_5 *have negative real parts.*

Theorem 10

Given the linearized system of equation(1) is exposed prey, infected prey, treatment- free equilibrium point E6{S=0,E=$\frac{h}{\phi}$($\frac{-a(k\phi-h)}{\phi(ck-\beta k)}$, $N=\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}$, $T=\delta\frac{(\frac{2h}{\phi}(\frac{-a(k\phi-h)}{\beta(ck-\beta k)}}{v-f}$,P=0} is locally asymptotically stable.

Proof

The Jacobian matrix is

$$J_6=\begin{bmatrix} m_{11} & 0 & 0 & 0 & 0 \\ \beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) & m_{22} & 0 & 0 & 0 \\ \frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)} & \sigma & m_{33} & 0 & -j\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) \\ 0 & \delta & \delta & m_{44} & 0 \\ 0 & 0 & 0 & 0 & m_{55} \end{bmatrix}$$

Where,

$m_{11} = a-\left(\frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right)-\beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)$

$m_{22} = -(\sigma+\delta)$

$m_{33} = -\delta-e$

$m_{44} = v-f$

$m_{55} = \psi\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)$-h

The eigenvalues

$\lambda_1 = a - \left(\frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right) - \beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) < 0, \lambda_2 = -(\sigma+\delta) < 0, \lambda_3 = -\delta - e < 0, \lambda_4 = v - f < 0,$
$\lambda_5 = \psi\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) - h<0$

Hence the equilibrium point (1) is locally asymptotically stable if
$\lambda_1 < 0, \lambda_2 < 0$ *with the condition* λ_3, λ_4 *and* λ_5 *have negative real parts.*

Theorem 11

Given the linearized system of equation(1) is predator-free equilibrium point E7{ S=$\frac{h}{\phi}$, $E = \frac{2h}{\phi^2}\left(\frac{-a(k\phi-h)}{\beta(ck-\beta k)}\right)$,N=$\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}$,T=$\delta\frac{\left(\frac{2h}{\phi}\left(\frac{-a(k\phi-h)}{\beta(ck-\beta k)}\right)\right)}{v-f}, p = 0$} is locally asymptotically stable

Proof

The Jacobian matrix is

$$J_7=\begin{bmatrix} m_{11} & 0 & \frac{c\frac{h}{\phi}}{\left(1+\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)^2} & 0 & -\beta\frac{h}{\phi} \\ \beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) & m_{22} & \beta\frac{h}{\phi} & 0 & 0 \\ \frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)} & \sigma & m_{33} & 0 & -j\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) \\ 0 & \delta & \delta & m_{44} & 0 \\ 0 & 0 & 0 & 0 & m_{55} \end{bmatrix}$$

Were,

$m_{11} = a\left(1-\frac{2h}{\phi}\right) - \left(\frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right) - \beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)$

$m_{22} = -(\sigma+\delta)$

$m_{33} = \left(\frac{c\frac{h}{\phi}}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right) - \left(\frac{c\frac{h}{\phi}}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)^2}\right) - \delta - e$

$m_{44} = v - f$

$m_{55} = \psi\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)$

The eigenvalue is

$\lambda_1 = a\left(1-\frac{2h}{\phi}\right) - \left(\frac{c\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right) - \beta\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right) < 0, \lambda_2 = -(\sigma+\delta) < 0, \lambda_3$

$= \left(\frac{c\frac{h}{\phi}}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)}\right) - \left(\frac{c\frac{h}{\phi}}{1+\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)^2}\right) - \delta - e < 0, \lambda_4 = v - f < 0,$

$\lambda_5 = \psi\left(\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}\right)<0$

Hence the equilibrium point (1) is locally asymptotically stable if
$\lambda_1 < 0, \lambda_2 < 0$ *with the condition* λ_3, λ_4 *and* λ_5 *have negative real parts.*

Theorem 12

Given the linearized system of equation (1) is the interior equilibrium point E8{S=S*, E=E*,N=N*,T=T*,P=P*} is locally asymptotically stable

Proof:

$$J_8=\begin{bmatrix} a\left(1-\frac{2s*}{k}\right)-\frac{cN*}{1+N*}-\beta P*-\beta N* & 0 & \frac{-cs*}{(1+N*)^2} & 0 & -\beta S* \\ \beta N* & -(\sigma+\delta) & \beta S* & 0 & 0 \\ \frac{cN*}{1+N}* & \sigma & \frac{CS*}{1+N*}-\frac{CN*S*}{(1+N*)^2}-jp*-\delta-e & 0 & -jN* \\ 0 & \delta & \delta & v-f & 0 \\ P*\emptyset & 0 & P*\psi & 0 & \Psi N*+\Phi S*-h \end{bmatrix}$$

The eigen value is

$$\lambda_1 = a\left(1-\frac{2s*}{k}\right)-\frac{cN*}{1+N*}-\beta P*-\beta N*<0, \lambda_2=-(\sigma+\delta)<0, \lambda_3=\frac{CS*}{1+N*}-\frac{CN*S*}{(1+N*)^2}-jp*-\delta-e<0, \lambda_4 = v-f<0,$$

$$\lambda_5=\Psi N*+\Phi S*-h<0$$

The characteristic equation is $\wedge_1(\lambda)=\lambda^5+B_4\lambda^4+B_3\lambda^3+B_2\lambda^2+B_1\lambda+B_0$

Were

$B_4=4I-(m_{11}+m_{22}+m_{22}+m_{44}+m_{55})$

$B_3=-6I^2(m_{11}+m_{22}+m_{22}+m_{44}+m_{55})3I+m_{22}m_{33}+m_{22}m_{44}+m_{33}m_{44}-m_{11}m_{22}+m_{11}m_{33}+m_{11}m_{44}-m_{12}m_{22}+S*P*\beta\phi)$,

$B_2=4I^3-(m_{11}+m_{22}+m_{22}+m_{44}+m_{55})3I^2+(2m_{22}m_{33}+2m_{22}m_{44}+2m_{33}m_{44}-2m_{11}m_{22}+2m_{11}m_{33}+2m_{11}m_{44}-2m_{12}m_{22}+2S*P*\beta\phi+m_{11}N^*P^*j\psi)I-(m_{22}m_{33}m_{44}+m_{22}m_{33}m_{11}+m_{22}m_{44}m_{11}-m_{33}m_{44}m_{11}+m_{12}m_{21}m_{33}+m_{12}m_{21}m_{44}+m_{11}N^*P^*j\psi+m_{12}N^*P^*j\phi+m_{21}S^*P^*\beta\psi-m_{22}S^*P^*\beta\phi-m_{33}S^*P^*\beta\phi$

$$\begin{aligned} B_0 = I^4-((&m_{11}+m_{22}+m_{22}+m_{44}+m_{55})I^3 \\ &+(m_{11}m_{22}+m_{11}m_{33}+m_{11}m_{44}+m_{22}m_{33}+m_{33}m_{44}+N^*P^*j\psi-m_{12}m_{21})I^2 \\ &-(m_{11}m_{22}m_{33}+m_{11}m_{22}m_{44}+m_{11}m_{33}m_{44}+m_{22}m_{33}m_{44}+m_{11}N^*P^*j\psi \\ &+m_{33\,N^*P^*j\psi-m_{33}m_{12}m_{21}-m_{44}m_{12}}m_{21}-m_{12}N^*P^*j\phi)I+m_{11}m_{22}m_{33}m_{44}+m_{11}m_{33}n^*P^*j\psi \\ &-m_{33}m_{44}m_{12}m_{21}-m_{12}m_{33}N^*P^*j\phi) \end{aligned}$$

By Routh Hurwitz criterion, all the eigen values of J_7 have negative real parts.

If $B_3>0$

$B_3B_2>B_1$

$B_3B_2B_1>B_1^2+B_3^2B_0$

Therefore, the given system of the non linear differential equation(1) is locally asymptotically stable around the non-negative equilibrium point {S=S*,E=E*,N=N*,T=T*,P=P*} if the conditions mentioned in the theorem holds.

Global stability analysis

We perform a global analysis of the system (1) around the non-negative equilibrium point G (S*,E^*,N*, T*, P*) of the coexistence. The following theorem of Lyapunov function Δ is considered.

Theorem 13

Let $\Delta=\frac{1}{2}(s-S^*)^2+\frac{1}{2}\varsigma_1(E-E^*)^2+\frac{1}{2}\varsigma_2(N-N^*)^2+\frac{1}{2}\varsigma_3(T-T^*)^2+\frac{1}{2}\varsigma_4(P-P^*)^2$

Where $\varsigma_1,\varsigma_2,\varsigma_3,\varsigma_4>0$ *are to be carefully chosen such that* $\Delta(G)=0$ *then* G(S*,E^*,N*,T*,P*) and $\Delta=(S,E,N,T,P)>0\ S,E,N,T,P|G.$

If the time derivative of Δ *is* $\frac{d\Delta}{dt}<0,\forall,S,E,N,T,P\in\Gamma^+$*tends to* $G*$ *of the system is Lyapunov stable and* $\frac{d\Delta}{dt}<0\ S,E,N,T,P\epsilon\Gamma^+$ near implies thar G is globally stable.

Proof

$\frac{d\Delta}{dt}$ =(s-S^*)$\frac{ds}{dt}+\varsigma_1(E-E^*)\frac{dE}{dt}+\varsigma_2(N-N^*)\frac{dN}{dt}+\varsigma_3(T-T^*)\frac{dT}{dt}+\varsigma_4(P-P^*)\frac{dP}{dt}$

The above equation becomes

$\frac{d\Delta}{dt}$ =(s-S^*)$\{a\left(1-\frac{2s}{k}\right)-\frac{cN}{1+N}-\beta P-\beta N\}$(s-$S^*$)$+\varsigma_1(E-E^*)\{\beta SN\}(E-E^*)+\varsigma_2(N-N^*)\{\frac{CS}{1+N}-\frac{CNS}{(1+N)^2}-jp-\delta-e\}(N-N^*)+\varsigma_3(T-T^*)\left\{v-f+\frac{\delta N}{T}\right\}(T-T^*)+\varsigma_4(P-P^*)\{\psi N+\phi S-h\}(P-P^*)$

By rearranging we obtain

$\frac{d\Delta}{dt}$ =(s-S^*)$\{a\left(1-\frac{2s}{k}\right)-\frac{cN}{1+N}-\beta P-\beta N\}+\varsigma_1(E-E^*)\{\beta SN\}+\varsigma_2(N-N^*)\{\frac{CS}{1+N}-\frac{CNS}{(1+N)^2}-jp-\delta-e\}+\varsigma_3(T-T^*)\left\{v-f+\frac{\delta N}{T}\right\}+\varsigma_4(P-P^*)\{\psi N+\phi S-h\}$

Thus, it is possible to set $\varsigma_1,\varsigma_2,\varsigma_3,\varsigma_4>0$ such that del> 0 is an endemic positive equilibrium point is globally stable. Therefore, it is pointed out the parameters play a key role in controlling the stability aspects of the system.

HOPF BIFURCATION

In this section, we examined the Hopf bifurcation around the interior equilibrium point E4. The parameter a is a basic representation of the growth rate of prey S and identified as a bifurcation parameter. Hopf bifurcation occurs when Jacobian matrix E4 has a pair of merely imaginary eigenvalues and the other eigenvalues have non-positive real parts and Re$[\frac{d\lambda}{da}]|_{a-a_0\neq 0}$.Presume that the characteristic equation at the interior equilibrium point E4 is as follows:

$\lambda^5+B_4\lambda^4+B_3\lambda^3+B_2\lambda^2+B_1\lambda+B_0$ …… (3)

For merely imaginary eigenvalues, the coefficients of characteristic polynomial (3) satisfy the following condition:

$B_3B_2B_1>B_3^2B_0+B_1^2$

Suppose $\pm i\omega$ *is a pair merely imaginary eigenvalues corresponding to* a_0. We solve from the characteristic equation (3) tends to a

$$[4\lambda^3+3\lambda^2B_3+2B_2\lambda+B_1]\frac{d\lambda}{da}+\left(\lambda^3\frac{dB_3}{da}+\lambda^2\frac{dB_2}{da}+\lambda\frac{dB_1}{da}+\frac{dB_0}{da}\right)=0$$

Hence

$\frac{d\lambda}{da}=\frac{\left(\lambda^3\frac{dB_3}{da}+\lambda^2\frac{dB_2}{da}+\lambda\frac{dB_1}{da}+\frac{dB_0}{da}\right)}{[4\lambda^3+3\lambda^2B_3+2B_2\lambda+B_1]}$ ……(4)

Substitute iω

$$\frac{d\lambda}{da}|_{i\omega}=-\left(\frac{-i\omega^3\left(\lambda^3\frac{dB_3}{da}+\lambda^2\frac{dB_2}{da}+\lambda\frac{dB_1}{da}+\frac{dB_0}{da}\right)}{-4i\omega^3-3i\omega^2B_3-2B_2i\omega+B_1]}\right)$$

Hence

$$\mathrm{Re}([\frac{d\lambda}{da}]|_{i\omega})=-\left(\frac{|B_1-3\omega^2B_3|\left[\frac{dB_0}{da}\omega^2\frac{dB_2}{da}\right]+[2B_2\omega-4\omega^3]\left[\omega^3\frac{dB_3}{da}-\omega\frac{dB_1}{da}\right]}{|B_1-3\omega^2B_3||2B_2\omega-4\omega^3|}\right)$$

Theorem 14:

Consider the bifurcation parameter as 'a' then system (1) sustains a Hopf bifurcation provided.

$$(|B_1-3\omega^2B_3|\left[\frac{dB_0}{da}\omega^2\frac{dB_2}{da}\right]+[2B_2\omega-4\omega^3]\left[\omega^3\frac{dB_3}{da}-\omega\frac{dB_1}{da}\right])\neq 0$$

NUMERICAL RESULTS

The system of the nonlinear differential equation (1) for the numerical solution. In this section, we existing solutions under stability analysis.

1. First, we take the parameter of the system as (β,k,ψ,j,υ,δ,c,f,φ,e,h,a) =
2. (1.05,1.25,0.23,0.545,0.005,1.236,1.450,0.212,2.024,2.05,2.11,1.07) at the population (S, E, N,T,P) = (10.25,10.36,10.46,10.06,10.13) The given system is asymptotically stable (Fig. 1).

3. If we take the parameter of the system as mentioned above in point (1). Then the initial condition satisfies (S,E,N,T,P)=(10.2,0,0,0,0) is the susceptible prey population (Fig 2).
4. If we take the parameter of the system as mentioned above in point (1). Then the initial condition satisfies (S,E,N,T,P)=(0,10.2,0,0,0) is the Exposed prey population (Fig 3).
5. If we take the parameter of the system as mentioned above in point (1). Then the initial condition satisfies (S,E,N,T,P)=(0,0,10.2,0,0) is the Infected prey population (Fig 4).
6. If we take the parameter of the system as mentioned above in point (1). Then the initial condition satisfies (S, E, N, T, P) = (1.2,0,0,0,1),(1.2,0,0,1.2)the contact rate of susceptible prey and predator population (Fig 5).
7. If we take the parameter of the system as mentioned above in point (1). Then the initial condition satisfies (S, E, N, T, P) = (0,1.2,0,0,1),(0,1.2,0,0,1.2) the contact rate of Exposed prey and predator population (Fig 6).
8. If we take the parameter of the system as mentioned above in point (1). Then the initial condition satisfies (S, E, N, T, P) = (0,0,1.2,0,1),(0,0,1.2,0,1.2) the contact rate of Infected prey and predator population (Fig 7).
9. If we take the parameter of the system as mentioned above in point (1). Then the initial condition satisfies (S, E, N, T, P) = (1.2,0.1, 1,1,1),(1.3,0.6,0.7,0.2,0.1), (1.2,0.6,1.7,0.1,0.1), (1.2,1.46,1.7,1.2,0.1) the contact rate of prey, Treatment and predator interaction (Fig 8).

DISCUSSION AND CONCLUSION

The Susceptible-Exposed-Infected-Treatment (SEIT) model provides a comprehensive framework for understanding the dynamics of disease transmission within a prey population, incorporating the impact of treatment on disease recovery. Treatment plays a crucial role in reducing the number of infected individuals within the prey population. The inclusion of a treatment class significantly alters the disease dynamics, leading to a decrease in the overall infection prevalence. This demonstrates the importance of medical intervention in managing wildlife diseases. The basic reproduction number was derived and analyzed to understand the conditions necessary for disease persistence or eradication. Our results indicate that reducing below one through treatment efforts can lead to the eventual eradication of the disease. The stability analysis of the model's equilibrium points shows that effective treatment can lead to a stable disease-free equilibrium. In the absence of sufficient treatment, the system may reach an endemic equilibrium where the disease persists at a constant level. The interaction between disease dynamics and prey-predator relationships is complex. Disease-induced mortality in the prey population can indirectly affect predator dynamics. Effective treatment not only benefits the prey population by reducing disease burden but also stabilizes the predator population by ensuring a steady prey supply. The findings underscore the importance of implementing treatment programs in wildlife populations to control disease outbreaks. This approach can prevent significant declines in prey populations, thereby maintaining ecological balance. Wildlife managers should consider incorporating regular health assessments and treatment interventions in their conservation strategies. SEIT model, highlighting the importance of treatment in managing disease dynamics and maintaining ecological stability.

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Table 1 Stability analysis of equilibrium points

Equilibrium point	Explanation	Stable/unstable
E1{S=0,E=0,N=0,T=0,P=0}	Trivial	Saddle point
E2{S=k,E=0,N=0,T=0,P=0}	Exposed prey, infected prey, treatment &predator	Stable
E3{S=$\frac{h}{\phi}, E=0, N=0, T=0, P=\frac{-a(k\phi-h)}{k\beta\phi}$}	Exposed prey, Infected prey& treatment-free	Stable
E4{S=K,E=0,N=$\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}, T=0, P=\frac{-a(k\phi-h)}{k\beta\phi}$}	Exposed prey & treatment-free	Stable
E5{ S=$\frac{h}{\phi}, E=\frac{h}{\phi}(\frac{-a(k\phi-h)}{\phi(ck-\beta k)})$,N=$\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}, T=0, P=0$}	Treatment and predator-free	Stable
E6{S=0,E=$\frac{h}{\phi}(\frac{-a(k\phi-h)}{\phi(ck-\beta k)}, N=\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}, T=\delta\frac{(\frac{2h}{\phi}(\frac{-a(k\phi-h)}{\beta(ck-\beta k)}}{v-f}$,P=0}	Susceptible prey and predator-free	Stable
E7{ S=$\frac{h}{\phi}, E=\frac{2h}{\phi^2}(\frac{-a(k\phi-h)}{\beta(ck-\beta k)})$,N=$\frac{-a(k\phi-h)}{\beta\phi(ck-\beta k)}$,T=$\delta\frac{(\frac{2h}{\phi}(\frac{-a(k\phi-h)}{\beta(ck-\beta k)}}{v-f}, p=0$}	Predator-free	stable
E8{S=S*,E=E*,N=N*,T=T*,P=P*}	Coexistence	

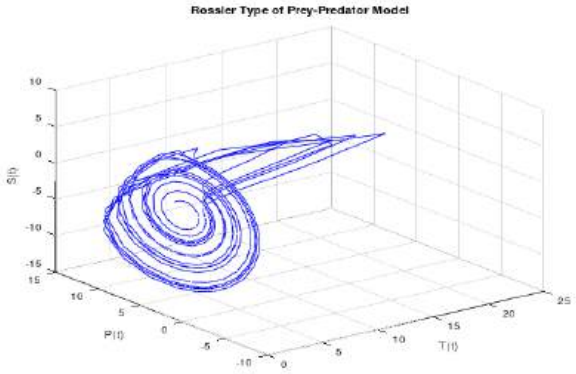


Figure 1: Rossler type of prey-predator is asymptotically stable

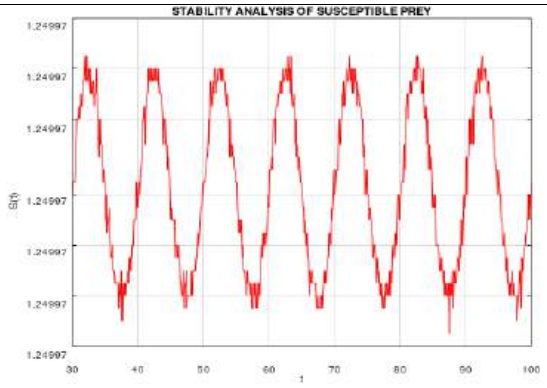


Figure 2:The stability analysis of susceptible prey population

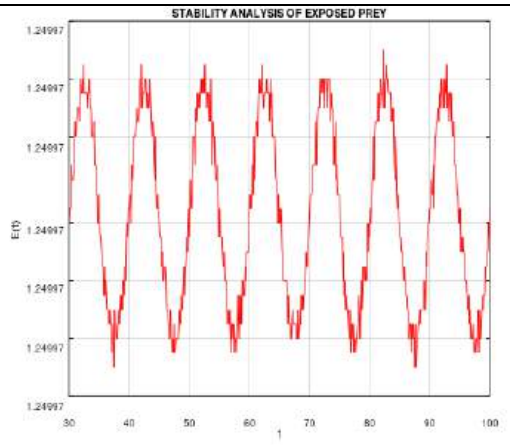


Figure 3:The stability analysis of Exposed prey population

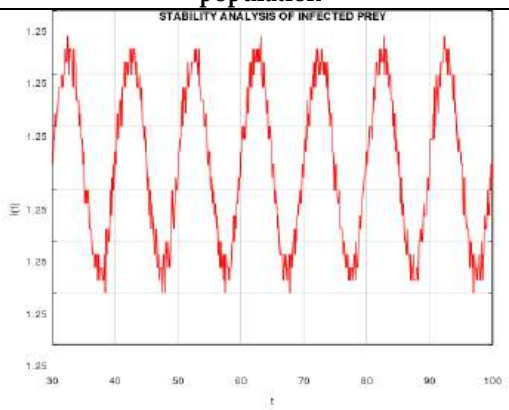


Figure 4: The stability analysis of Infected prey population

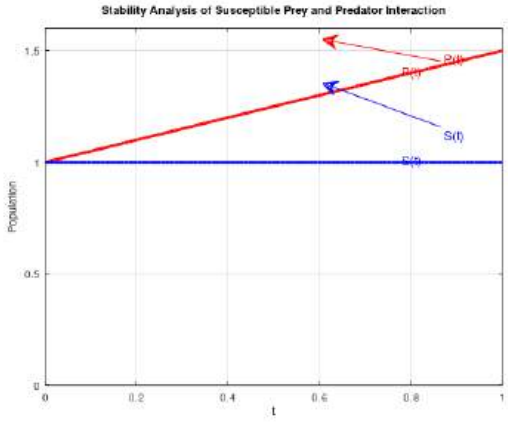


Figure 5: The stability analysis of susceptible prey and predator population

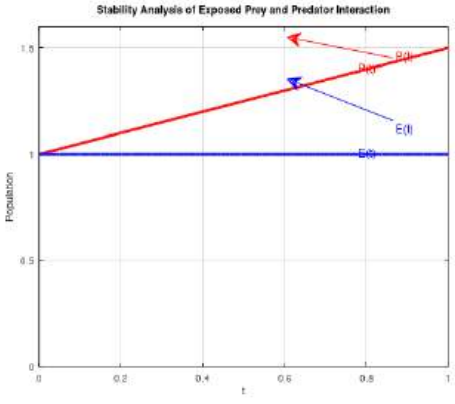


Figure 6: The stability analysis of Exposed prey and predator population

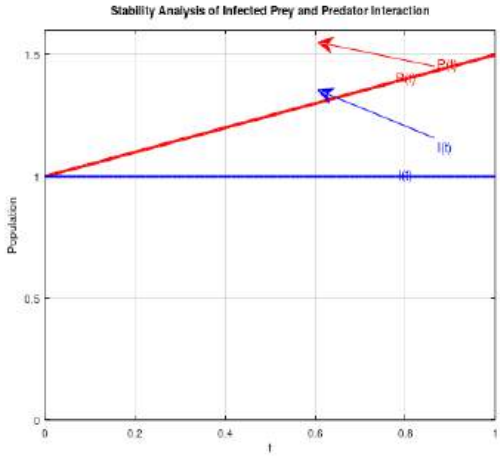


Figure 7: The stability analysis of Infected prey and predator population

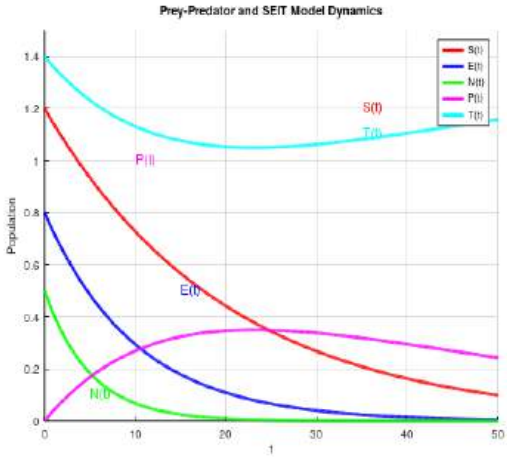


Figure 8: The stability analysis of susceptible-Exposed Infected prey, Treatment and predator Interaction

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RESEARCH ARTICLE

Formulation and Evaluation of Herbal Lip Balm using *Basella alba*

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ABSTRACT

Cosmetics have been in demand for incredibly long. Diurnal lip care cosmetics contain dangerous factors like heavy essences and preservatives, which makes them dangerous. Nowadays ladies are more serious about their beauty and for making face updates and seductive, lip care cosmetics and substantial powders are extensively used. Herbal lip attar gives attractiveness to lips by coloring and maintains its wimpy, promoting healthy lips. Lip redolence isn't gender-specific; men and women can use it. In the present day, the mature population uses Lip balm, numerous newer tones have also arrived in request to mileage products as per consumer demand. Most frequently, lip balm can get ingested; thus, it becomes obligatory for health controllers to authorize them cautiously. Lip balm can be used for coloring and moisturizing the lips. Herbal expression is a sign of safety, satisfaction, and surety as lower or no detriment to the druggies and so herbal Lip balm can be made without the colors being compromised. This lip balm is formulated according to scientific procedure and is estimated to be in standard conditions. *Basella Alba* fruits are high in nutritional value and are promising crops. The reddish-violet color of the fruit is due to the presence of betacyanin in them. Current cosmetic lip products are based on the use of toxic chemical ingredients with various adverse effects.

Keywords: Natural, Herbal, Colour, Ingredients, Lip balm, Formulation, Side effects, Safe.

INTRODUCTION

Lips, the visible body part at the mouth of humans and many animals, are soft and movable and serve as the opening for food intake and in the articulation of sound and speech. Coloring lips is practiced over the years since the ancient period. Some synthetic lip colorants, cheap and easy to make and obtain, can harm the lip skin. Also, lips do not contain any oil glands and therefore need hydration and protection in all seasons. In the present day, lip balm usage has increased and also the colour shades and other choices have been changed. More often, the applied lip balm is eaten away and ingested; therefore, it becomes mandatory for health regulators to approve them cautiously. Lip balms can be used for coloring and moisturizing the lips. Herbal, is a sign of safety, satisfaction, and surety of less or no harm to the users and so herbal lip balm can be made without the colors being compromised. *Basella Alba* fruits are high in nutritional value and are promising crops. The reddish- violet color of the fruit is due to the presence of betacyanin in them. Though the extracted color pigments are susceptible to light and air, their stability could be maintained by keeping them in low temperatures (≤14°C) and also devoid of light and air. These can then be a potent organic color pigment that can be used in cosmetic industries stating the stability conditions. Olive oil used for the formulation of this herbal pigmented lip balm is exploited for its blending properties with the waxes and imparting the lip balm to coat in a thin film. The beeswax could retain the moisture necessary to heal the dried chapped scaly lips and maintain their quality. The rose oil and almond essential oil were used to flavor the lip balm. Methylparaben was used to provide its soothing and preservative properties, including lip balm's antimicrobial and antifungal properties[1]**.**

Plant profile

Botanical name : *Basella alba*
Family : *Basellaceae*
Genus : *Basella*
Species : *Basella alba L*

MATERIAL AND METHOD

Basella Alba

The fruit was collected from the plant *Basella Alba*. The plant was authenticated by SIDDHA MEDICINAL PLANT GARDEN (Central Council for Research in Siddha)Ministry of Ayush, Govt. of India

FORMULATION

Weigh all of the ingredients in a porcelain dish. Melt the beeswax and cocoa butter in a water bath before placing porcelain dish 1 within. Melt the olive and almond oils in a water bath and place the porcelain dish 2 inside. Combine the contents of the ceramic dish. 2 can be put into porcelain dish 1 at 40℃ and continually mixed. Add the *Basella Alba* fruit extract to the mixture. It can be used as both a colorant and an antioxidant. Almond oil includes vitamin E, which promotes cell growth and smoothness. Rose essential oil is used for flavoring. To produce the desired texture, the mixture was transferred from the water bath to the ice bath, hardened, and homogenized with a mortar and pestle. Finally, include methylparaben as a preservative. The compositions listed below were created using the approach provided. Testing the temperature of the softening process.

EVALUATION

MELTING POINT

The drug-containing capillary was dipped in liquid paraffin using melting point equipment with magnetic stirring. Melting was assessed visually and the melting point was reported[24].

SPREADABILITY

The spreadability test estimates the force required to apply lip balm. The parallel-plate method is commonly used to determine and quantify the spreadability of semisolid preparations. This procedure is simple and cost-effective. The steps taken in this evaluation are To evaluate spreadability, a sample was crushed between two glass slides and weight was added to the pan. The time it took for the upper glass slide to move across the lower slide was recorded.
G - Good: Lip balm is consistent, without fragmentation, and applies perfectly without deformation.
I - Intermediate: uniform; leaves few fragments; appropriate application; little deformation of the lip balm.
B - Bad: not uniform; leaves many fragments; difficult or inappropriate application, intense deformation of the lip balm[25][26].

pH

The pH of the lip balm was determined to investigate the possibility of any side effects. As an acidic or alkaline pH may irritate lips, it was determined to keep the pH of the formulation as close to neutral as possible. The pH measurement was studied by dissolving 1gm of sample into 100ml of water. The pH measurement was done by using a pH meter[11].

PERFUME STABILITY

After 30 days, the developed herbal lip balm was tested for aroma under normal storage circumstances of cool temperature [15].

SKIN IRRITATION TEST

The procedure involves applying a small amount of prepared substance to the dorsal surface of the left-hand skin for 10 minutes in volunteer applicants. The skin is inspected for signs of inflammation, rash, erythema, and edema.

SOLUBILITY

To determine the solubility of prepared herbal lip balm, it was dissolved in organic solvents such as ethanol and chloroform.

AGING STABILITY

The stability of the product was evaluated by storing at 400C for 1 hr. Then various parameters such as bleeding, crystallization of the surface, and ease of application were observed.[13]

RESULT

These results suggest that the Herbal Lipbalm formulation using Basella alba has the potential to provide long-lasting moisturizing and protection to the lips. (Table 1)

DISCUSSION

The present work is undertaken to formulate and evaluate herbal lip balm with the hope of minimizing the side effects of chemical colors. Plant pigments provide antioxidant properties along with the coloring property used in this herbal formulation, we have used both the properties of the Spinacia oleracea plant, and as the results obtained the formulated herbal lip balm has antioxidant properties. The antioxidant activity can be enhanced under stringent laboratory conditions as this formulation was done at the college pilot scale level. We may replace the chemical-based synthetic color and antioxidant with herbal-based preparations. The formulated herbal lip balm had efficient melting and molding capacity, successfully evaluated with various parameters. The color of the lip balm was pale pink. The pH of lip balm was found to be 5.42. Which was in the range of pH of the skin therefore it signified that it is compatible with the skin (lip) which was further confirmed by a skin irritation test done in a survey on voluntarily participated candidates. The melting point of lip balm was between 72℃ to 76℃. It confirmed that the formulated lip

balm might be stable at room temperature or even at comparatively high temperatures but below 72℃ and therefore melting temperature was acceptable. The surface anomalies were also not found. The force of application or spreadability was found even but further homogenization can be done for better results. The aging stability was also found smooth but for a shorter time and then the color further faded because stabilizer was not added. A solubility test was also performed and found soluble in chloroform. The skin irritation test showed no such sign of itching, irritation, redness, and inflammation. The overall work revealed that the formulated herbal lip balm was safe and compatible to the skin compared to previous studies. Further studies on the herbal lip balm can be done to enhance antioxidant properties and color stability at room temperature.[15]

CONCLUSION

The present work carried out the formulation and evaluation of herbal lip balms was aimed at formulating a lip balm using herbal ingredients with an idea to minimize the side effects that occur by using available chemical-based synthetic lip balms. The prepared formulation of lip balm was evaluated and it was found that the herbal lip balm, was based on consistency. Therefore, from the present investigation it was concluded that this formulated herbal lip balm provides a better option for anyone applying lip balm with minimal side effects and also has antioxidant properties which help for better health benefits. Further studies can be carried out based on the present study of formulation and evaluation of herbal lip balm using *Basella Alba* extract as follows:[13] To enhance the even texture and smoothness one can go for a better homogenizing method. To get the various shades in formulated herbal lip balm the amount of pigment can increase and decrease accordingly.

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Table :1 Evaluation of Herbal Lipbalm using *Basella Alba*

S.NO	INGREDIENTS	QUALITY	ROLES
1	Bees Wax	4 gm	Thickening Agent
2	Cocoa Butter	4 gm	Glossing Agent
3	Olive Oil	7 ml	Moisturizing Agent
4	Almond Oil	1 ml	Antioxidant
5	Spinacia Extract	3 ml	Colouring Agent
6	Rose Oil	3 drops	Flavouring Agent
7	Methyl Paraben	2 drops	Preservatives

Table:2 Methods and Materials for Formulation of Herbal Lipbalm

Water bath	Glass rod
Bunsen burner	China dish
Spatula	Filter paper
Weighing balance	Beaker
Tripod stand	Glass slide

Table:3 Result for the Formulation and Evaluation of Herbal Lipbalm using *Basella Alba*

S.NO	EVALUATION PARAMETER	INFERENCE
1	Color	Pink
2	Melting Point	74℃
3	Spread ability(Qualitative)	Even
4	Skin Irritation Test	No
5	Solubility	Choloroform
6	pH	5.42
7	Ageing Stability	Smooth& Pale Pink
8	Perfume Stability	+++

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RESEARCH ARTICLE

Inverse Semitotal Domination Number of Some Graphs Derived from Paths and Cycles

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ABSTRACT

To determine the inverse semitotal domination number of some graphs derived from paths and cycles. Consider the problem of selecting two disjoint sets D_1 and D_2 of transmitting stations in which the distance between any two transmitting stations is 1 or 2, so that every station not belonging to D_1 has a link with at least one station in $D_1$and similarly, for D_2, where $|D_1|$ and $|D_1 \cup D_2|$ are minimum among all pairs of disjoint sets of transmitting stations. In this paper we have determined the inverse semitotal domination number for snake related graphs, friendship graphs, comb graphs, broom graphs, firecracker graphs and twig graphs. The relationship with other graph theoretical parameters are also discussed. This study fills the research gap by examining the correlation between inverse domination number and semitotal domination number. Inverse semitotal dominating set provides a subordinate set for the respective semitotal dominating set.

Keywords: graphs, domination number, inverse semitotal domination number, graph theoretical parameters

INTRODUCTION

The graphs considered here are simple, finite, nontrivial, undirected and without isolated vertices. The graph $G = (V, E)$ considered here have $n = |V|$ vertices and $m = |E|$ edges. A set D of vertices in a graph G is a dominating set if every vertex not in D is adjacent to at least one vertex in D. The domination number $\gamma(G)$ of G is the order of a smallest dominating set in G.Any dominating set with $\gamma(G)$ vertices is called a $\gamma(G)$ – set of G.The concept of inverse domination was introduced by V.R. Kulli and S.C. Sigarkanti[1]. Let D be a minimum dominating set of G. If $V - D$ contains a dominating set say D' then D' is called an inverse dominating set with respect to D. The inverse domination number $\gamma'(G)$ of G is the order of a smallest inverse dominating set in G. Any inverse dominating set with $\gamma'(G)$ vertices is called a $\gamma'(G)$ – set of G.The concept of semitotal domination was introduced by Wayne Goddard, Michael A. Henning and Charles A. McPillan[2]. A set D of vertices in a graph G with no isolated vertices to be a semitotal dominating set, abbreviated semi-TD-set, of G if it is a dominating set of G and every vertex in D is within distance 2 of another vertex of D. The semitotal domination number, denoted by $\gamma_{t2}(G)$, is the minimum cardinality of a semi-TD-set. Any semitotal dominating set with $\gamma_{t2}(G)$ vertices is called a $\gamma_{t2}(G)$ – set of G. Motivated by these two domination parameters inverse semitotal domination number was devised in the previous paper[3]. The devised set can be find in the complement of the minimum semitotal dominating set and it act as a subordinate set. In this paper we determine the inverse semitotal domination number of some graphs derived from paths and cycles and its relationship with other graph theoretical parameters are also discussed.

Exact values for some standard graphs[3]

i) For any path P_n of order $n \geq 4$, $\gamma'_{t2}(P_n) = \begin{cases} 2, & n = 4 \\ \left\lceil \frac{2(n+1)}{5} \right\rceil, & n > 4 \end{cases}$

ii) For any cycle C_n of order $n \geq 4$, $\gamma'_{t2}(C_n) = \left\lceil \frac{2n}{5} \right\rceil$

iii) For the complete graph K_n of order $n \geq 4$, $\gamma'_{t2}(K_n) = 2$

iv) For the complete bipartite graph $K_{m,n}$ where $m, n \geq 2$, $\gamma'_{t2}(K_{m,n}) = 2$

v) For the star graph $k_{1,n}$ where $n \geq 3$, $\gamma'_{t2}(K_{1,n})$ – set does not exist.

METHODS

Definition: Let D be a minimum semitotal dominating set of G. If $V - D$ contains a semitotal dominating set say D' then D' is called an inverse semitotal dominating set with respect to D. The minimum cardinality of an inverse semitotal dominating set of G is called the *inverse semitotal domination number* and is denoted by $\gamma'_{t2}(G)$. Any inverse semitotal dominating set with $\gamma'_{t2}(G)$ vertices is called a $\gamma'_{t2}(G)$ – set of G.

Example: For the graph G_1 in Figure 1,$D' = \{v_3, v_7\}$ forms a $\gamma'_{t2}(G_1)$– set. Hence $\gamma'_{t2}(G_1) = 2$.

RESULTS AND DISCUSSION

Inverse semitotal domination number of some graphs derived from paths and cycles:

Here, we determine the inverse semitotal domination number of triangular snake graphs, alternate triangular snake graphs, friendship graphs, comb graphs, broom graphs, firecracker graphs and twig graphs.

Theorem: The inverse semitotal domination number for any triangular snake graph, where $n \geq 3$ is $\gamma'_{t2}(T_n) = \left\lceil \frac{n}{2} \right\rceil$.

Proof

Let $G = T_n$ be the triangular snake graph obtained from a path $\{v_i : 1 \leq i \leq n\}$ by joining v_i and v_{i+1} to a new vertex u_j for $1 \leq j \leq n-1$. Let $V = \{v_i, u_j : 1 \leq i \leq n \text{ and } 1 \leq j \leq n-1\}$ be a vertex set of the triangular snake graph. For $n = 3$, clearly $\gamma'_{t2}(T_n) = \left\lceil \frac{n}{2} \right\rceil$.

Case (i) Suppose $n \geq 5$ is a positive odd integer.
It is clear that a $\gamma_{t2}(G)$ – set is $\left\{v_{2i}: 1 \leq i \leq \frac{n-1}{2}\right\}$. The corresponding $\gamma_{t2}^{'}(G)$ – set is contained in the complement of the $\gamma_{t2}(G)$ – set. Let $D^{'} = \left\{v_{2i-1}: 1 \leq i \leq \frac{n+1}{2}\right\}$ be a semitotal dominating set and no other semitotal dominating set in the complement of the $\gamma_{t2}(G)$ – set has cardinality less than the cardinality of $D^{'}$ which dominates the whole vertex set of T_n. Thus$D^{'}$ is the$\gamma_{t2}^{'}(G)$ – set. Therefore, $\gamma_{t2}^{'}(T_n) = \left\lceil\frac{n}{2}\right\rceil$.

Case (ii) Suppose $n \geq 4$ is a positive even integer.
It is clear that a $\gamma_{t2}(G)$ – set is $\left\{v_{2i}: 1 \leq i \leq \frac{n}{2}\right\}$. The corresponding $\gamma_{t2}^{'}(G)$ – set is contained in the complement of the $\gamma_{t2}(G)$ – set. Let $D^{'} = \left\{v_{2i-1}: 1 \leq i \leq \frac{n}{2}\right\}$ be a semitotal dominating set and no other semitotal dominating set in the complement of the $\gamma_{t2}(G)$ – set has cardinality less than the cardinality of $D^{'}$ which dominates the whole vertex set of T_n. Thus$D^{'}$ is $\gamma_{t2}^{'}(G)$ – set. Therefore, $\gamma_{t2}^{'}(T_n) = \left\lceil\frac{n}{2}\right\rceil$.

Theorem
The inverse semitotal domination number for any alternate triangular snake graphs, where,$n \geq 3$, for which the triangle starts from the first vertex is $\gamma_{t2}^{'}(A(T_n)) = \left\lceil\frac{n}{2}\right\rceil$.

Proof
Let $G = A(T_n)$. Let $V = \left\{v_i, u_j: 1 \leq i \leq n \text{ and } 1 \leq j \leq \left\lceil\frac{n}{2}\right\rceil\right\}$ be the vertex set of the alternate triangular snake graph. The path vertices are labelled as $\{v_i: 1 \leq i \leq n\}$ and the new vertices adjacent to the edges of the path are labelled as $\left\{u_j: 1 \leq j \leq \left\lceil\frac{n}{2}\right\rceil\right\}$ where u_1 is adjacent to v_1 and v_2, u_2 is adjacent to v_3 and v_4, and so on. For $n = 3$, clearly $\gamma_{t2}^{'}(A(T_n)) = \left\lceil\frac{n}{2}\right\rceil$.

Case (i) Suppose $n \geq 5$ is a positive odd integer.
It is clear that a $\gamma_{t2}(G)$ – set is $\left\{v_{2i}: 1 \leq i \leq \frac{n-1}{2}\right\}$. The corresponding $\gamma_{t2}^{'}(G)$ – set is contained in the complement of the $\gamma_{t2}(G)$ – set. Let $D^{'} = \left\{v_{2i-1}: 1 \leq i \leq \frac{n+1}{2}\right\}$ be a semitotal dominating set and no other semitotal dominating set in the complement of the $\gamma_{t2}(G)$ – set has cardinality less than the cardinality of $D^{'}$ which dominates the whole vertex set of $A(T_n)$. Thus $D^{'}$ is $\gamma_{t2}^{'}(G)$ – set. Therefore, $\gamma_{t2}^{'}(A(T_n)) = \left\lceil\frac{n}{2}\right\rceil$.

Case (ii) Suppose $n \geq 4$ is a positive even integer.
It is clear that a$\gamma_{t2}(G)$ – set is $\left\{v_{2i}: 1 \leq i \leq \frac{n}{2}\right\}$. The corresponding $\gamma_{t2}^{'}(G)$ – set is contained in the complement of $\gamma_{t2}(G)$ – set. Let $D^{'} = \left\{v_{2i-1}: 1 \leq i \leq \frac{n}{2}\right\}$ be a semitotal dominating set and no other semitotal dominating set in the complement of the $\gamma_{t2}(G)$ – set has cardinality less than the cardinality of $D^{'}$ which dominates the whole vertex set of $A(T_n)$. Thus $D^{'}$ is $\gamma_{t2}^{'}(G)$ – set. Therefore, $\gamma_{t2}^{'}(A(T_n)) = \left\lceil\frac{n}{2}\right\rceil$.

Theorem
The inverse semitotal domination number for any alternate triangular snake graphs, where $n \geq 3$, for which the triangle starts from the second vertex is

$$\gamma_{t2}^{'}(A(T_n)) = \begin{cases} \frac{n}{2}, & for\ n = 4, 6, 8 \\ \left\lceil\frac{n}{2}\right\rceil, & for\ odd\ n \geq 3. \\ \frac{n}{2} + 1, & even\ n \geq 10 \end{cases}$$

Proof:

Case (i) Suppose $n \geq 3$ is a positive odd integer.

Let $V = \left\{v_i, u_j : 1 \leq i \leq n \; and \; 1 \leq j \leq \left\lfloor \frac{n}{2} \right\rfloor\right\}$ be a vertex set of $A(T_n)$. The path vertices are labelled as $\{v_i : 1 \leq i \leq n\}$ and the new vertices adjacent to the edges of the path are labelled as $\left\{u_j : 1 \leq j \leq \left\lfloor \frac{n}{2} \right\rfloor\right\}$ where u_1 is adjacent to v_2 and v_3, u_2 is adjacent to v_4 and v_5, and so on. For $n = 3$, obviously $\gamma_{t2}'(A(T_n)) = \left\lceil \frac{n}{2} \right\rceil$.

Subcase (i) Suppose $n = 5, 7$.

It is clear that a $\gamma_{t2}(A(T_n))$ – set is $\left\{v_{2i} : 1 \leq i \leq \frac{n-1}{2}\right\}$ then the corresponding $\gamma_{t2}'(A(T_n))$ – set is $\left\{v_{2i-1} : 1 \leq i \leq \frac{n+1}{2}\right\}$. Therefore, $\gamma_{t2}'(A(T_n)) = \left\lceil \frac{n}{2} \right\rceil$.

Subcase (ii) Suppose $n \geq 9$.

It is clear that a $\gamma_{t2}(A(T_n))$ – set is $\{v_2, v_4\} \cup \left\{v_{2i-1} : 4 \leq i \leq \frac{n+1}{2}\right\}$. The corresponding $\gamma_{t2}'(A(T_n))$ – set is contained in the complement of $\gamma_{t2}(A(T_n))$ – set. Let $D' = \{v_1, v_3, v_5\} \cup \left\{v_{2i} : 3 \leq i \leq \frac{n-1}{2}\right\}$ be a semitotal dominating set and no other semitotal dominating set in the complement of the $\gamma_{t2}(A(T_n))$ – set has cardinality less than the cardinality of D' which dominates the whole vertex set of $A(T_n)$. Thus D' is $\gamma_{t2}'(A(T_n))$ – set. Therefore, $\gamma_{t2}'(A(T_n)) = \left\lceil \frac{n}{2} \right\rceil$.

Case (ii) Suppose $n \geq 4$ is a positive even integer.

Let $V = \left\{v_i, u_j : 1 \leq i \leq n \; and \; 1 \leq j \leq \left\lfloor \frac{n-1}{2} \right\rfloor\right\}$ be a vertex set of the alternate triangular snake graph. The path vertices are labelled as $\{v_i : 1 \leq i \leq n\}$ and the new vertices added to the edges of the path are labelled as $\left\{u_j : 1 \leq j \leq \left\lfloor \frac{n-1}{2} \right\rfloor\right\}$ where u_1 is adjacent to v_2 and v_3, u_2 is adjacent to v_4 and v_5, and so on.

Subcase (i) Suppose $n = 4, 6, 8$.

It is clear that a $\gamma_{t2}(A(T_n))$ – set is $\left\{v_{2i} : 1 \leq i \leq \frac{n}{2}\right\}$ then the corresponding $\gamma_{t2}'(A(T_n))$ – set is $\left\{v_{2i-1} : 1 \leq i \leq \frac{n}{2}\right\}$. Therefore, $\gamma_{t2}'(A(T_n)) = \frac{n}{2}$.

Subcase (ii) Suppose $n \geq 10$.

It is clear that a $\gamma_{t2}(A(T_n))$ – set is $\{v_2, v_4\} \cup \left\{v_{2i-1} : 4 \leq i \leq \frac{n}{2}\right\}$. The corresponding $\gamma_{t2}'(A(T_n))$ – set is contained in the complement of the $\gamma_{t2}(A(T_n))$ – set. Let $D' = \{v_1, v_3, v_5\} \cup \left\{v_{2i} : 3 \leq i \leq \frac{n}{2}\right\}$ be a semitotal dominating set and no other semitotal dominating set in the complement of the $\gamma_{t2}(A(T_n))$ – set has cardinality less than the cardinality of D' which dominates the whole vertex set of $A(T_n)$. Thus D' is $\gamma_{t2}'(A(T_n))$ – set. Therefore, $\gamma_{t2}'(A(T_n)) = \frac{n}{2} + 1$.

Theorem

The inverse semitotal domination number for the friendship graph, where $n \geq 2$, is $\gamma_{t2}'(F_n) = n$.

Proof

Let $G = F_n$ be the friendship graph formed by joining n copies of the cycle graph C_3 with a common vertex. Let $V = \{v_i : 1 \leq i \leq 2n + 1\}$ be a vertex set of the friendship graph. Let v_1 be the universal vertex of F_n.Since v_1 dominates the entire vertex set of the friendship graph, it must be included in the $\gamma_{t2}(G)$ – set. Hence $\{v_1, v_k\}$ for any $k \in i \neq 1$, forms $\gamma_{t2}(G)$ – set then the respective $\gamma_{t2}'(G)$ – set is contained in the complement of the $\gamma_{t2}(G)$ – set. Let $D' = \left\{v_i : \forall v_j \in D', v_i v_j \notin E \;\; 2 \leq i \leq 2n + 1\right\}$ be a semitotal dominating set and no other semitotal dominating set in the complement of $\gamma_{t2}(G)$ – set has cardinality less than the cardinality of D', which dominates the whole vertex set of F_n. Thus D' is $\gamma_{t2}'(G)$ – set. Therefore, $\gamma_{t2}'(F_n) = n$.

Theorem: The inverse semitotal domination number for the comb graph, where $n \geq 3$, is $\gamma_{t2}'(P_n^+) = n$.

Proof

Let $G = P_n^+$ be the comb graph, where $P_n^+ = P_n \odot K_1$. Let $V = \{v_i, u_j : 1 \le i, j \le n\}$ be the vertex set of the comb graph, where $\{v_i : 1 \le i \le n\}$ corresponds to the pathP_n and $\{u_j : 1 \le i \le n\}$ corresponds to the pendant vertices connected to each path vertex.

Case (i) Suppose $n \ge 3$ is a positive odd integer

Obviously,$\left\{v_{2i-1}, u_{2j} : 1 \le i \le \frac{n+1}{2},\ 1 \le j \le \frac{n-1}{2}\right\}$ forms the$\gamma_{t2}(G)$ – set. Its complement set$\left\{v_{2i}, u_{2j-1} : 1 \le i \le \frac{n-1}{2},\ 1 \le j \le \frac{n+1}{2}\right\}$ forms the$\gamma_{t2}'(G)$ – set with respect to $\gamma_{t2}(G)$ – set. Therefore, $\gamma_{t2}'(P_n^+) = n$.

Case (ii) Suppose $n \ge 4$ is a positive even integer

Obviously,$\left\{v_{2i-1}, u_{2j} : 1 \le i, j \le \frac{n}{2}\right\}$ forms the$\gamma_{t2}(G)$ – set. Its complement set $\left\{v_{2i}, u_{2j-1} : 1 \le i, j \le \frac{n}{2}\right\}$ forms the$\gamma_{t2}'(G)$ – set with respect to the$\gamma_{t2}(G)$ – set. Therefore, $\gamma_{t2}'(P_n^+) = n$.

Theorem: The inverse semitotal domination number for the broom graph, where $n \ge 5$and $m \ge 3$, is $\gamma_{t2}'(B_{n,m}) = \left\lceil \frac{2m}{5} \right\rceil + (n - m)$.

Proof: Let $G = B_{n,m}$ be the broom graph has $n - m$ pendant vertices adjacent to either the origin or the terminus of the path P_m. Let $V = \{v_i, u_j : 1 \le i \le m, 1 \le j \le n - m\}$ be the vertex set of the broom graph where $\{v_i : 1 \le i \le m\}$ corresponds to the vertices of path P_m and $\{u_j : 1 \le j \le n - m\}$ corresponds to $(n - m)$ pendant vertices. We observe that a $\gamma_{t2}(G)$ – set is the $\gamma_{t2}'(P_m)$ – set of the path P_m of $B_{n,m}$. Then,

$\gamma_{t2}'(G) - set = (\gamma_{t2}(P_m) - set) \cup \{u_j : 1 \le j \le n - m\}$

$|(\gamma_{t2}'(G) - set)| = |(\gamma_{t2}(P_m) - set)| + |\{u_j : 1 \le j \le n - m\}|$

$= \left\lceil \frac{2m}{5} \right\rceil + (n - m)$.

Theorem: The inverse semitotal domination number for the firecracker graph where $n \ge 2, k \ge 3$ is $\gamma_{t2}'(F_{n,k}) = \begin{cases} nk - 2n + 1 + \left\lceil \frac{n}{3} \right\rceil, & if\ n \equiv 0 (mod\ 3) \\ nk - 2n + \left\lceil \frac{n}{3} \right\rceil, & otherwise \end{cases}$.

Proof: Let $G = F_{n,k}$ be the firecracker graph obtained by the concatenation of nk-stars by linking one leaf from each. Let $V = \{v_i : 1 \le i \le nk\}$ be the vertex set of the firecracker graph. Consider the pathP_n obtained by linking one leaf from each copies of k-stars, which are labelled as $\{v_i : 1 \le i \le n\}$. The remaining vertices adjacent to the path vertices are labelled as $\{v_i : n + 1 \le i \le 2n\}$ and the remaining pendant vertices are labelled as $\{v_i : 2n + 1 \le i \le nk\}$.

Clearly, the set$D = \gamma(P_n) - set \cup \{v_i : n + 1 \le i \le 2n\}$ forms the$\gamma_{t2}(G)$ – set. The corresponding $\gamma_{t2}'(G)$ – set is contained in the complement of the $\gamma_{t2}(G)$ – set.

Case (i) In $V \setminus D$, we observe thatfor $n \equiv 0 (mod\ 3)$

$\gamma_{t2}'(G)$ – set $= (\gamma'(P_n) - set) \cup \{v_i : 2n + 1 \le i \le nk\}$

$|(\gamma_{t2}'(G) - \text{set})| = |(\gamma'(P_n) - set)| + |\{v_i : 2n + 1 \le i \le nk\}|$

$= \left(\left\lceil \frac{n}{3} \right\rceil + 1\right) + nk - 2n$

Case (ii) In $V \setminus D$, we observe that for $n \not\equiv 0 (mod\ 3)$

$\gamma_{t2}'(G)$ – set $= (\gamma'(P_n) - set) \cup \{v_i : 2n + 1 \le i \le nk\}$

$|(\gamma_{t2}'(G) - \text{set})| = |(\gamma'(P_n) - set)| + |\{v_i : 2n + 1 \le i \le nk\}|$

$= \left\lceil \frac{n}{3} \right\rceil + nk - 2n$

Theorem: The inverse semitotal domination number for the twig graph, where $m \geq 2$, is $\gamma_{t2}^{'}(T_m) = 2m + 2$.

Proof: Let $G = T_m$ be the twig graph formed from a path P_n by attaching two pendant vertices to each internal vertices of the path. Let $V = \{v_i, u_j : 1 \leq i \leq n, 1 \leq j \leq 2m\}$ be the vertex set of the twig graph, where $\{v_i : 1 \leq i \leq n\}$ corresponds to P_n and $\{u_j : 1 \leq j \leq 2m\}$ corresponds to the pendant vertices added to each internal vertices of P_n. For $n \geq 4$ and $m \geq 2$, we observe that,$\{v_i : 2 \leq i \leq n-1\}$ forms the$\gamma_{t2}(G)$ – set. The complement of the $\gamma_{t2}(G)$ – set, which is $\{v_1, v_n\} \cup \{u_i : 1 \leq i \leq 2m\}$, forms the$\gamma_{t2}^{'}(G)$ – set with respect to the $\gamma_{t2}(G)$ – set.
Therefore, $\gamma_{t2}^{'}(T_m) = 2m + 2$.

RELATIONSHIP WITH GRAPH-THEORETICAL PARAMETERS

Theorem: For any connected graph G with $n \geq 4$, $\gamma_{t2}^{'}(G) + \chi(G) \leq 2n - 2$ and the equality holds if and only if G is isomorphic to K_4.

Proof: It is clear from the definition that $\gamma_{t2}^{'}(G) \leq n - 2$ and $\chi(G) \leq n$. Thus, $\gamma_{t2}^{'}(G) + \chi(G) \leq n - 2 + n = 2n - 2$. Suppose G is isomorphic to K_4, then obviously,$\gamma_{t2}^{'}(G) + \chi(G) = 2n - 2$. Conversely, let $\gamma_{t2}^{'}(G) + \chi(G) = 2n - 2$, the only possible case is$\gamma_{t2}^{'}(G) = n - 2$ and$\chi(G) = n$. If $\chi(G) = n$, then G is isomorphic to K_n. In K_n, $\gamma_{t2}^{'}(G) = 2$, so that G is isomorphic to K_4.

Theorem: For any connected graph G with $n \geq 4$, $\gamma_{t2}'(G) + \Delta(G) \leq 2n - 3$ and the equality holds if and only if G is isomorphic to K_4.

Proof: It is clear from the definition that $\gamma_{t2}'(G) \leq n - 2$ and $\Delta(G) \leq n - 1$. Thus, $\gamma_{t2}'(G) + \Delta(G) \leq n - 2 + n - 1 = 2n - 3$. Suppose G is isomorphic to K_4, then obviously, $\gamma_{t2}'(G) + \Delta(G) = 2n - 3$. Conversely, let$\gamma_{t2}'(G) + \Delta(G) = 2n - 3$, the only possible case is$\gamma_{t2}'(G) = n - 2$ and$\Delta(G) = n - 1$. If $\Delta(G) = n - 1$, then G is isomorphic to K_n. In K_n, $\gamma_{t2}'(G) = 2$, so that G is isomorphic to K_4.

Theorem: For any connected graph G with $n \geq 4$, $\gamma_{t2}'(G) + \kappa(G) \leq 2n - 3$ and the equality holds if and only if G is isomorphic to K_4.

Proof: It is clear from the definition that $\gamma_{t2}'(G) \leq n - 2$ and $\kappa(G) \leq n - 1$. Thus, $\gamma_{t2}'(G) + \kappa(G) \leq n - 2 + n - 1 = 2n - 3$. Suppose G is isomorphic to K_4, then obviously,$\gamma_{t2}'(G) + \kappa(G) = 2n - 3$. Conversely, let $\gamma_{t2}'(G) + \kappa(G) = 2n - 3$, the only possible case is$\gamma_{t2}'(G) = n - 2$ and$\kappa(G) = n - 1$. If $\kappa(G) = n - 1$, then G is isomorphic to K_n. In K_n, $\gamma_{t2}'(G) = 2$, so that G is isomorphic to K_4.

CONCLUSION

In this paper we have determined the inverse semitotal domination number of some graphs derived from paths and cycles. We have also discussed its relationship with other graph theoretical parameters such as chromatic number of a graph, vertex connectivity and maximum degree of a graph and have shown the bound is sharp for the complete graph with four vertices. Further, the characterization of the graphs with this parameter can be investigated.

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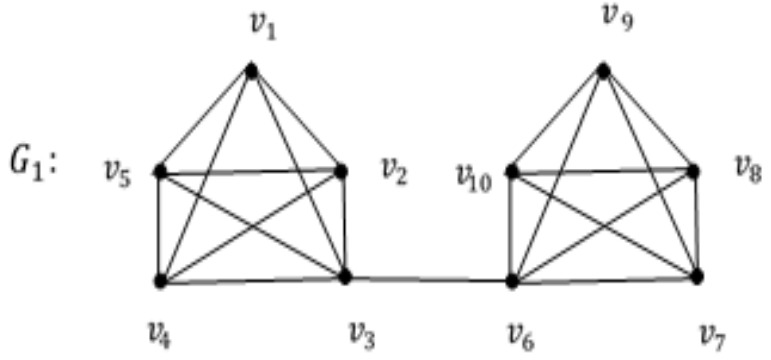


Figure 1: The graph G_1 having $D' = \{v_3, v_7\}$ as a $\gamma'_{t2}(G_1)$– set.

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REVIEW ARTICLE

Beyond Conventional Skincare: The Rise of Nanoemulsions in Topical and Transdermal Medicine

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ABSTRACT

Nanoemulsions are highly promising for cosmetic and drug delivery applications due to their thermodynamic stability and small droplet size, which enhance skin penetration and drug solubility. Their benefits include reduced side effects, ease of production, and the ability to solubilize a wide range of active ingredients. However, challenges such as formulation limitations and skin barrier permeability still exist. The absorption rate of drugs through the skin depends on factors like the drug type and dose, the choice of surfactant, water content, and the presence of penetration enhancers. Several methods, including phase inversion, ultrasonication, microfluidization, and high-pressure homogenization, are used to prepare nanoemulsions. Despite some drawbacks, nanoemulsions provide an innovative approach to enhance both medication delivery and skincare formulations, making them a powerful tool in therapeutic and cosmetic products.

Keywords: Drug Delivery, Emulsion, Nanoemulsion, Transdermal, Topical

INTRODUCTION

Nanoemulsions

Emulsions are composed of two immiscible liquids that, because of an excess of free energy at the surface of the internal phase, produce a thermodynamically unstable system. Comparing nanoemulsions to regular emulsions, the former usually have a more consistent or narrow size distribution, Using droplet sizes between 10 and 100 nm [1]. Nanoemulsions are mixtures of oil, water, and surfactants or cosurfactants. They produce steady, evenly spaced droplets with dimensions in the nanometer range. For a variety of uses, including the food and pharmaceutical industries, this structure improves their stability and bioavailability [2]. Indeed, a kind of multiphase colloidal dispersion renowned for its stability and purity is called a nanoemulsion. They consist of microscopic droplets dispersed across an immiscible liquid. Their stability and transparency are enhanced by their tiny droplet size, which makes them appropriate for a variety of applications such as food, cosmetic, and drug delivery formulations [3].

Transdermal

The skin is thought to be a desirable organ for systemic (transdermal) and local (topical, dermal) administration of active compounds despite this permeability problem[4].The largest organ in the human body, it provides a wide, painless, and convenient interface for the application of medications and cosmetics. Cosmeceuticals play the vital role in skincare by offering targeted benefits like rejuvenation, moisturization, nourishment, and protection. Transdermal delivery further enhances these advantages, bypassing gastrointestinal issues and minimizing fluctuations in drug concentrations. It's a promising approach for effective skincare.

Types of nanoemulsions [5]

Three types of nanoemulsions are distinguished by their oil and water phases

1. Oil in water (o/w). The exterior aqueous phase of this system contains distributed internal phase oil droplets.
2. Water in oil (w/o): The water droplet from the internal phase of the nanoemulsion is distributed throughout the external oil phase in this system.
3. Bi-continuous: The system contains a nanoemulsion with a mixture of water and oil droplets.

Component of Nanoemulsion

1. Oil
2. Surfactant
3. Co- Surfactant
4. Aqueous phase

Oil

The choice of oil in a nanoemulsion is vital for high drug loading. The oil must dissolve the active ingredients and work well with other components to ensure effective distribution in the aqueous phase. Oils can be natural, synthetic, or semi-synthetic [6].

Surfactant

Surfactants reduce surface and interfacial tension, playing roles such as emulsifiers, foaming agents, wetting agents, detergents, and dispersants based on their hydrophilic-lipophilic balance (HLB). In nanoemulsions, hydrophilic surfactants (HLB > 10) stabilize oil-in-water (o/w) emulsions, while hydrophobic surfactants (HLB < 10) are used for water-in-oil (w/o) emulsions. Surfactant mixtures with varying HLB values can be used to create stable nanoemulsions when diluted with water [7].

Co-surfactant

These substances were used in the nanoemulsion formulation when the surfactant failed to reduce the interfacial tension that developed between water and oil. Additionally, by piercing a surfactant monolayer and upsetting its

crystalline liquid phase, it added some fluidity to the interfacial tension of surfactants with high stiffness. Propylene glycol, poly glyceryl oleate, and PEG 400 are examples of co-surfactants[8].

Aqueous phase

Deionized water, with a neutral pH of 7 and no electrolytes, is commonly used as the aqueous phase in nanoemulsions. The characteristics of the aqueous phase, such as pH, electrolytes, and ionic concentration, influence nanoemulsion stability and droplet size[9].

Advantages of Nanoemulsion

1. Thermodynamically stable systems like nanoemulsions enable the system to self-emulsify, producing features that are not dependent on the method used.
2. They are the medication's super solvent. They can improve the bioavailability of poorly soluble pharmaceuticals and solubilise hydrophilic and lipophilic drugs.
3. The dispersed phase, which can be either hydrophilic or lipophilic (w/o or o/w nanoemulsions), might act like a possible reservoir for either type of medication.
4. The nano emulsion droplets' mean diameter is less than 0.1 m, filtering can be used to sterilise them.
5. It is possible to transport hydrophilic and lipophilic medicines in nanoemulsion [10].

Limitations of Nanoemulsion

1. Effective drug administration via the skin's rate-controlling barrier is a major difficulty in developing nanoemulsions as a topical medication delivery method.
2. The rheology characteristics of a nanoemulsion are crucial for medication delivery through the skin, even with formulations with small particle sizes [11].
3. The poor viscosity and spreadability of the nanoemulsion formulation make it inconvenient to utilize [12].

Factors Affecting Nanoemulsion-Enhanced Drug Permeation through the Skin

Amount of Drug

Nanoemulsions are highly effective for delivering both lipophilic and hydrophilic drugs due to their ability to absorb significant amounts of active ingredients. The concentration gradient created between the internal and external phases enhances the drug's thermodynamic properties, promoting its diffusion from the internal phase into the epidermal layers, thereby improving drug absorption and effectiveness [13].

Amount of Surfactant

The selection of surfactant is crucial in nanoemulsion synthesis, affecting skin penetration and drug solubilization. An ideal surfactant should have good solubilizing ability for the active ingredient and support oil nanoemulsification. Non-ionic surfactants are preferred over cationic and anionic ones, as they are gentler on the skin. While cationic and anionic surfactants can enhance skin suppleness and elasticity by binding water to the skin's surface, non-ionic surfactants are generally recommended for better skin compatibility [14].

Amount of Water

Drug penetration in a nanoemulsion system was found to be linearly correlated with water content [15]. Because the skin and the nanoemulsion system have different moisture contents, the drug molecules are driven strongly through the skin's layers [16]. Many researchers have also observed improved medication delivery as a result of hydration and an increase in water phase [17, 18]. Their exceptional mobility is due to both the small particle size but high droplet density of the nanoemulsions and the naturally occurring and continuously changing surfaces of the drug molecules [19].

Penetration Enhancers

Glycerides, fatty acids/alcohols, and vegetable oil are examples of lipids in the SC that have polarities similar to those of an oil lipid phase and can enhance skin penetration.For the purpose of treating arthritis, muscular soreness, and mild joint pain, topical camphor, menthol, and methyl salicylate were more effectively absorbed when fixed oils such soybean oil were used[20].Through interactions with the SC, these penetration enhancers create a reversible reduction in the skin's barrier characteristics [21, 22].

Techniques for Nanoemulsion Preparation

Techniques for high energy emulsification

High-pressure homogenizations

High-pressure homogenization creates nanoemulsions by forcing a mixture of oil and aqueous phases through a tiny hole under pressures of 500-5000 psi. This process generates very fine particles (as small as 1 nm) due to hydraulic shear and turbulence. A monomolecular layer of phospholipids separates the oil and water phases. The main downside is high energy consumption despite the rise in temperature during processing.

Microfludization

This special mixing technique makes use of a high-pressure positive displacement pump that runs between 500 and 20,000 psi. is seen in (fig 2). The phases are compelled to flow through tiny channels by this pressure. When the two phases are combined and forced through an interaction chamber, the coarse emulsion forms into a nanoemulsion. This is designed to flow via tiny passages [23, 24].

Ultrasonication

The process of creating nanoemulsion is covered in several research publications that try to use ultrasonic sound frequency to reduce droplet size. At system pressures higher than the ambient value indicated in (Fig. 3), another method is to use a constant amplitude sonotrode. An ultrasonic field's cavitation threshold is known to rise with increasing external pressure, which decreases the formation of bubbles. Since cavitation is the primary process of low-frequency power dissipation, significant variations in power density can be linked to changes in the navigational ultrasonic system. Additionally, a water jacket is used by the system to control the temperature to the required level [25].

Sonication

Kinetically stable nanoemulsions can be made by ultrasonic homogenization or sonication. When liquids containing surfactants and cosurfactants are brought into contact with the sonicator probe of an ultrasonic homogenizer, mechanical vibration, and cavitation are created. This delivers the necessary energy input to produce tiny droplets [26, 27]. With increasing ultrasonic homogenization time, power levels, and surfactant content, the dispersed phase particle size in sonicated nanoemulsions decreases[28]. Optimizing ultrasonic reaction chamber design, operating parameters, and product formulation (e.g., surfactant concentration and oil phase type and content) are necessary to achieve a dispersed phase droplet size of 20 nm [29].

Low-energy methods for emulsification

phase inversion method

To achieve fine dispersion, the emulsification process makes use of the chemical energy generated by these phase changes. Either altering the composition of the emulsion while keeping the temperature constant, or the opposite, causes the phase change. When Shinoda *et al.* initially calculated the phase inversion temperature, they concluded that a rise in temperature causes the polymer chain to break down, changing the chemical makeup of polyoxymethylene surfactants [30].

Solvent Evaporation Technique

To avoid particle aggregation and crystal formation, a high-speed stirrer is used to produce the pharmaceutical solution, which is subsequently emulsified in a different liquid that is not the prescription solvent. A precipitate of the drug may result from evaporating the solvent [31].

Hydrogel Technique

Such a technique is analogous to solvent evaporation. Drug anti-solvent and drug solvent are miscible, which is the only distinction between the two procedures. Higher shear force prevents Ostwald ripening and crystal formation [32].

Characterization of Nanoemulsions

Droplet size

Transmission electron microscopy (TEM) is used to study nanoparticle size and morphology. Samples are placed on a copper-carbon TEM grid, dried, and coated with gold before being examined under a scanning electron microscope at 20 kV. This process includes steps like air-drying, critical point drying, and sputter-coating for accurate analysis of stable emulsions [33].

Interfacial tension

Interfacial tension is used to study the characteristics and formulation of nanoemulsions. Ultralow interfacial tension is observed when the oil and aqueous phases are in equilibrium with the surfactant phase. This can be accurately measured using a spinning drop apparatus, which helps detect extremely low interfacial tension values [34].

Zeta potential

Zeta potential measures the particle charge, which is crucial for the stability of nanoemulsions. A high zeta potential (above 30 mV) indicates stability, as it prevents aggregation by maintaining strong repulsive forces between particles. A low zeta potential means flocculation occurs, with attraction outweighing repulsion. Factors like particle source, electrolyte content, pH, hydration, and particle shape influence zeta potential and the electrostatic stability of nanoemulsions [35].

Refractive index: The refractive index, which represents the isotropic quality of the formulation, is the net value of the nanoemulsion component parts. It is a method for determining if a formulation is transparent as well as for thermodynamic stability study of the sample [34]. It is clear that the formulation is transparent if the system's RI comparison is comparable to that of water. Using a refractor, the refractive index was determined [36].

Viscosity

Viscosity, which measures a fluid's resistance to flow, is an important characteristic of nanoemulsions. The Brookfield DV-II+ Pro viscometer is commonly used to measure viscosity by averaging three data points at a specific shear rate. Measurements are taken at various rpm values (0.5, 1, 2.5, and 5) after the mixture sits for five minutes at room temperature or a controlled temperature. Results typically show that as storage temperature decreases, the viscosity of the nanoemulsion increases. The readings from the viscometer's dial are noted to quantify this [37]. Mass/volume equals viscosity.

Entrapment efficiency

The encapsulation efficiency (% EE) of a drug in a nanoemulsion is calculated by assessing the amount of free (unentrapped) drug. The formula is:% EE = [(Amount of drug added - Free drug) / Amount of drug added] × 100this measures how much of the drug is successfully encapsulated in the formulation [34].

Marketed formulation on nanoemulsion [38]

Applications of Nanoemulsion [39, 40,41].

Nanoemulsion for oral route

Due to their slow rate of dissolution, poorly water-soluble medications have limited bioavailability; nevertheless, oral delivery of these pharmaceuticals by o/w nanoemulsion increases their solubility, absorption, and bioavailability.

Nanoemulsion for ophthalmic administration

Improved topical hydrophobic medication administration to the ocular is being investigated with oil in water emulsions. Lipophilic medication combined with ocular emulsions unquestionably offer a more favorable balance between enhancing ocular bioavailability and patient experience relief after applying topical medication on the eye. For example, indomethacin, piroxicam, and pilocarpine, cyclosporine.

Nanoemulsion for nasal route

Analysing the nose route concerning the parenteral and perioral routes, there are numerous advantages. For example, drug absorption is increased because the nasal mucosa and nanoemulsion droplet have more time to interact, bypassing the liver's initial metabolism.

Nanoemulsion for transdermal delivery

There are three possible entry points for the chemical into the epidermis layer: the stratum corneum, hair follicles, or sweat ducts. These routes limit the absorption of drugs and lower their bioavailability. To regulate medication redistribution across blood and lymph arteries and to enhance drug targeting.Nanoemulsion is a promising technology with advantages such as minimal preparation cost, good stability during storage, no organic solvent, and thermodynamic stability. It can also achieve systemic administration through skin pores.

Nanoemulsion in cosmetic

Nanoemulsion is thought to be an excellent vehicle for regulated cosmetic delivery and helps disperse active ingredients throughout the skin layer. Because micro emulsion causes sedimentation, creaming, and flocculation, nanoemulsion is employed in cosmetics.

Future Prospects and Emerging Research Areas:

Nanotechnology

This involves the use of extremely small particles or structures, such as nanofibers and microneedles, to enhance drug delivery through the skin. Drugs can be more effectively absorbed and released over time by using nanofibers to create a structure that resembles a mesh [42].

Polymeric Systems

Polymeric hydrogels and nanoparticles use materials that encircle the medication in a network. These systems both shield medications from deterioration and facilitate their more efficient skin absorption. Drugs can be encapsulated in polymeric nanoparticles, which allow for a controlled release and gradual release over time [51].

Lipid-Based Carriers

These lipid-based carriers, which include liposomes and solid lipid nanoparticles, enhance the solubility and stability of drugs that would otherwise be difficult to deliver. Solid lipid nanoparticles are minuscule solid lipid particles that have the ability to encapsulate medications, shielding them from external influences and ensuring a prolonged release [42].

Microneedle Arrays

These tiny needle arrays in the form of a grid penetrate the skin's outermost layer gently, forming microchannels. The distribution of medications straight into the skin's deeper layers is made easier by these microchannels. This method works well for deep administration of medications such as hormone therapies and immunizations since it is less intrusive and uncomfortable than standard injections [43].

Bio adhesive Formulations

These formulations include ingredients that stick to the skin for a long period, prolonging the time and improving the efficiency of medicine delivery. Bio-adhesive compounds make sure the medication stays on the skin longer, whichimproves absorption and permits a steady and regulated release [44].

CONCLUSION

Nanoemulsions, with their nanoscale droplet size and thermodynamic stability, offer great potential for improving the administration of topical and transdermal drugs, as well as in cosmetic formulations. They provide benefits like high drug solubility, ease of manufacture, and enhanced therapeutic efficacy with fewer side effects. However, challenges such as formulation limitations and skin barrier permeability need to be addressed. Drug penetration is influenced by factors like concentration, surfactant type, water content, and penetration enhancers. Various methods, including phase inversion, high-pressure homogenization, microfluidization, and ultrasonication, are used to prepare nanoemulsions. Despite some drawbacks, advances in penetration enhancement and formulation techniques are expanding the applications of nanoemulsions in medicine and skincare. More research is needed to optimize these systems and overcome current challenges.

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Table:1 Marketed formulation on nanoemulsion

Manufacturer	Drug	Brand name	Therapeutic indication
AstraZeneca	2, 6-diisopropylphenol.	Diprivan	Narcotic
Troika	2, 6-diisopropylphenol.	Troypofol	Narcotic
Mitsubishi Pharmaceutical	Dexamethasone Sodium Phosphate	Decadron	Steroid
Mitsubishi Pharmaceutical	Palmitoyl prostaglandin E1	Liple	Antithrombotic
Kaken Pharmaceuticals	Flurbiprofen ester	Bupropion	Nonsteroidal anti-inflammatory agent
FreseniusKabi	Retinol, Calciferol, Tocopherol, Phylloquinone	Vitalipid	IV nutrition

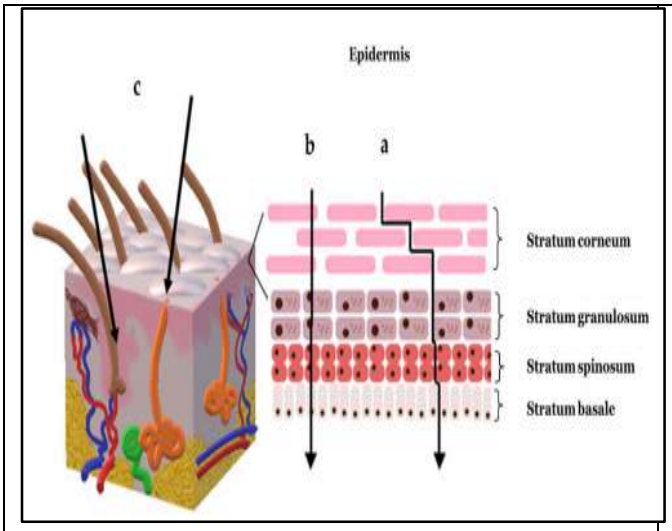


Fig 1. Layers of skin and penetration routes (a) intercellular (b) transcellular (c) transappendageal pathways [4].

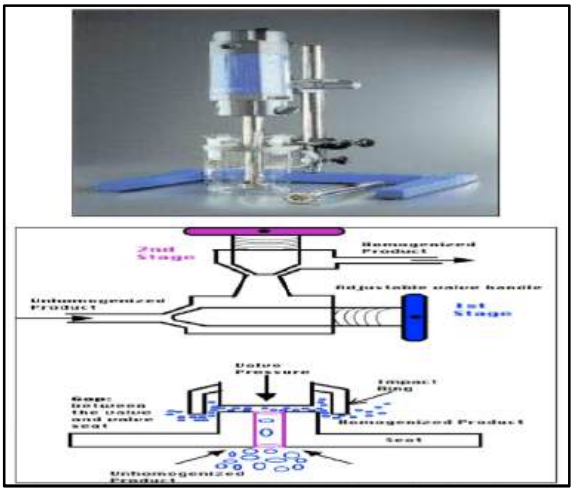


Fig 2. The working mechanism of a microfluidizer [3].



Fig 3. Probe Sonication [3].

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RESEARCH ARTICLE

A Contemporary Strategy for Addressing Fuzzy Task Conflicts by Measure Mean Ranking Method

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ABSTRACT

Transportation and assignment models participate major task in logistics and make available procession organization for reducing cost and time, for superior service. In this paper a fuzzy Assignment Model for defuzzification by proposed method Measure mean ranking technique, its σ-cuts for linear and nonlinear orientation functions is used. The proposed Mean square ranking Assignment model is tested by considering an instance with three parameters as fuzzy cost, fuzzy time and fuzzy quality with universal LR triangular fuzzy numbers and a realistic data is tested with two parameters fuzzy cost and fuzzy time as indiscriminate LR triangular fuzzy numbers by a choice of cases. This method helps in transmission and implementing the individuals to mechanism effectively on one-one basis so that it increases the number of prospective bidders and it minimize the total fuzzy assignment cost and total fuzzy time.

Keywords: Fuzzy Assignment Problem - Measure Mean - Robust's – PERT - Centroid - ranking method - Hungarian method
MSC 2020 No : 47S40

INTRODUCTION

Assignment problem is used global in solving factual humanity tribulations. It the stages an essential responsibility in the manufacturing and is worn exceptionally frequently in solving problems of trade, organization discipline and it has numerous other applications. Therefore, the inadequate resources must be utilized competently such that the most favorable existing possessions can be assigned to the a large amount desirable responsibilities so as to maximize and minimize the revenue and outlay in that order. Multi-objective assignment problem with trapezoidal fuzzy number was described by Pramanik *et.al.,*[4]. Classify the modeling using fuzzy technique which was motivated by Mohan kumar *et.al.*[8,13,15]. Assignment problem using fuzzy method solved by including Kagade *et.al.,*[1,2,4,5]. Srinivasan *et.al.,*[7] recently obtained fuzzy assignment problem with various ranking methods. In this Paper, In order to acquire in the vicinity of optimal solution a novel method Hungarian's method algorithm is presented using measure mean ranking Assignment Model is proposed and a fuzzy Assignment Problem with three parameters fuzzy cost, fuzzy time and fuzzy quality are proposed to find an finest solution with total assignment minimum cost

Basic Results

In this topic deals with Fuzzy set, Fuzzy number, L-R fuzzy numbers, σ-cut of L-R fuzzy number, Hungarian method for solving fuzzy combinatorial optimization dilemma.

Fuzzy Set

Let $\widetilde{A}$ be the subset of *X* where, *X* is the universe of objects then traits function by

$$\mu_{\widetilde{A}} = \begin{cases} 1 \ if \ x \in \widetilde{A} \\ 0 \ if \ x \notin \widetilde{A} \end{cases}$$

The *fuzzy set* $\widetilde{A}$ will be the function $\mu_{\widetilde{A}}$: X → [0, 1], $\mu_{\widetilde{A}}$ is called the *integration function* which is a desirability on the unit interval that measures the degree to each $x \in \widetilde{A}$

Fuzzy number

A Fuzzy set defined on universal of real numbers *R* is said to be a *fuzzy number* has the following attributes:

(i). $\widetilde{A}$ is convex, $\mu_{\widetilde{A}}(\beta a+(1-\beta)b\,\beta) \geq \min imum(\mu_{\widetilde{A}}(a), \mu_{\widetilde{A}}(b)) \forall\, a,b \in R \, and \ 0 \leq \beta \leq 1$

(ii). $\widetilde{A}$ is normal, (i.e.) the integration function of $\widetilde{A}$ has at least one element x ∈ X whose Integration desirability is unity.

(iii). $\mu_{\widetilde{A}}$ is continuous except at a finite number of points in its domain.

(iv). The duration or the expenses of the generalised fuzzy number is

$$\left[A_{ij}\right]A_{ij} = (A_{ij}{}^{(1)}, A_{ij}{}^{(2)} A_{ij}{}^{(3)} A_{ij}{}^{(4)}; W_{ij})$$

Assignment and Allocation dilemma

One particular kind of transit challenge, which is also a resource allocation problem is the allocation dilemma. The challenge in this situation is how to divide up the n jobs that need to be completed by the n machines. There are several uses for this problem in allocation problems, where various entities are assigned to or allocated to other entities. When allocating various tasks to various machines, the goal is to choose the best allocation (distribution) that will reduce the overall cost or time required for the machines to complete all of the tasks. The assignment problem: The challenge, given n machines and n tasks, is to assign or allocate the machines and tasks so that each task is designated by precisely one machine, with each machine dedicated to a certain duty. The goal is to reduce the overall the expense or duration of assigning the i^{th} work to the j^{th} machine, which is indicated by the symbol [f_{ij}].

Fuzzy Combinatorial optimization dilemma

Let's suppose X assignments and X individuals available for performing these. On considering every person can complete every task, even though they may face challenges in terms of efficiency. The objective is to find the lowest possible cost for a task assigned to an individual, denoted by c_{ij}, in the scenario where i is the individual and j is the specific work. The focus is on minimizing the cost while ensuring optimal task allocation. The dilemma of dealing with a simple task and its associated expenses is resolved in the following manner. The combinatorial optimization dilemma can be expressed in geometrically as n x n cost associated with decision whose price will be real numbers as mentioned in the table. Below tabulation is formed by thorugh knowledge with prior methods in reference like Pascal Triangular Approach that holds as like below

$$P(A) = \frac{a+2b+c}{4}$$

Sub interval average method that holds as like below

$$R\left(A^i\right) = \frac{(i+1)}{2x_i}\sum_{i=1}^{n} a_i = \frac{(i+1)}{2i(i+1)/2}\sum_{i=1}^{n} a_i$$

Magnitude Ranking that holds as like below

$$Mag(a,b,c) = \frac{1}{2}\left(\int_0^1 c+3a-b\right) f(r)dr$$

Mathematical Representation of FAP

The fuzzy combinatorial optimization dilemma with cost matrix is modifying into mathematically representation is as follows:

Minimum $\tilde{w} = \sum_{i=1}^{n}\sum_{j=1}^{n}\tilde{c}_{ij}x_{ij}$

Subject to

$\sum_{j=1}^{n} x_{ij} = 1;$ s = 1, 2, 3, . . . n

$\sum_{i=1}^{n} x_{ij} = 1;$ q = 1, 2. 3, . . n

where $x_{ij} = \begin{cases} 1, \text{ i } \rightarrow \text{ j} \\ 0, \text{ otherwise} \end{cases}$

Measure Mean Ranking Method

Steadily the concept for creating ranking for fuzzy numbers have been used widely with various implementation. Getting new tricks in this citation Measure Mean Ranking traits are implemented for sorting trapezoidal fuzzy numbers. Hence these technique deals with course of action to instruct fuzzy sets in which a sorting approach $\Re(\tilde{A})$ is calculated for the fuzzy numbers $\tilde{A} = (m, n, \alpha, \beta)_{LR}$ from its σ-level cut is $\tilde{A}_\sigma = [m - \alpha L^{-1}(\sigma), n + \beta R^{-1}(\sigma)]$ according to the formula

$M(\tilde{A}) = \frac{5(m - \alpha L^{-1}(\sigma))+4b+3(n + \beta R^{-1}(\sigma))}{12}$

Robust's Ranking Method

Give a convex fuzzy number a, the Robust's sorting method is defined by $R(a) = \frac{1}{2}\int_0^1 (a_L, a^U)da$, where (a_L, a^U) is the σ level cut of the fuzzy number a. The Robust's ranking index R(a) gives the desirability of the fuzzy number, it satisfies the magnitude and additive property.

$R(a) = \frac{1}{2}\int_0^1 (a_L, a^U)da$

PERT Ranking Method

A project evaluation review technique procedure involves implementations like ordering fuzzy sets in which sorting approach P(Ã) is intended to triangular fuzzy number Ã = (m, n, α, β)$_{LR}$ from its σ-level cut is

$\tilde{A}_\sigma = [m - \alpha L^{-1}(\sigma), n + \beta R^{-1}(\sigma)]$ look on to formula $P(\tilde{A}) = \frac{(m - \alpha L^{-1}(\sigma)) + 4b + (n + \beta R^{-1}(\sigma))}{6}$

Centroid Mean Ranking Method

The centroid mean sorting proceeds for ordering fuzzy sets wherein sorting approach C(Ã) is calculated for the fuzzy number Ã = (m, n, α, β)$_{LR}$ from its σ-level cut is $\tilde{A}_\sigma = [m - \alpha L^{-1}(\sigma), n + \beta R^{-1}(\sigma)]$look on to formula

$C(\tilde{A}) = \frac{(m - \alpha L^{-1}(\sigma)) + b + (n + \beta R^{-1}(\sigma))}{3}$

Numerical Example

A Selvarajan & Co., company has n tasks to be completed with n individuals. If every person can do every task, even though they may face difficulty in terms of efficiency, the intent is to get the least cost for the task assigned to the individual denoted by c_{ij} , where i is the individual and j is the allocated work. The cost Matrix are triangular fuzzy numbers as follows in the table The dilemma is to determine what is best validated so that the position's total sustained cost is as reduced as possible.

Solution

Given AP is balanced combinatorial optimization dilemma, since number of rows and columns are equal. The integration function of triangular fuzzy number is defined by

$$\mu_{\tilde{A}}(x) = \begin{cases} L\left(\frac{m-x}{\alpha}\right), x \le m, \alpha > 0 \\ R\left(\frac{x-n}{\beta}\right), x \ge n, \beta > 0 \\ 1 \qquad otherwise \end{cases}$$

and L-R representation of [a b c] = $[m - \alpha L^{-1}(\sigma), n + \beta R^{-1}(\sigma)]$ is σ level cut of the fuzzy number. The trapezoidal fuzzy number is converted to trans number using Measure Mean ranking method. The beneficial substantiated schedule using method of Measure Mean ranking method is

Uma → Cooking = 23.83333
Selva → Dressing = 42.16667
Raj → Managing = 31.08333
Ram → Plumbing = 33.75
Somu → Washing= 51.91667

Thus, the minimum beneficial substantiated cost is = 182.75

The beneficial substantiated schedule using method of Robust's ranking method is

Uma → Cooking = 24.5
Selva → Dressing = 42.5
Raj → Managing = 31.25
Ram → Plumbing = 34.25
Somu → Washing= 52.75

Thus, the minimum beneficial substantiated cost is = 184.75

Now, the beneficial substantiated schedule using method of PERT ranking method is

Uma → Cooking = 24.33333
Selva → Dressing = 42.33333
Raj → Managing = 31.16667
Ram → Plumbing = 34.16667
Somu → Washing= 51.16667

Thus, the minimum beneficial substantiated cost is = 184.16667

The beneficial substantiated schedule using method of Centroid ranking method is

Uma → Cooking = 24.66667
Selva → Dressing = 42.66667
Raj → Managing = 31.33333
Ram → Plumbing = 34.33333
Somu → Washing= 52.33333

Thus, the minimum beneficial substantiated cost is = 185.33333

The beneficial fuzzy substantiated schedule for the dilemma are the same among the three methods, but we proposed Measure Mean ranking method gives the trapezoidal fuzzy number's sorting significance, corresponding to most minimum cost for the dilemma compared to other two methods.

CONCLUSION

The substantiated triangular fuzzy numbers are used to classify fuzzy cost, which are regarded to be imprecise estimate the total cost. Moreover, the fuzzy combinatorial optimization dilemma technical has been transformed into the combinatorial optimization dilemma payoff cost using ranking function for fuzzy costs matrix and solves it by the Hungarian method

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Table 1 : Fuzzy Combinatorial optimization dilemma with Cost Payoff Matrix

Machines	**Operators**				
	1	**2**	**3**	**…j…**	P
1	M11	M 12	M 13	.. M 1j ..	M1p
2	M 21	M 22	M 23	.. M 2j ...	M2p
-					
I	M i1	M i2	M i3	.. M sq ..	M ip
-					
N	M p1	M p2	M 3	.. M pj ..	M pp

Table:2

		Name of the Work				
		Washing	**Plumbing**	**Managing**	**Dressing**	**Cooking**
Name of the Labour	Uma	(62 66 68)	(78 82 85)	(50 55 60)	(80 82 95)	(20 24 30)
	Selva	(86 90 92)	(65 68 70)	(72 76 80)	(40 42 46)	(55 57 60)
	Raj	(61 64 70)	(48 50 54)	(30 31 33)	(47 50 54)	(69 72 76)
	Ram	(72 75 77)	(31 34 38)	(49 53 57)	(68 70 74)	(51 56 59)
	Somu	(50 52 55)	(49 54 59)	(63 68 74)	(45 46 53)	(72 76 84)

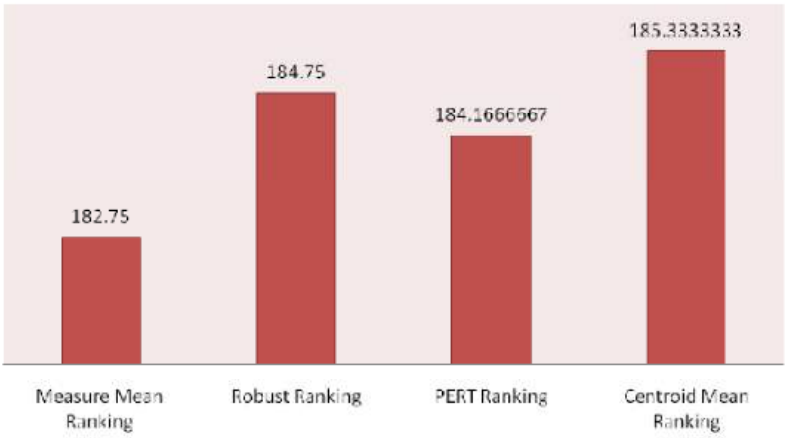


Figure:1 Solution of Fuzzy Combinatorial optimization dilemma with minimum cost

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RESEARCH ARTICLE

Phytoestrogens and Menopause : A Guide to Dietary Harmony

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ABSTRACT

The article titled 'Phytoestrogens and Menopause: A Guide to Dietary Harmony' explores the benefits of incorporating phytoestrogen-rich foods into a woman's diet to alleviate symptoms associated with menopause. Menopause, occurring between ages 45 and 55, results in reduced estrogen levels, leading to symptoms like hot flashes, mood swings, night sweats, and increased risks of osteoporosis and cardiovascular disease. In Ayurvedic medicine, menopause is viewed as the "Vata" stage, where imbalances in Vata dosha can cause symptoms such as dryness, anxiety, and fluctuating energy levels. Ayurveda emphasizes balancing Vata through herbs like *Ashwagandha*, *Shatavari*, and Fenugreek, which are also considered dietary phytoestrogens that help support hormonal balance and overall well-being. Phytoestrogens, such as isoflavones, lignans, and coumestans, mimic estrogen and interact with estrogen receptors, offering a natural alternative to hormone replacement therapy (HRT). Foods like soy products, flaxseeds, legumes, and whole grains are beneficial for reducing hot flashes, supporting bone and heart health, improving mood, and enhancing skin and vaginal health. While beneficial, individual responses may vary based on gut microbiota and hormone-sensitive conditions. The article calls for more research into the long-term impacts of phytoestrogens and advocates for personalized dietary approaches under professional guidance. Overall, this combined approach offers a natural strategy for managing menopausal symptoms.

Keywords: Dietary approach, Estrogen receptors, Isoflavones, Legumes , Menopause**,** Osteoporosis , Phytoestrogen

INTRODUCTION

The menstrual cycle of a woman culminates in menopause, a natural biological event that typically occurs between the ages of 45 and 55. This transition is associated with a reduction in estrogen levels, leading to symptoms like mood swings, vaginal dryness, hot flashes, night sweats, and an increased risk of cardiovascular disease and osteoporosis, among others [1,2] . While hormone replacement therapy (HRT) is a widely used conventional treatment for these symptoms, natural approaches, such as dietary adjustments, are becoming increasingly popular [3]. The phytoestrogenic diet is one promising strategy, which entails eating foods high in phytoestrogens, which are substances obtained from plants that function similarly to estrogen in the body. Because they bind to estrogen receptors and provide a moderate estrogen-like effect, phytoestrogens may help reduce menopausal symptoms. This article investigates Phytoestrogens are compounds that occur naturally in many plant-based foods, such as fruits, vegetables, grains, legumes, and seeds. These substances share a similar chemical structure with estrogen, the hormone that governs various functions in a woman's body, especially during her reproductive years. As estrogen levels decline during menopause, phytoestrogens can aid in easing the effects of this hormonal shift by acting as a weaker, plant-derived substitute for estrogen.

MATERIALS AND METHODS

This article is a narrative literature review aimed at exploring the role of phytoestrogenic diets in managing menopause symptoms. The study involved collecting, analyzing, and synthesizing existing scientific literature without involving human participants or direct experimentation.

METHODOLOGY FOR LITERATURE SEARCH

A systematic search of peer-reviewed literature was conducted across multiple databases, including PubMed, Scopus, and Web of Science. Keywords and combinations used in the search included “phytoestrogens,” “menopause,” “dietary interventions for menopause,” “isoflavones,” “lignans,” and “natural hormone replacement therapy.” The search was restricted to articles published in English from 1990 to 2023 to ensure the inclusion of recent and relevant findings.

Inclusion and Exclusion Criteria Inclusion Criteria

1. Articles discussing the impact of dietary phytoestrogens on menopause-related symptoms such as hot flashes, night sweats, bone health, cardiovascular health, and mood.
2. Reviews, meta-analyses, and primary studies focused on the role of isoflavones, lignans, or coumestans.
3. Studies examining dietary sources such as soy products, flaxseeds, sesame seeds, and red clover.

Exclusion Criteria

1. Articles unrelated to phytoestrogens or menopause.
2. Studies focused on synthetic treatments or interventions unrelated to diet.
3. Non-peer-reviewed literature or articles lacking methodological clarity.

Data Collection and Synthesis

The selected articles were reviewed to extract relevant data on the types of phytoestrogens, their dietary sources, and their biological effects on menopause symptoms. Findings were categorized into themes, including hot flash management, cardiovascular health, bone density preservation, and mood regulation. Key mechanisms of action and gaps in the current understanding were also identified.

MATERIALS

The review emphasized the dietary sources of phytoestrogens, including:

- Isoflavones: Found in soybeans, soy milk, tofu, and soy-based products.
- Lignans: Present in flaxseeds, sesame seeds, and whole grains.
- Coumestans : Found in red clover and alfalfa sprouts.

DISCUSSION

Types of Phytoestrogens

Phytoestrogens are categorized into three main types based on their chemical structure:

1. **Isoflavones**: Found primarily in soy products, isoflavones such as genistein and daidzein are the most well-studied and potent phytoestrogens [4,5]. Their chemical structure is similar to that of estrogen, enabling them to bind to estrogen receptors and exert estrogen-like effects.
2. **Lignans**: These are polyphenolic compounds found in seeds (especially flaxseeds and sesame seeds), whole grains, and some fruits and vegetables [6]. Lignans are metabolized by gut bacteria into enterolignans, which exhibit mild estrogenic activity.
3. **Coumestans**: A less common class of phytoestrogens, coumestans are found in red clover, alfalfa sprouts, and other legumes [7]. They are chemically similar to isoflavones and have estrogenic effects in the body.

Mechanism of Action

Phytoestrogens exert their effects by binding to estrogen receptors and mimicking the action of estrogen, though they do so at a much lower intensity. In some tissues, they can exert estrogenic effects, while in others, they can have an anti-estrogenic effect by competing with stronger endogenous estrogens. This dual mechanism can be advantageous, particularly for reducing the risk of hormone-dependent cancers like breast cancer. During menopause, the body's estrogen levels decline, and phytoestrogens can help alleviate symptoms by binding to estrogen receptors in cells, producing estrogen-like effects. There are two primary ways phytoestrogens act:

1. **Weak estrogenic effect**: When estrogen levels are low, phytoestrogens can bind to estrogen receptors and produce mild estrogen-like effects, helping to regulate hormonal balance and alleviate symptoms such as hot flashes, night sweats, and vaginal dryness.
2. **Anti-estrogenic effect**: In some tissues, phytoestrogens may compete with stronger forms of estrogen, potentially blocking their activity. This may reduce the risk of hormone-sensitive cancers, such as breast cancer, by lowering the effects of estrogen in these tissues

BENEFITS OF PHYTOESTROGENS IN MENOPAUSE

Reduction of Hot Flashes and Night Sweats

One of the most well-known and bothersome symptoms of menopause is the occurrence of hot flashes and night sweats. Phytoestrogens, particularly soy isoflavones (such as genistein and daidzein), have been shown to reduce the frequency and intensity of these symptoms. Research has demonstrated that women who consume soy-based products or supplements with isoflavones may experience a significant decrease in the occurrence of hot flashes compared to those who do not consume them.[8]

Support for Bone Health

Estrogen plays a critical role in maintaining bone density, and its decline during menopause can lead to a higher risk of osteoporosis. Phytoestrogens, especially lignans (found in flaxseeds and sesame seeds), can help improve bone health by promoting calcium absorption and reducing bone resorption. Studies suggest that consuming phytoestrogens may help slow down bone loss and even enhance bone mineral density in postmenopausal women.[9]

Heart Health Benefits

Menopause is often associated with an increased risk of cardiovascular disease due to the decline in estrogen, which has a protective effect on the heart. Phytoestrogens may help reduce cardiovascular risk factors by improving blood vessel function, reducing LDL cholesterol (bad cholesterol), and stabilizing blood pressure [10]. Some studies show that women who consume isoflavones or lignans may experience better heart health markers compared to those who don't.

Improved Mood and Emotional Well-being

During menopause, hormonal changes can lead to mood swings, irritability, anxiety, and even depression. Phytoestrogens may help regulate mood by balancing hormone levels and improving brain function. Research suggests that isoflavones may have a positive impact on reducing anxiety and mood swings [11]. Additionally, they may help in protecting against cognitive decline, which is a concern for many women during this time.

Vaginal Health and Dryness Relief

Vaginal dryness is a common symptom of menopause due to the decline in estrogen, leading to discomfort and pain during sexual activity. Phytoestrogens, particularly those found in soy and red clover, can help alleviate vaginal dryness by mimicking estrogen's effects on vaginal tissues, thus improving lubrication and reducing irritation.

Weight Management

Many women experience weight gain during menopause, partly due to hormonal changes. Phytoestrogens may help prevent fat accumulation and support **insulin sensitivity**. For instance, **flaxseeds**, which contain lignans, have been shown to have a beneficial impact on reducing belly fat and improving metabolic markers in menopausal women.

Improved Sleep Quality

Sleep disturbances, such as insomnia and poor sleep quality, are common during menopause due to hormonal fluctuations. The mild estrogen-like effects of phytoestrogens may help improve sleep patterns by reducing hot flashes and stabilizing mood, both of which can interfere with restful sleep.

Reduced Risk of Hormone-Dependent Cancers

Phytoestrogens can exert both **estrogenic** and **anti-estrogenic** effects depending on the tissue. In some cases, they may help protect against estrogen-dependent cancers, such as breast cancer.[12] By modulating estrogen levels in the body, phytoestrogens may lower the risk of hormone- sensitive cancers, making them a potential preventive option for some women.

Skin Health

Estrogen contributes to maintaining skin elasticity and moisture. As estrogen levels decline during menopause, women often notice changes in their skin, such as increased dryness and the appearance of wrinkles. Phytoestrogens may help by promoting collagen production, improving skin elasticity, and reducing the visible signs of aging.

Key Phytoestrogen-Rich Foods to Include in a Menopausal Diet

Soy Products

Soybeans and soy-based foods, such as tofu, tempeh, edamame, and soy milk, are the most significant sources of isoflavones (genistein and daidzein).

Flaxseeds

Flaxseeds are an excellent source of lignans, which can be converted into enterolignans by gut bacteria. Ground flaxseeds are the best way to maximize nutrient absorption. Flaxseeds also provide omega-3 fatty acids, which are beneficial for overall health.

Sesame Seeds
Like flaxseeds, sesame seeds are rich in **lignans** and are easy to incorporate into your diet by adding them to salads, yogurt, or smoothies.

Legumes and Beans
Chickpeas, lentils, and other beans provide moderate amounts of phytoestrogens and are versatile in soups, stews, and salads.

Whole Grains
Whole grains such as oats, barley, quinoa, and wheat contain small amounts of lignans and help support overall health during menopause.

Berries
Certain berries like strawberries, raspberries, and blueberries are rich in phytoestrogens and antioxidants, which support the immune system and overall health.

Cruciferous Vegetables
Vegetables like broccoli, kale, Brussels sprouts, and cauliflower contain compounds that influence estrogen metabolism and can help balance estrogen levels in the body.

Red Clover and Alfalfa Sprouts
These sprouts are good sources of coumestans and are available as dietary supplements or can be consumed fresh in salads or sandwiches.

Apples and Carrots
Both apples and carrots contain modest amounts of phytoestrogens and can be easily incorporated into daily meals.

Other Vegetables
Other vegetables like spinach, tomatoes, and sweet potatoes contain lower levels of phytoestrogens but still contribute to an overall balanced diet.

List of Phytoestrogen-Rich Foods to Include in Your Diet
Ayurvedic Perspective On Menopause And Phytoestrogens
In Ayurveda, menopause is viewed as a natural transition in a woman's life, associated with the "Vata dosha" (air and space energy) imbalance. This phase is considered a time for nurturing and grounding the body and mind. Ayurvedic principles emphasize balancing hormones and reducing symptoms of menopause using natural remedies like herbs, phytoestrogens, and dietary changes. From an Ayurvedic perspective, phytoestrogens found in natural foods like soy, flaxseeds, and legumes align with the concept of "medhya rasayana" (nourishing and rejuvenating remedies for the body and mind). These plant-based compounds provide a gentle, natural way to support the body's transition through menopause, reducing symptoms like hot flashes, anxiety, and fatigue Ayurvedic principles emphasize balancing hormones and reducing symptoms of menopause using natural remedies like herbs, phytoestrogens, and dietary changes.

Ayurvedic Herbs and Foods as Phytoestrogen Sources
1. *Shatavari* (*Asparagus racemosus*): Known as a rejuvenating herb for women, Shatavari is rich in phytoestrogens and helps balance hormones, reduce hot flashes, and support reproductive health [13]
2. *Ashwagandha* (*Withania somnifera*): A potent adaptogen that reduces stress, alleviates mood swings, and supports better sleep during menopause [14]
3. Flaxseeds (Alsi): Recommended in Ayurveda for their cooling properties and lignan content, flaxseeds help maintain hormonal balance and promote skin and bone health[15]

4. Sesame Seeds (Til): Valued in Ayurveda for their warming and nourishing properties,
5. Fenugreek (Methi): A commonly used Ayurvedic herb that aids in balancing hormones and reducing menopausal discomforts. [16]. By combining the wisdom of Ayurveda with modern dietary strategies, women can experience a more balanced and harmonious transition during menopause.

LIMITATIONS AND CONSIDERATIONS

While phytoestrogens are generally safe and well-tolerated, there are a few important considerations. Women with hormone-sensitive conditions (e.g., breast cancer) should consult their healthcare provider before significantly increasing phytoestrogen consumption. Additionally, soy products, while beneficial for most, can interfere with thyroid function in women with thyroid disorders. Therefore, personalized dietary advice is essential. Furthermore, the effectiveness of a phytoestrogenic diet can vary depending on individual factors such as gut microbiota composition, which affects the metabolism of lignans into enterolignans. Not all individuals may experience the same level of benefit, and a varied diet with multiple sources of phytoestrogens is recommended.

CONCLUSION

The phytoestrogenic diet offers a promising natural approach to managing menopause symptoms. By incorporating foods rich in isoflavones, lignans, and coumestans, such as soy products, flaxseeds, legumes, and whole grains, women may experience relief from common menopausal symptoms like hot flashes, night sweats, and mood swings. Phytoestrogens may also help maintain bone health, support cardiovascular health, and aid in weight management during menopause. However, more research is needed to confirm their long-term benefits and to determine the best dietary strategies for individuals. Women considering this approach should consult with a healthcare professional to tailor a diet plan that fits their specific health needs.

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Table: 1 - List of Phytoestrogen Rich Foods

Food	Type of Phytoestrogen	Key Nutrients
Soybeans (edamame, tofu, tempeh, soy milk)	Isoflavones (genistein, daidzein)	Protein, isoflavones, calcium, iron
Flaxseeds	Lignans (enterodiol, enterolactone)	Omega-3 fatty acids, fiber
Sesame seeds	Lignans	Calcium, iron, healthy fats
Chickpeas (garbanzo beans)	Isoflavones, lignans	Protein, fiber, B vitamins
Lentils	Isoflavones, lignans	Protein, fiber, folate
Whole grains (oats, barley, quinoa)	Lignans	Fiber, vitamins, minerals
Red clover	Coumestans	Coumestrol, antioxidants
Berries (strawberries, raspberries, blueberries)	Flavonoids, lignans	Antioxidants, vitamin C
Cruciferous vegetables (broccoli, Brussels sprouts, kale)	Indole-3-carbinol, flavonoids	Fiber, vitamins, antioxidants
Apples, carrots	Isoflavones, lignans	Fiber, vitamin C, beta-carotene
Alfalfa sprouts	Coumestans	Protein, fiber, vitamins

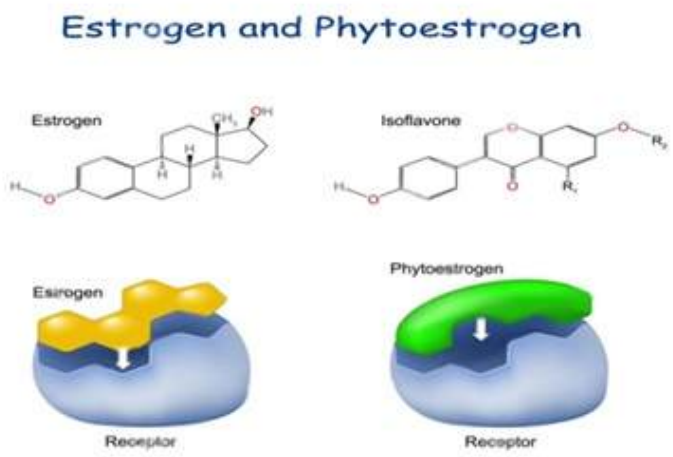


Fig: 1 Structure of estrogen and phytoestrogen



Tofu – Indonesian dish - East Asian dish

Tempeh- Indonesian dish

Edamame

Fig:2

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RESEARCH ARTICLE

Optimal Case Mix with Decomposition and Reformulation Techniques using Branch-and-Bound Method

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ABSTRACT

The emerging field of applied science known as "Operational research" provides a solid foundational understanding of the decision science instruments used to create the collection. The reformulations are suitable to be solved within the frame work of conceptual and computational for solving Mixed-Integer Linear Programming (MILP) problems employing the decomposition principle. In this paper describes a methodology for the case mix problem in the medical sector, and to solve the huge integer optimality, an efficient solution approaches on Branch-and-Bound to decompose and reformulated. This paper work adopts the unit perspective and focuses on the allocation and utilization of resources, and introduces stimulation techniques to access the performance of capacity planning and enhance the ideal trade-off between resource efficiency and service. When works from the column generation perspective, the integer linear programming model can be formulated differently. In terms of the solution, numerical tests and the provided and contrasted computing findings show that the Branch-and-Bound technique works much better than the integer linear programming method, and decomposition on wards performs much better than decomposition on surgeons. Decompose constraints forward into surgeon groups and patient groups to determine the optimal case mix solution and corresponding resource and capacity allocation.

Keywords: Integer Linear Programming, Decomposition, Allocations, Branch-and-Bound, Reformulation, Patient case mix, Optimality Capacity Planning.

INTRODUCTION

In operations research, problems are dissected into fundamental components and then tackled through defined steps via mathematical analysis. Integer programming stands out as a potent tool in resolving numerous critical optimization challenges. Branch-and-bound emerges as a pivotal technique within this domain, offering a structured approach to problem-solving. This method involves breaking down optimization problems into smaller, manageable sub-problems and employing a bounding function to eliminate those sub-problems incapable of containing the optimal solution. Through iterative refinement and elimination, branch-and-bound efficiently navigates the solution space, ultimately converging towards the optimal solution. The case mix problem in the healthcare sector encompasses the intricate long- and medium-term decisions made at both the patient volume planning and control level, as well as at the resources planning and control level of production within a hospital. These decisions revolve around determining the number of patients with varying pathologies that can be effectively treated and the corresponding resource capacity requirements. Critical considerations involve navigating the trade-offs between the capacity provisioned and the diverse demands of patients across different departments within the hospital, emphasizing the need for strategic allocation and optimization of resources to ensure efficient and effective healthcare delivery.

MIXED INTEGER-BRANCH- AND-BOUND METHOD

It was first developed by A H Land and AG Doig. It can be used to solve all integer, mixed integer and zero-one integer programming problems. Given an IP problem, the LP problem obtained by ignoring all integer constraints on variables is said to be its LP relaxation.

IP Problem	LP Problem
Max $z = C^T x$ Subject to $Ax \leq b$ $x \geq 0$ and integer	Max $f(x) = C^T x$ Subject to constraints $Ax \leq b$ $x \leq X^0$ $x \geq X^L$ Where X^0 and X^L are the are the rates of upper and lower bound for the decision variable

It divides the feasible solution area into smaller areas until the optimal solution is reached. It does so by placing limits on the value of the objective function that allows for the sub problem to be prunned if the optimum solution was found. For the purpose of this study, the hospital is treated as a profit maximiser, given the rising economic pressures in the health care sector (OECD 2010). In short, based on the estimations of the amount of patients with a specific pathology that will be admitted to the hospital as well as based on financial contribution estimations, expected length of surgery, length of stay per pathology and knowledge of which surgeon group will be assigned to which ward for care of a patient with said pathology, it is necessary to determine for this study how many patients from each pathology group can be treated by the hospital in one year for the purpose of maximizing total contributions, as well as subsequently assigning operating rooms to groups of surgeons and allocating beds to each ward. In this research, we have a comprehensive study of case mix planning problem specifying within a hospital. Considering multiple resources with fixed capacities like operating rooms and beds, hospitals select the optimal patient case mix in order to maximize the resource efficiency (the total financial contribution). We build a mathematical model for the case mix problem and design efficient branch-and-price algorithms to solve integer program model optimally.

CASE-MIX PROBLEM STATEMENT

To respond to the rising pressures on health care sector, the hospital is presumed to be a profit maximizes. the expected financial contribution, the expected surgery time and the expected length of stay for each pathology, and the knowledge about which surgeon group and which ward a patient with a specific pathology will go to, it can be said that in this taxi cab problem the case mix research in this article is the quantity of patients which types can be managed at the hospital for the next year in order to maximize the total contributions, and accordingly determine on which surgeon groups an operating room is allocated and how many beds are allocated to each ward. This leads to the delivery of a 'best' patient case mix pattern of maximum profits and a time-phased distribution of resources.

In this paper, the health care provider (i.e., hospital) is assumed to be a profit maximise, which intends to select an optimal case generating maximum profits under the provided resource capacity and other certain constraints. It is assumed that there is reserved capacity for emergency patients at the hospital. Hence, only elective surgery cases are considered. Additionally, it is noteworthy that the "profit" is not limited to the financial contribution.

In addition, in order to build a mathematical model for the case mix problem, the required notations are defined below. The following observations and assumptions

1. Number of different hospital business units and act as independent unit. Other resources are not covered in this research.
2. In hospital unit consists of surgeon groups and ward with a constant number of beds to the patients in the entering unit.
3. Assumed to be Active days and Inactive days. The block length is defined as eight hours. Finally, it should be mentioned that the special surgery cases with a planned duration that is longer than the block length will be excluded from our discussion.
4. To assume, beds allocated to a ward are only reserved patients from the corresponding department. In contrast with the time-phased allocation of OR blocks, beds are assigned to each ward in a fixed pattern. Theoretically, a flexible bed allocation schedule that allows bed sharing will help to level the bed occupancy among various wards and thus boost the overall utilization of the bed capacity.
5. The first step is the surgeon group doing surgery on the patient. The second step is the OR time corresponding to patient in surgery duration. The third step is the number of days for patient occupies bed in the corresponding ward (LOS) and the fourth step is the reward of the treatment.
6. LOS represents the patient within one group with same parameters, but those from different groups differ from each other for at least one of the parameters.
7. In case mix problem assume the period consists of a cycle length of one week (repeated cycles). See Figure 1 for an illustration of the relationship among wards, surgeon groups and patient groups within a hospital.
8. Number of patients in patient group under surgery during a cycle period is constrained by different factors.
9. Surgeon capacity sets an upper limit for the maximum number of patients during the cycle. Thereby, for each patient group a numerical range is specified for the total number of patients that can get admitted during one cycle length.

S-Surgeon group
P-Patient group
Indices:
W=Set of Wards.
S = Set of Surgeon groups.
P = Set of Patient group.
D =Set of day with in a cycle.
A = Active days. (Active days=Monday to Friday & Inactive days = Saturday and Sunday)
S_W=Subset of surgeon groups whose patients are moved toward W after treatment.
P_W =Subset of patient groups P whose patient occupies the bed.
P_S= Subset of patient groups whose patients are operated on by surgeon group.
AP_d=Subset of Active days it applies patients P still occupy a bed on day.
P_p= Profit in patients of patient group.
d_p=Duration time in patients of patient group.
LB_p=Lower bound on number of patient P that treated per day a cycle.
UB_p=Upper bound on number of patient P that treated per day a cycle.
BD=Available beds.
BLOCK=Total number of available operating room block.
LEN = Assumed 480 minutes.
U_{pa} = The number of patients of patient group that receive surgery on active day.

V_w = The number of beds allocated to ward.
Z_{sa}=The number of OR blocks assigned to surgeon group S on active day.
Then, with the assumptions and notations given above, the case mix problem that aims at maximizing the overall hospital profits is formulated as an integer linear programming (ILP) model.

MATHEMATICAL FORMULATIONS

Maximize$\sum_{p\epsilon P} P_p \sum_{a\in A} E_{pa}$ (1)
Subject to constraints
$\sum_{w\in W} V_w \leq BS$ (2)
$\sum_{p\in P_w} \sum_{a\in A_{pd}} E_{pa} \leq F_w$ (3)
$\sum_{S\in S} G_{sa} \leq Bl$ (4)
$\sum_{p\in P_s} d_p E_{p_a} \leq z_{sa} l_G$ (5)
$LB_P \leq \sum_{a\in A} E_{p_a} \leq U_{B_P}$ (6)
$E_{p_a}, F_w, G_{sa} \in z^+$ (7)

Maximize the sum of the profits from treating all patients during one cycle.
Constraint (2) Allocation capacity of beds. Constraint (3)Daily bed used cannot exceed its limit. Constraint (4)Time phase Constraint (5) every surgeon group has assigned to patient on each active day. Constraint (6) each patient group as numerical range fixed as number of patient admitted on Active days. Constraint (7)Decision variable for non-negative integers. Generally the formulation results in a huge Integer program for hospital of regular size[eg: 25 depart]. The ILP Modeling produces l+5m+5n decision Variables, the formulated ILP model contain 1525 Integer variables. The new branching conditions will further constrain the master problem, which will be solved again. An integer solution to the master problem is known to be a lower bound and the optimal solution to the relaxed problem is a known upper 20 bound on the optimal objective value. The new ones will be checked against the best bounds, and will replace them if they are better. The loop of iteration continues until the branch-and-bound tree is completely traversed or the optimal upper bound == optimal lower bound.

DECOMPOSITION BASED REFORMULATION

Decomposition on wards means that a set of variablesU_{pa} for all active days a and for all patient group P whose patient are transferred to ward will be aggregated to form feasible column for each ward W

Decomposition based reformulation on wards

To represent these columns a new binary decision variables is introduced and define as follow

C_{wk}=$\begin{cases} 1; if\ column\ k\ is\ selected\ for\ w \\ 0; otherwise \end{cases}$

K =set of feasible column

Reformulated as follows

Max $\sum_{w\in W} \sum_{k\in K} p_{wk}\, C_{wk}$ (8)
Subject to constraint
$\sum_{w\in W} \sum_{k\in K} F_{wk}\, C_{wk} \leq BS$ (9)
$\sum_{w\in W} \sum_{k\in K} G_{wak}\, C_{wk} \leq BL$ (10)
$\sum_{k\in K} C_{w\,k}$=1 (11)
$C_{wk} \in \{0,1\} \quad w \in W, k \in K$ (12)

Reformulation of wards

Max $\sum_{p\in P_w} P_p \sum_{a\in A} E_{pak} - (\sum_{k\in K} F_{wk}\, C_{1w} + \sum_{a\in A} G_{wak} C_{2BL})$ (13)
Subject to constraints
$\sum_{p\in P_w} \sum_{a\in A_{pd}} E_{pak} \leq F_{wdk}$ (14)

$\sum_{p\ \in P_w} d_p E_{pak} \leq G_{sak}$ (15)

Decomposition based reformulation on surgeon group

If the decomposition is based on the surgeon groups, a set of variables U_{pa} for all active days *a*and for all patient groups *p* whose patients are operated on by surgeon groups are aggregated to form a column for surgeon groups. Similarly, a new binary decision variable is introduced to represent these columns:

$C_{SK} = \begin{cases} 1; if\ column\ k\ is\ selected\ for\ S \\ 0; otherwise \end{cases}$

Reformulated as follows

$Max \sum_{s\in S} \sum_{k\in K} P_{sk}\, C_{sk}$ (16)

Subject to constraint

$\sum_{w\in W} F_w \leq \text{BS}$ (17)

$\sum_{s\in Sw} \sum_{k\in K} F_{sdk}\, C_{sk} \leq F_w$ (18)

$\sum_{s\in S} \sum_{k\in K} G_{sak} C_{sk} \leq BS$ (19)

$\sum_{k\in K} C_{sk} = 1$ (20)

$\text{C}_{\text{sk}} \in \{0,1\}$ (21)

Reformulation on surgeons

$\text{Max} \sum_{p\in P_s} P_p \sum_{a\in A} E_{pak} - (\sum_{k\in K} F_{sk}\, C_{3w} + \sum_{a\in A} G_{sak} C_{4BL})$ (22)

$\sum_{p\in P_s} \sum_{a\in A_{pd}} E_{pak} \leq F_{sdk}$ (23)

$\sum_{p\in P_s} d_p E_{pak} \leq G_{sak}$ (24)

Decomposition on patient group

When the decomposition unit is set as the patient group, a set of variables for all active days and for a patient group are aggregated to form a feasible column for this patient group , which is expressed by the defined binary column variable

$C_{PK} = \begin{cases} 1; if\ column\ k\ is\ selected\ for\ P \\ 0; otherwise \end{cases}$

Reformulated as follows

$Max \sum_{p\in P} \sum_{k\in K} P_{pk}\, C_{pk}$ (18)

Subject to constraints

$\sum_{w\in W} V_w \leq BS$ (25)

$\sum_{p\in P} \sum_{k\in K} V_{pdk} C_{pk} \leq V_w$ (26)

$\sum_{s\in S} Z_{sa} \leq BL$ (27)

$\sum_{p\in P} \sum_{k\in K} Z_{pak} C_{pk} \leq Z_{sa}$ (28)

$\sum_{k\in K} C_{pk} = 1$

$C_{pk} \in \{0,1\}$ (29)

Column Initialization

The generation of initial columns is combined with a problem feasibility in one Numerical Range (6) of patient admissions of each group is modified into the fixed lower bound in the original ILP model:

$\sum_{a\in A} U_{pa}$=LB_p,$\forall p \in P$

Clearly, the feasible solution of the reduced model is also feasible to the original ILP.

- If the reduced model has no feasible solution that is the given capacity cannot satisfy the minimum

requirement of patient admissions and thus the problem is infeasible.

- After fixing the number of admitted patients of each group to its lower bound.
- To find more initial columns, the admission volume for a certain patient group is relaxed to its upper bound (i.e., ≤ UBp), while the number of admitted patients for all other groups is kept at their lower bound.

Branching

we adopt the branching strategy based on the capacity assignment variables F_w and G_{wa} for the decomposition model onwards, or F_{sd} and G_{sa} for decomposition surgeon groups. If the solved optimal solution to the master ILP is not integral, there exist at least two fractional column variables related to one ward, for instance C_{wk} and C_{wk}^1 at least one value of the capacity assignment variable F_w and G_{wa} different from each other in these two columns, (i.e.) $G_{wak} < G_{wak}^1$

The branching conditions

$G_{wa} \leq G_{wak}$ and $G_{wa} \geq G_{wak}+1$

Branching on the capacity assignment variables not only excludes the fractional optimal solution effectively, but also partitions the solution space into two branches more evenly.

Bounding

A complete computation process can be divided into two parts: searching for the optimal solution and proving its optimality. Applying bound a help the current node in the branch-and-bound tree possesses the potential to outperform the present best bound. To find Integer feasible solution and to provide lower bound on the optimal value.

Cut off Value

When solving the integer problems, a cut off value can be specified to help terminate the calculation earlier. If the objective value of the integer problem is recognized as impossible to exceed the cut off value of the integer problem is recognized as impossible to exceed the cut off value, then no need to continue searching for the optimal solution or any feasible solutions. The objective value can beat the cutoff value is often less time-consuming than to obtain an optimal or feasible solution.

Existing results

Stefan Weltge, Leo Liberti and Marco Lübbecke. (2018) this paper introduces a branch-and-price algorithm for solving mixed-integer linear programs with separable structure, highlighting the benefits of decomposition methods in addressing large-scale optimization problems. Andrea Lodi, AntonioFrangioni, and Michele Monaci. (2019) this paper presents a Dantzig-Wolfe decomposition approach for solving robust mixed-integer programming problems, demonstrating its applicability in addressing uncertainty in optimization models. W. S. Guerino, AlexandreSalles da Cunha, and Eduardo Uchoa. (2020) this paper proposes a branch-and-cut decomposition approach for solving the capacitated arc routing problem with time windows, showcasing advancements in solving complex routing problems using decomposition techniques

CONCLUSIONS

The ILP models start with a number of constraints with dummy data that involve no more than 5 parts. Without loss of generality, it is assumed that each part has three surgeon groups with handling 3 testing parameters. For each patient group, the lower bound on the number of patients admitted per cycle is set as one and upper bound is generated randomly from the discrete uniform distribution within the interval [3, 6]. Similarly, expected for surgeon duration [60,240] and the mean value credit as [12, 30]. In the presence of only one ward, to solved and obtains the optimal solution with proven optimality result. If number of wards are increases to 3, the computing process slow down to 49 seconds. Now the proposed Branch-and-Bound algorithm successfully exhibit their efficiency and

effectiveness to solve case-mix problem. First factor the number of sub problems to be solved at each round in surgeon group decompose method is three times more than ward decompose method. Second factor One relaxation efficiency is defined as the difference between the LP relaxation value and optimal value over the optimum the relaxation efficiency in surgeon group [5 to 10%], the decomposition of ward gives closer bound within 0.01%. To allowing a decomposition unit to access solution space to be explored even if the chance of finding the optimal or a feasible solution there is very small. Branched and bounded algorithm ends when all solutions are pruned or fixed. It only implemented one particular branch-and- bound method for a single (although reasonably generic) class of problems using a modelling language (CPLEX, GAMS, OPL, MPL, etc.) it is easy to make the computer solve the problem. In recent phase developed Machine Learning (MIL) algorithms could provide new tools for MIP computations, and lead it towards even flexible and sophisticated outcomes. In the case mix problem, the objective of maximize the total hospital profit and formulated as an integer linear program model to determine the obtained case mix solution and computational reformulated capacity allocation in Branch-and-Bound to extremely speedy and effective the tackling the case mix problem. This work adopts the unit perspective and focuses on the allocation and utilization of resources, and introduces stimulation techniques to access the performance of capacity planning and enhance the ideal trade-off between resource efficiency and service.

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Table.1 Analyze the IPP model various systems

Problems	Objective function	Subject to constraints
Production Problem	Total Cost = (Selling Price-Budget) (Max)	Machine time Assembly time Budget
Production Allocation Problem	Selling price(max)	Drilling Shaping Polishing
Marketing Problem	Cost perton (Min)	Materials
Investment Problem	Investment the money(max)	Availability of money Government bonds Shares Mutual fund Money market
Agricultural Problem	Cost+ Manure+ Selling Price=Total Cost (Max)	Yield products
Man Power Problem	Nurses work on shifts(min)	Number of nurses

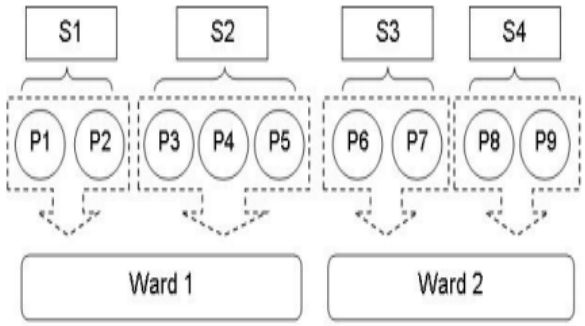
Table 2: Decomposition Analysis for wards and surgeons

S. No.	Parameter			Decomposition Analysis			
	Wards	Beds	Blocks	Group of Wards		Surgeon Groups	
				Solution	Time	Solution	Time
1	1	8	1	240	0.2	240	0.2
2	3	25	2	480	3.75	480	3.75
3	5	50	3	520	4.20	520	4.20
4	8	75	4	1040	5.65	1040	5.65
5	10	100	5	3140	6.25	3040	6
6	15	125	6	4180	7.85	3980	6
7	20	150	7	5545	9.26	5340	6
8	25	175	8	6500	9.26	6789	6
9	30	200	9	7225	10	7025	6

Table 3: Comparison of Relaxation of Efficiency

Ward	Beds	Block	optimum	Ward decomposition	Surgeon decomposition	Efficiency
5	50	3	1400	1400	1530	4.02 %
10	100	5	3372	3372	3476	4.15 %
15	150	8	4775	4775	5140	7.63 %
20	200	10	5716	5716	5920	8.76 %

25	250	12	6992	6992	6300	9.76 %
25	250	15	7300	7300	7600	7.63 %
25	250	20	7502	7502	7890	9.75 %



S-Surgeon group
P-Patient group
Fig.1. Relationship between Wards, Patient, Surgeon groups

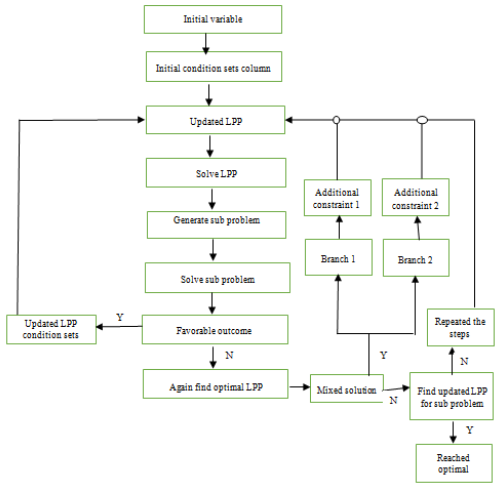


Fig.2 Flow chart for case mix problem

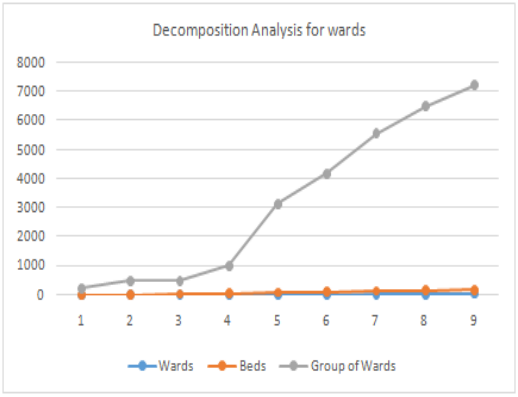


Figure 3: Graphical analysis of decomposition results in ward

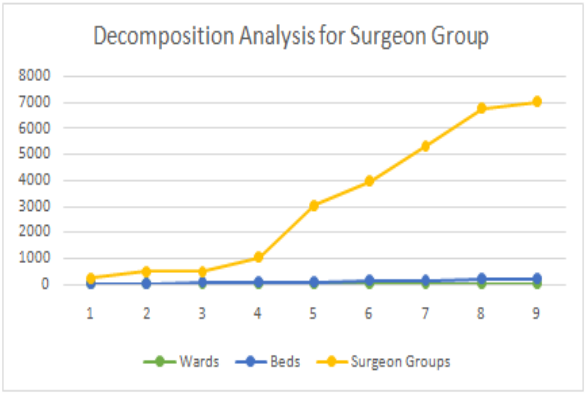


Figure 4: Graphical analysis of decomposition results in surgeon group

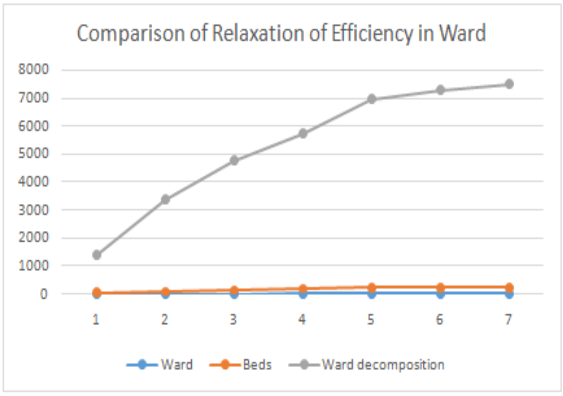


Figure :5 Comparison of Relaxation of Efficiency in ward

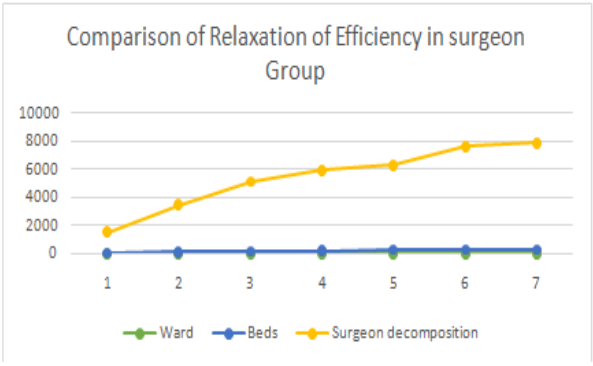


Figure 6: Comparison of Relaxation of Efficiency in surgeon Group

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RESEARCH ARTICLE

Regulatory Framework for Medical Device in Emerging Market

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ABSTRACT

By 2025, the rapidly expanding Indian medical field is predicted to be worth $280 billion. India is among the top 20 countries in the world for medical device sales. By 2025, its present worth of $5.2 billion is predicted to rise to $50 billion. However, India still imports over 70% of its medical equipment and does not produce many of them domestically. Medical gadget manufacturing and monitoring are strictly regulated processes. There were no particular laws governing medical devices in India; instead, the Drugs and Cosmetics Act of 1940 governed them. The new Indian medical device laws, known as the Indian Medical Device Rules, 2017, were announced by the Central Drug Standard Control Organization to fill this loophole. These were modified in accordance with the requirements and became the Medical Devices (Amendment) Rules, 2020, which went into effect in April 2020. categorization, enrolment, manufacturing and import, branding, sales, and post-market obligations are just a few of the regulations that are covered by these standards. The regulations are a step in the right direction and cover the majority of the EU approval process, which requires that the devices are safe and fulfil their intended purpose. However, given the speed at which medical device technology is developing, there is a strong need for clarification and a revision of the current regulatory framework to harmonize standards and bring them into compliance with more sophisticated laws such as those of the EU.

Keywords: Medical devices, EU approval process, Amendments, sales, brand

INTRODUCTION

In the twenty-first century, India's healthcare system has seen substantial improvements. India has achieved an increase of ten percent in this area throughout the years, and it is anticipated that it will exceed $280 billion by 2025[1]. In contrast to the US, EU, China, and global average, which were $9403, $3613, $420, and $1061, respectively, India's per capita healthcare spending in 2016 was $75, which was insignificant. [2] The Indian healthcare market is currently valued at $128 billion and is projected to expand at a rate of 12% over the next four years. [3] In order to verify the safety, efficacy, and quality of medical devices used for disease diagnosis, avoidance, or medical care, medical device regulation is an essential component of the healthcare sector. In order to protect public health and keep up with advancements in medical technology, the regulatory environment for medical equipment is always changing. [4,5] Any apparatus, machinery, devices, or other like objects used to identify, treat, or prevent disease or other health issues in people are considered medical devices. These gadgets could be as simple as tongue depressors and thermometers or as complex as pacemakers, robotic surgical systems, and magnetic resonance imaging (MRI) equipment. Any tool, equipment, execute, machine, appliance, implant, in vitro reagent, software, material, or other comparable or related item that the manufacturer intends to be used, either alone or in combination, for a medical purpose is considered a medical device by the World Health Organization (WHO). [6] In India, almost 70% of medical equipment is brought in. [7] The disparity between manufacturing and imports offers medical device producers a significant chance to close this gap through domestic production and sales. The process of developing medical devices is now laborious and extremely complicated. One of the most structured procedures is approval, which is subject to strict regulations and oversight under the Medical Devices (Amendment) Rules, 2020 and the Indian Medical Device Rules (IMDR) 2017[8,9] categorization, authorization, manufacturing and import, labelling, sales, and post-market obligations are only a few of the regulations that are covered by these standards.

HISTORY

The first US medical device rules were put into effect in the early 20th century, marking the beginning of the background of medical device regulation. Since then, new laws and organization have been established to ensure the safety and effectiveness of medical devices, resulting in a substantial evolution in the regulation of these devices. A foundation for medical device regulation in the United States was established in 1976 by the Medical Device Amendments, which were created by the FDA. (10,11) The medical device regulatory environment of today is a dynamic, intricate structure involving numerous agencies and jurisdictions. The FDA is in charge of regulating medical devices in the US (12,13), whereas the European Medicines Agency (EMA) and the European Commission are in charge of this in Europe (14,15).

CURRENT REGULATORY FRAMEWORK

Ensuring that all goods on the market are high-quality, safe, and effective for both patients and physicians is the aim of the current medical device regulatory system. Pre-market assessment and clearance, post-market surveillance, and the required reporting of adverse events are all part of the regulatory process. To protect the public and keep up with the quick changes in the medical device sector, the regulatory framework governing these devices is always evolving. (16,17)

COUNTRY – SPECIFIC REGULATORY FRAMEWORKS UNITED STATES

The United States, the Federal Food, Drug, and Cosmetic Act governs medical devices in the United States. Prior to the medical device being marketed in the United States, the FDA must receive the marketing application and issue approval.[18] The FDA's Centre for Devices and Radiological Health (CDRH) is principally responsible for overseeing medical devices in the US before and after they are put on the market.[19] Medical devices are now categorized in the US using a risk-based system, which bases the categorization on the dangers of using the equipment.[18] Class I devices have the lowest danger, Class II devices have intermediate risk, and Class III devices have the highest risk[20].

DEVICE CLASSIFICATION

CLASS I DEVICES

These are gadgets that don't pose a ridiculous risk of patient illness or harm. General controls, which include widely recognised standards for labelling, manufacture, post-market surveillance, and reporting, govern Class I devices. When there is a reasonable assurance that general controls alone will be adequate to ensure safety and efficacy, devices are given class I designation. Additionally, the FDA has been given countermeasures including recall prerogative and seizure. The majority of class I devices do not require formal FDA review prior to going on sale. The FDA does not conduct independent evaluations of these products, nor is it necessary to verify each one's efficacy and safety prior to release. Products in the class I category include, for instance, crutches, tongue depressors, and portable surgical tools. [21-23]

CLASS II DEVICES

Class II devices are higher-risk devices for which there is enough data to support special controls and for which ordinary controls alone are insufficient to ensure safety and efficacy. Since these devices are more likely to cause injury than class I devices, they are subject to additional regulations and extra controls, which the FDA may verify. Additionally, most class II devices require FDA approval of a 510(k) premarket notification procedure prior to release. The manufacturer of the medical device must provide evidence in the 510(k) procedure that the new device is equivalent to one that is legally sold. Few 510(k) applications require clinical data, despite the fact that this can usually be confirmed by bench and testing on animals alone. High-tech items like oxygen masks, tampons, pumps for infusion, surgical drapes, and heart monitors are typically included in this category of devices. [21, 22]

CLASS III DEVICES

Class III devices are either life-sustaining or life-supporting, or they are crucial in preventing human health deterioration. Heart valves, coronary stents, pacemakers, and other devices are examples of class III devices. Since they are thought to present the greatest risk of disease or harm, general and particular controls by themselves are not enough to prove safety and efficacy. As a result, the FDA must provide premarket clearance (PMA) for the majority of class III devices prior to their release. [21]

DEVICE APPROVAL

Class I devices have been authorized despite any clinical or pre-clinical studies due to their minimal risk and presumed safety and effectiveness. The 510(k)clearance procedure is used to approve Class II devices. Although pre-clinical data for these devices frequently show that they function as planned, clinical efficacy data are frequently unavailable. Premarket authorization is required for Class III devices (PMA). A modest safety trial and an investigational new device (IND) application are necessary for this phase. A potential clinical trial that compares the IND to the standard of care is a crucial component of the IND application. These studies might take years to finish, cost millions of US dollars, and are usually randomized. However, high-risk devices may be authorized under the 510(k)clearance process if they are judged to be roughly comparable to an existing device. The majority of device applications are handled via the 510(k) method, which processes 4,000 applications annually as opposed to less than 100 PMA applications.[24] Companies are motivated to have their devices deemed substantially equivalent and thus eligible for 510(k) clearance, as evidenced by the fact that the mean cost from concept to approval, as reported in an industry.

POST MARKET SURVEILLANCE

The Safe Medical Devices Act of 1990 established post-market surveillance, [27] requiring healthcare facilities to notify manufacturers and the FDA of serious injuries or deaths related to devices, and allowing the FDA to require device tracking, a post-market registry, or a clinical trial if necessary. The FDA receives between 80,000 and 120,000 adverse-event reports per year [24,28] Because the reporting system is optional for consumers and healthcare providers, adverse events are believed to be significantly under-reported. [29–31] Patients, providers, and other healthcare providers can report detrimental incidents via the FDA Med Watch reporting program, which receives about 5,000 reports annually, with nurses accounting for 25% of reports and physicians for only 8%. [24] Public

health advisories, health alerts, and product cancellations or removals may result from FDA investigations based on these monitoring systems. Allograft tissue is an intriguing class of materials frequently employed in orthopaedics. Section 361 of the Public Health Service Act defines these products, which is why they are called "361" products. These products are meant for homologous usage and have undergone minimum processing. They cannot contain a cell or tissue that might pose a safety risk when mixed with another tissue. They can't be mixed with another medication, gadget, tissue, or biologic agent. They are unable to function in a systemic manner and are dependent on living cells.[32] They are exempt from the PMA procedure if these requirements are satisfied. [33] As a result, independent post-market clinical studies typically include the only information on the clinical efficacy of these products. Because these goods can be licensed for use without efficacy evidence as long as they meet the previously mentioned conditions, manufacturers are not as motivated to look into efficacy. These goods are frequently utilised in orthopaedics, such as fresh osteochondral allografts, particulate juvenile articular cartilage allograft, allograft bone and demineralised bone matrix products, and tendon grafts for ligament restoration.

POLICIES IMPLEMENTED IN MEDICAL DEVICES REGULATION IN THE US

The interactions between pharmaceutical and medical device producers and government regulatory agencies are the focus of the regulatory affairs, or government affairs, area. The main government agency in charge of these companies in the US is the Food and Drug Administration (FDA). The FDA's Centre for Devices and Radiological Health (CDRH) regulates businesses that manufacture, repackage, relabel, and/or import medical devices sold in the United States. The evolution of regulatory affairs in the US has been impacted by a number of factors, including changes in governmental policy, technology improvements, and the complexity of the regulatory environment. In 1976, the pre-market approval (PMA) system was established. Similar to the PMA process for new drug applications, extensive testing is required to ensure that a device is safe and effective for its intended purpose, particularly for products that are vital to preserving human life or averting health harm. However, a second, less strict procedure designated as the 510(k) clause was developed in 1976 to facilitate the sale of later versions due to the large number of products existing on the market [34].

EUROPEAN UNION

In vitro diagnostic (IVD) and medical devices (MD) have proven crucial in saving lives and offering healthcare solutions for disease prediction, diagnosis, treatment, and prevention. Given the wide range of medical devices available on the market, a strong and open regulatory framework is required to enhance clinical safety and establish equitable market access for producers and medical practitioners. [37] On May 5, 2017, two new European regulations went into effect: Regulation (EU) 2017/745 on Medical Devices (MDR) and Regulation (EU) 2017/746 on In Vitro Diagnostic Medical Devices (IVDR). The three pertinent European institutions—the European Commission, the European Parliament, and the European Council—agreed on the legislation at the legislative level. After a phased transition period and an extra year's delay because of the global COVID-19 epidemic, the Medical Devices legislation is now completely applicable as of May 26, 2021. In order to facilitate a seamless transition and prevent market disruption, the In Vitro Diagnostics legislation will go into force in May 2022. They do not need to be converted into national legislation because they are immediately relevant in all EU member states as rules rather than directives. As a result, the MDR and IVDR will reduce interpretational differences throughout the EU market and provide national regulators with far greater authority and supervision over the medical device sector. [38] These new rules will regulate the production and transportation of medical equipment in the European Union. As a result, businesses must proactively adhere to these reforms; failing to do so may result in the loss of their operating licence. In order for the medical device sector to swiftly adjust to the new legislative environment, a new model must be created. In accordance with the new Biomedical Device regulations, this model must prioritise true unfulfilled clinical need in unique chronic situations in order to obtain rapid market access. [39]

DEVICE CLASSIFICATION

The European Union's system for classifying devices is comparable to the US FDA's.

CLASS I DEVICES

Devices classified as class I have a low risk of injury.

CLASS IIa DEVICE

Class IIa devices are those deemed relatively low risk to humans. Examples of class IIa devices include intravenous pumps and electronic wheel chairs.

CLASS IIb DEVICE

Class IIb devices pose a relatively high risk of harm to the human body.

CLASS III DEVICES

Class III gadgets are thought to pose the greatest risk of injury to patients and either require electricity to operate or put the patient's life in peril.

DEVICE APPROVAL

Class I devices in the European Union are authorised based on the manufacturer's declaration of conformance with fundamental requirements, such as good manufacturing procedures, appropriate labelling, and sufficient packing and storage, in a procedure akin to that of the USFDA system. Devices classified as Class IIa must be submitted to a notified entity. A literature review and pre-clinical data proving the device's intended function are typically required by the notified body for class IIa devices. However, the requirements are set by the particular notified body. Approval of class IIa devices typically takes one to three months. Both class III and class IIb, which include the majority of orthopaedic devices, call for application to a recognised body. Clinical and preclinical data demonstrating the device's efficacy and safety are included in these submissions. Clinical data demonstrating the device's performance and safety, as well as a study of related approved devices, are usually included in the supporting evidence. With historical control patients, the clinical trials are usually non-randomized single-arm case series. The particular standards for every device clearances in the European Union are set by the notified body engaged by the device producer in the approving nation.

POST MARKET SURVEILLANCE

Post-market safety surveillance is the responsibility of the appropriate officials in each of the EU's member states. It has been necessary since 2011 to include all adverse occurrences in the European Databank on Medical Devices (Eudamed). The manufacturers of authorised devices, the history of certifications granted, revoked, or rejected, and the device's current clinical studies are also listed by Eudamed. In the event that the device's long-term safety is uncertain, the notified authority may mandate that businesses do post-market research as a part of the CE mark certification.

POLICIES IMPLEMENTED IN MEDICAL DEVICES REGULATION IN THE EU

With assistance from important organisations like the Medical Device Coordination Group (MDCG) and the European Medicines Agency (EMA), the European Commission is in charge of regulating medical devices in the EU. These regulatory agencies are essential to guaranteeing that medical device laws are followed and applied consistently across all EU member states. In responsibility of the regulatory affairs in the EU, the EMA and the MDCG assist in the publication of EU medical device regulations and are responsible for monitoring the regulation of pharmaceuticals and medical devices, accordingly [40,41]. The MDCG is an organisation of professionals established in compliance with EU law to provide guidance and ensure that medical device laws are applied consistently across EU member states. Even aftercurrent medical device regulations have been examined, there is still a need to review the procedures for regulatory authorisation of medical equipment in the US and Europe [42–44].

COMPARISION OF THE REGULATORY SYSTEMS OF UNITED STATES AND THE EUROPEAN UNION

The regulatory systems in the US and the EU diverge from the very beginning. Concerns over patient safety in the 1970s in the US served as the impetus for the Medical Device Amendments of 1976 and the FDA's regulation of

devices. The EU market's unification, which sought to boost invention and manufacturing processes throughout Europe, served as the impetus for the Medical Device Directives. The EU approach requires device producers to collaborate with private notified entities, but the US FDA method mandates that businesses engage exclusively with the government regulatory body tasked with safeguarding the public's health. It has been questioned by some authors whether the notified organisations are more concerned with bringing technologies to market than with ensuring public health and safety. [45, 46-48] The EU system may be able to shepherd new gadgets to patients faster than the US system, which is the biggest obvious difference between the two systems. While the FDA's requirement for proof of efficacy necessitates extensive studies comparing patients treated with the medical device to the control group reflecting the current standard of treatment, the EU's requirement for demonstration of performance can be met with a single-arm case series. The Guard Wire (Medtronic) gadget is a great illustration of this distinction, while not being an orthopaedic device.[49] The company demonstrated the device's ability to aspirate embolic debris distal to an angioplasty treatment in a saphenous vein graft using a case series including 22 patients in order to obtain the CE mark. However, an 800-patient randomised, controlled clinical trial proving that the device's use decreased 30-day embolic consequences after saphenous vein graft angioplasty was necessary as evidence of efficacy for FDA approval. [50] No conclusive studies have shown that the USFDA method is better than the EU process, regardless its longer duration to market. Only a non-peer-reviewed research supported by Adva Med, a trade group that represents the medical device industry, compared recalls in the two systems. According to this data, between 2005 and 2009, there was little impact in device recalls between FDA-approved and EU-approved devices. [51] Before Eudamed was created in 2011, the European Union lacked a common reporting system for device recalls and safety-related incidents, which has hampered research on device safety. Heneghanet al. conducted a study in the United Kingdom [52].

CONCLUSION

This article presents a comparative examination of medical device legislation and regulations in a number of countries, highlighting significant differences in regulatory regimes across different countries. India and Africa have much looser regulatory frameworks, while the United States and Europe have the most stringent laws. The paper offers suggestions for developing nations to enhance their regulatory systems, such as establishing regulatory agencies and bolstering enforcement procedures, based on its research of case studies pertaining to medicaldevices. The need of medical device regulations is emphasized throughout the article, particularly In developing nations where access to dependable medical equipment is essential. It highlights the need for legislators and business professionals to collaborate and apply best practices in order to create a regulatory environment that encourages innovation while ensuring patient safety.

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Table 1: Difference in Device Regulation in the United States and European Union

FACTOR	UNITED STATES	EUROPEAN UNION
Purpose/ Structure	The FDA is a government agency mandated to protect the public's health.	Notified bodies regulate device approval as private companies. Competent authorities are government agencies that regulate post market surveillance of safety and facilitate trade among countries of the European Union.
Centralization	The FDA regulates device approval and surveillance under one umbrella	More than 70 notified bodies regulate device approval separately. A competent authority in each of the countries of the European Union is tasked with device safety and surveillance.
Funding	Federal appropriations provide >80% of funding. User fees provide approximately 20% of funding.	Notified bodies are completely funded by contracts with device manufacturers. Finding of competent authorities varies by country.
Data requirement for approval	A device must prove to be safe and Efficacious through premarket authorization approval or prove to besubstantially equivalent to a predicate device through 510 (k) clearance.	Proof is required that the device can perform its intended function.
Premarket transparency	Proprietary limits exist on the sharing of information, but safety and approval data are shared through the FDA.	Approval decisions of the notified bodies are not made public.
Device surveillance	Reporting by manufacturers and healthcare institutions to the FDA is mandatory. Reporting by healthcare professionals and consumers is voluntary. The FDA can issue public health advisories, safety alerts, and product suspensions or withdrawals.	Manufacturers must submit adverse events to competent authorities. All adverse events have been required to be submitted to the European Databank on Medical Devices since 2011. Post market data are shared among competent authorities can issue adverse event reports and field safety notices or device recalls.

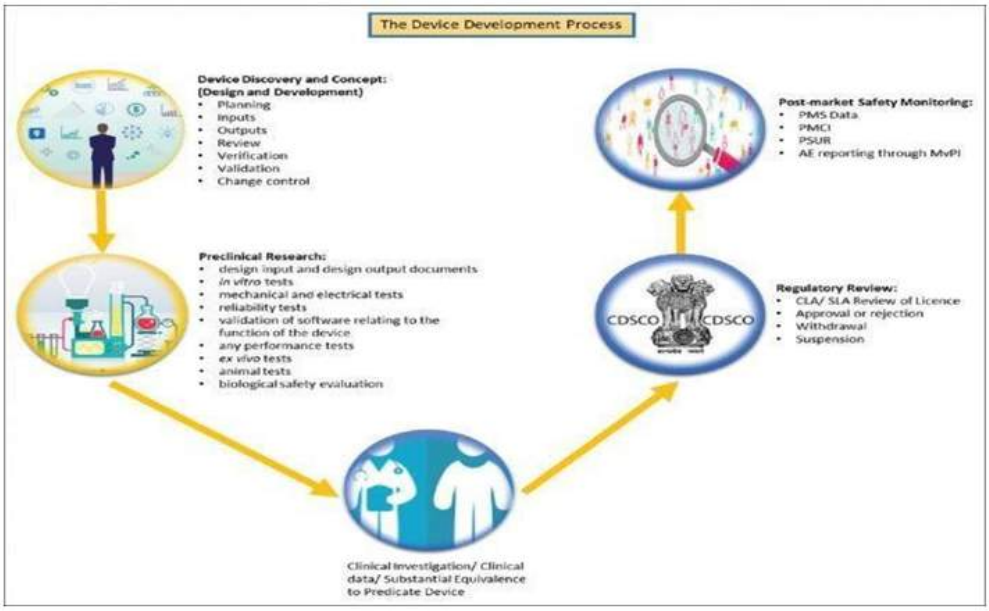


Figure 1: Explains the device development process from conception to post-marketing surveillance (PMS).—

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RESEARCH ARTICLE

An Experimental Study on Organic Fraction of Municipal Solid Waste Pellets through Scanning Electron Microscopy Analysis

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ABSTRACT

Solid waste is being utilized as a significant source of renewable energy. The Central Pollution Control Board (CPCB) reports that 152,749 tons of solid waste are processed, with 50% (79,956 tons) wastes are sent to treatment and 18% (29,427 tons) were sent to landfills. The rising volume of the organic fraction of municipal solid waste in urban areas presents a challenge for waste management but also offers a significant opportunity for sustainable agricultural practices. Compost is a nutrient rich organic material that results from the decomposition of organic waste. These organic materials typically include food residues, coffee grounds, tea bags and other biodegradable substances that are separated from the inorganic components like plastics and metals. The use of compost provides numerous advantages, including its application in agriculture, its odourless nature, and the absence of harmful microorganisms, all of which contribute to soil enrichment. Pellet is a compacted form of the organic materials found in municipal solid waste. In this study Organic Fraction of Municipal Solid Waste compost is converted into pellets. The Perungalathur site was selected for the collection of municipal solid waste, which was then processed using a two-stage composting method. The resulting mature compost was pelletized, and its properties were examined through scanning electron microscopy (SEM) analysis.

Keywords: Municipal solid waste, Pelletization, Pellet growing medium, Conventional medium, Organic fraction.

INTRODUCTION

As per the year of 2022, Central Pollution Control Board (CPCB) reports that 152,749 tons of solid waste are processed, with 50% (79,956 tons) wastes are sent to treatment and 18% (29,427 tons) were sent to landfills. The growing volume of organic waste poses management challenges but offers opportunities to convert it into valuable resources like compost, biogas. This project addresses the escalating environmental issues related to the use of synthetic fertilizers and the exhaustion of natural resources by investigating the potential of municipal solid waste (MSW) compost cum pellets as a sustainable growing medium for the agriculture. The organic fraction of municipal solid waste is converted into pellets and its physical properties are analysed by Scanning Electron Microscope. The primary goal of this initiative is to reduce the municipal solid waste and to use organic fractioned compost as an alternative growing medium for crop cultivation.

STUDY AREA

For waste collection and waste segregation process Tambaram, Perungalathur and Guduvanchery sites were selected. The bio degradable waste obtained from the Tambaram site is transferred to the Perungalathur site for the composting process. Fig.1 shows the Perungalathur site. In the Perungalathur site, 5.91 MT/ day of biodegradable wastes are collected and composted. The site was located at a latitude of 12.9007° and a longitude of 80.0815°.

MATERIALS AND METHODS

Collection of MSW and Separation of OFMSW

The collection of municipal solid waste refers to the systematic process of gathering everyday garbage from residential, commercial, institutional, and sometimes industrial sources within a municipality. Separation involves isolating biodegradable materials like food waste, plant residues, and other compostable substances from non-organic components such as plastics, metals, and glass. The separation can be done by manual sorting, mechanical sorting, optical separation, and electromagnetic separation. In this project, the separation of OFMSW was done by manual sorting. Fig.2 shows the manual sorting of OFMSW. This method involves human intervention to segregate different types of wastes. A total of 20 kg of municipal solid waste (MSW) is collected, of which17 kg consists of organic waste and 10 kg of compost was obtained. Manual sorting allows workers to carefully separate recyclable materials, improving recovery rates. Compared to expensive automated sorting systems, hand sorting requires minimal infrastructure and machinery. Lacking of proper safety and sanitation measures, unsafe working environments, slow process while compared to mechanized sorting systems, making it unsuitable for large waste volumes are the drawbacks of manual sorting method *Composting* Composting is a natural process that recycles organic materials into a nutrient-rich soil amendment. Compost is a mixture that consist of decayed organic matter which is used for fertilizing and conditioning the land. The several methods of composting are windrow composting, forced aeration systems, in-vessel systems, Two-stage composting, Vermi Composting. A two-stage composting method, combining semi-windrow and in-vessel techniques, was implemented for composting OFMSW in this study.Fig.3 shows the mature compost of municipal solid waste. The matured quality of compost will be obtained earlier while compared to the other methods of composting. Through the two-stage composting process the matured compost was obtained on the 30th day.

Organic Matter Analysis

The evaluation of compost quality was conducted through various parameters, including potential of hydrogen, NPK, carbon-to-nitrogen ratio, moisture content and total organic matter. Generally, completed composts have a pH range of 5.0 to 8.5. The pH was obtained at a range of 7. An optimal carbon-to-nitrogen (Carbon:Nitrogen) ratio ranging from 10:1 to 20:1 is essential to avoid nitrogen immobilization in plants. Maintaining appropriate moisture levels, typically between 40% and 85%, is essential for facilitating microbial activity in the composting process. The

obtained moisture content was between 50% and 60%. Through the ignition method, the organic matter was obtained at 60%.

Pelletization

The procedure for producing pellets from mature compost encompasses multiple stages that guarantee the compost is adequately prepared for palletization. This process initiates with composting, followed by mixing, moisture regulation, pelletizing, cooling, and drying. Introduce the prepared material into a pellet mill. As the material moves through a die, it experiences elevated pressure and temperature, resulting in its compression into pellets. The die features small openings that define the shape of the pellets, while a blade trims them to the specified length upon exit. Optimal conditioning temperatures are between 50°C and 90°C, with the majority of producers conditioning feed at approximately 78°C to 80°C. This process facilitates starch gelatinization and enhances the digestibility of nutrients such as starch, dry matter, and crude protein. Fig.4 shows the pellet balls.

SEM analysis

Scanning Electron Microscopy (SEM) analysis serves as an essential method for examining the microstructure and composition of pellets, especially in materials such as iron ore and biomass. This technique offers comprehensive insights into the physical characteristics and elemental makeup of pellets, which are critical for evaluating their quality and functionality. The application of SEM facilitates high-resolution imaging of the surface morphology of pellets, uncovering details including particle size and distribution, surface morphology, elemental composition, microstructure, moisture content, porosity and permeability, bulk density, cation exchange capacity and soil texture. Fig.5 shows the SEM analysis of pellet. Understanding these aspects is vital for determining how they affect the strength and performance of the pellets. A high-energy electron gun generates a beam of electrons. The electron beam interacts with the surface of the sample, causing the emission of secondary electrons, backscattered electrons, and X-rays, which are detected by various detectors. Different signals provide information on various properties: surface imaging, providing topographic information. It provides information about surface composition and atomic number contrast and elemental composition analysis. The detected signals are processed to form an image on a computer screen. The image's resolution depends on the electron beam's wavelength and the detectors used Spectrum graph provided in Fig.6 reveals a detailed elemental analysis of the pellet showing the presence of several elements such as Nitrogen, Phosphorus, Potassium, Magnesium, Chlorine, Carbon, Iridium, Oxygen, Calcium, Silicon, Sodium. The peaks at different energy levels on the x-axis (measured in keV) correspond to the presence of these elements in the sample. The counts on the y-axis indicate the relative abundance of each element. Higher peaks suggest a higher concentration of the corresponding element. From Table 1, A high carbon content of 20.2% in the pellets suggests a good source of organic material, which can enhance soil fertility and support microbial activity. A high oxygen content of 45.14% indicates that the material can support aerobic processes, crucial for healthy root development and nutrient cycling. Adequate nitrogen levels of 7.34% can promote vigorous plant growth, enhancing leaf and stem development. Potassium level of 2.38% enhances drought resistance, disease resistance, and overall plant vigor, contributing to better crop yields. The presence of calcium at the level of 9.29% suggests that the pellets can help improve root and shoot development, as well as overall plant health. Magnesium level of 0.80% in the pellets can support efficient photosynthesis and nutrient transport within the plant. Silicon level of 7.15% can improve structural integrity and stress tolerance in plants, making them more resilient. Using OFMSW pellets as a growing medium can be a sustainable and effective way to recycle organic waste while improving soil quality and crop yields.

CONCLUSION

The municipal solid waste pellets utilized as a growing medium for crops exhibit significant nutritional properties, as analyzed through Scanning Electron Microscopy. Their incorporation supports sustainable agricultural practices, applicable in both soil-based and soilless cultivation systems, while also improving soil fertility. Elemental analysis conducted through the scanning electron microscope (SEM) revealed a high availability of essential nutrients necessary for plant growth, which could enhance crop yield.

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Table 1 : Compositional Analysis of OFMSW Pellet

Element	Extracted Spectrum	Extracted Spectrum	Extracted Spectrum	Extracted Spectrum	Extracted Spectrum
	Net Counts	Weight %	Atom %	Atom % err	Chemical Formula
C K	6350	20.92	29.99	0.36	C
N K	554	7.34	9.02	1.37	N
O K	6205	45.14	48.59	0.79	O
Na K	214	0.71	0.53	0.06	Na
Mg K	277	0.80	0.56	0.06	Mg
Al K	444	1.23	0.79	0.05	Al
Si K	2396	7.15	4.38	0.08	Si
Cl K	358	1.63	0.79	0.11	Cl
K K	375	2.38	1.05	0.08	K
Ca K	1183	9.29	3.99	0.23	Ca
Ir M	530	3.42	0.31	0.03	Ir
		100.00	100.00		



Fig 1: Perungalathur site



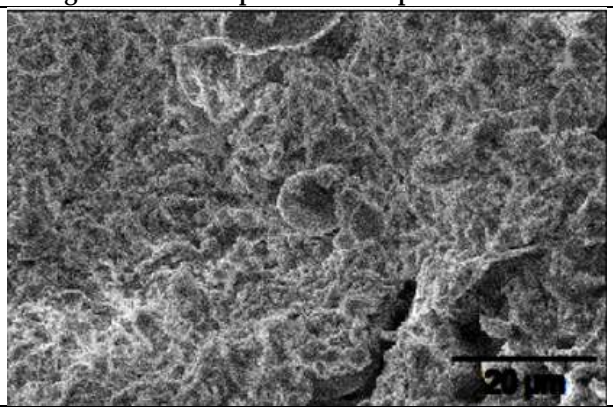
Fig 2 Manual sorting of OFMSW



Fig 3: Mature compost of municipal solid waste



Fig 4: Pellet balls



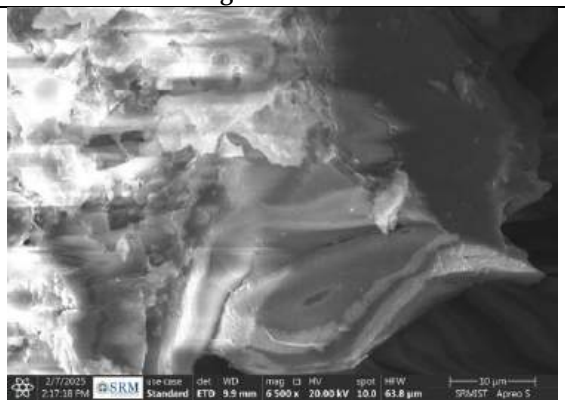


Fig.5 SEM analysis of Pellet

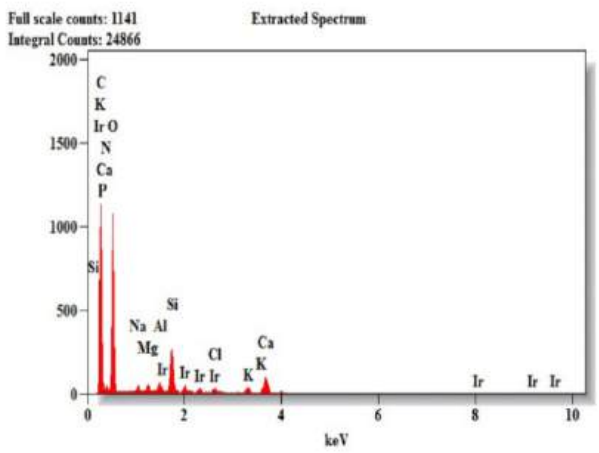


Fig.6 Compositional Analysis of organic fraction of municipal solid waste Pellet

RESEARCH ARTICLE

Role of Nutrition Education to Increase Essential Nutrient Intake and Promote Wound Healing in Patient with Diabetic Foot Ulcers

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ABSTRACT

Diabetic foot ulcers (DFUs) are a leading cause of lower extremity amputations in diabetic patients, affecting up to 25% of diabetics. Chronic inflammation, oxidative stress, and reduced immune function contribute to delayed wound healing. Nutritional support is crucial for managing DFUs, as specific nutrients may influence inflammation, immune response, and tissue repair. A literature search was conducted using PubMed, Google Scholar, and ScienceDirect, reviewing observational studies, clinical trials, and meta-analyses published between 2015 and 2022. Total 16 articles has been reviewed in order to write this review paper. The focus was on the role of nutrition education in promoting wound healing in DFU patients. Essential nutrients such as antioxidants, vitamins (C, A, D, E), and minerals (zinc, selenium, manganese, copper) play a vital role in reducing inflammation and supporting wound healing. Deficiencies in these nutrients are common in DFU patients, hindering the healing process. Vitamin C is critical for collagen synthesis and immune function, while zinc supports immune response and tissue repair. Vitamin D, due to its influence on bone and immune function, has potential as an adjunct therapy for DFUs. Additionally, probiotics show promise in reducing inflammation and promoting faster healing. Adherence to recommended calorie and protein intake is crucial for wound recovery. Nutrition plays a

key role in managing diabetic foot ulcers by reducing inflammation, supporting immune function, and promoting tissue repair. Educating DFU patients on the importance of balanced nutrition, including adequate intake of vitamins, minerals, and antioxidants, is essential for improving wound healing outcomes. Further research is needed to fully understand the synergistic effects of these nutrients in chronic wound management.

Keywords: Diabetes , Foot ulcer , High protein, Immuno-nutrients, Antioxidant.

INTRODUCTION

One of the most frequent reasons for lower extremity amputation in diabetic individuals is diabetic foot ulcers (DFU). A foot ulcer can occur in about 25% of diabetics, and 16% of DFUs can result in amputation if left untreated. A multitude of interactions between different cell types, extracellular matrix, and cytokine mediators occur during the intricate process of wound healing. As a normal physiological reaction to tissue damage, inflammation is necessary for both the healing process and wound cleaning. [1] Acute inflammatory responses occur in normal wounds for a brief period of time and end quickly because of negative feedback mechanisms. In chronic wounds, like DFUs, however, inflammatory responses are unable to control themselves, leading to chronic inflammation and a slowdown in the healing process. The over activity of inflammatory cells in DFU patients leads to an increased production of reactive oxygen species (ROS). This, in conjunction with the down regulation of anti-inflammatory proteins like interleukin 10 (IL10), will increase the inflammatory load. A high ROS concentration can exacerbate the healing process by degrading the extracellular matrix through the up regulation of matrix metalloproteinase (MMPs) expression and the generation of more free radicals.[1] Apart from the elevated generation of reactive oxygen species (ROS) in diabetes, there is a reduced capacity to eliminate them because to malfunctioning reducing complexes (glutathione), reducing enzymes (glutathione reductase), and reducing amino acids (cysteine). Diabetic patients have both hyperglycemia and hypoxia due to disturbed vasculature, which hinders the healing of wounds and reduces the function of neutrophils and macrophages, thereby raising the risk of infection. Furthermore, diabetic patients have a chronic, non-healing wound due to down-regulation of anti- inflammatory molecules like transforming growth factor-beta (TGF-β) and IL10, and up- regulation of pro inflammatory cytokines such as interleukin 1β (IL1β), interleukin 6 (IL6), and tumor necrosis factor-alpha (TNF-alpha).[1] Controlling infection and inflammation both inside and outside the wound site is therefore a key objective of DFU wound management. In DFU patients, IL6 and C-reactive protein (CRP) are two of the best markers of inflammation and wound healing. The levels of glucose and the chronicity of wounds are highly associated with IL6 expression. Another intriguing indicator of delayed wound healing and infection in DFU patients is a high quantity of IL6. In addition, in DFU patients, there is a correlation between the size of the wound and both IL6 and CRP. Weigelt *et al.*'s investigation revealed that blood levels of CRP and IL6 were considerably greater in patients with grade 3 DFUs (as defined by the University of Texas Wound Classification) than in those with grade 1 DFUs.[1] Micro and macro vascular problems arise from a collection of metabolic illnesses called diabetes mellitus that have long-term effects on numerous organs. One of the most frequent consequences of diabetes is diabetic foot ulcers, which are frequently challenging to cure. Multiple cell types, cytokine mediators, and the extracellular matrix interact in a variety of ways throughout the wound healing process. Sufficient blood flow and nourishment to the area of injured tissue could make this approach effective.[3]

Etiology

Diabetes mellitus patients are at risk for ulcers due to distal peripheral neuropathy, peripheral vascular disease, trauma, ulcer history, and/or amputation. Peripheral neuropathy comes in many forms, but distal-symmetric sensorimotor neuropathy and autonomic neuropathy are the two most commonly linked to diabetic foot. Because neuropathy reduces sensitivity all the way to total loss, minor injuries like burns, incorrect nail cutting, and insufficient footwear can result in ulcers. The neuropathic foot is malformed, the skin feels warm and dry to the touch, the plantar surface has hyperkeratosis, the veins are turgid, and there are arterial pulses. Changes in

autonomic neuropathy lead to abnormalities in capillary microcirculation regulation, including turgidity of the veins and the emergence of shunts between arterioles and veins.[3,2] DFUs negatively impact patients' quality of life, health, and socioeconomic well-being. Nutrition is crucial to avoid DFUs and improve clinical outcomes. Chronic wound patients consume more energy and nutrients, while uncontrolled diabetes leads to increased protein catabolism.[4] The aim of this review paper is to highlight the role of nutrition education in wound healing for patients with diabetic foot ulcers.

METHODOLOGY

A literature search was performed using databases PubMed, Medline, Google scholar, ScienceDirect, to locate peer-reviewed articles of observational studies, clinical trials and meta- analysis. Articles were reviewed for inclusion based on their relevance to this subject matter. 16 articals are reffered from the year of 2015 till the year 2022.

RESULTS

Role of nutrients

Antioxidant , vitamins and minerals, among other nutritional components, may be able to lower chronic inflammation and may even play a crucial role in the healing process of chronic wounds. Strong antioxidants like zinc, manganese, and copper, together with vitamins C, A, and E, have potent anti-inflammatory qualities. Therefore, it is essential to look into whether these nutrients can change the inflammatory status in order to turn diabetic wounds from chronic or non-healing to normal wounds. It has been discovered that DFU patients consume significantly fewer of the nutrients listed above. However, the idea that a combination of these essential nutrients reduces inflammation and facilitates wound healing in DFUs is not well-supported by the available data. Thus, additional study is needed to determine how well these nutrients function to treat inflammatory conditions linked to DFUs. [2] Apart from its requirement for the synthesis of collagen, ascorbic acid is also necessary for the proper operation of the immune system. A significant cause of amputations in patients with persistent foot ulcers is osteomyelitis. Thus, in the absence of skin integrity, inadequate vitamin C feeding may promote the development of osteomyelitis. Bone fractures were common among the sailors who perished from scurvy centuries ago. It's intriguing to consider the possibility that vitamin C deficiency could exacerbate osteomyelitis risk by hindering bone growth.[6] Selenium enhances MSCs' multipotency, anti-inflammatory properties, and proliferation, promoting pro-angiogenesis, inflammation inhibition, and wound healing in human umbilical vein endothelial cells and exosome groups[15].Zinc is a crucial micronutrient for human physiology, supporting immune system function, cell proliferation, growth, and membrane repair.

Deficiency can lead to skin lesions, weakened immunity, and poor wound healing[16]. Vitamins and minerals are necessary for biological metabolism, which includes wound healing.[7] Diabetes population with foot ulcers are more susceptible to vitamin D deficiency because of the patients reduced physical activity, which is commonly mistaken for time spent outside and, thus, sun exposure. The function of vitamin D in maintaining bone homeostasis is widely acknowledged. Nonetheless, there are numerous extra skeletal impacts of vitamin D signaling. These include the control of cell division and proliferation, vascular and metabolic characteristics, immune system and muscle function, skin differentiation, and reproduction[7].As an adjuvant treatment for diabetic foot ulcers, vitamin D supplements are helpful. It might lessen the stress brought on by diabetic foot ulcers and hasten the healing process[12]. The National Pressure Ulcer Advisory Panel (NPUAP) in the year 2019 standards were used to determine the daily calorie and protein requirements, which are 30–35 kcal/kg of body weight and 1.2–1.5 g/kg of body weight, respectively. The NPUAP guidelines for energy and protein intakes as well as the DRIs for micronutrient intakes were compared with the patient intakes[8]. Probiotics, which the International Scientific Association of Probiotics and Prebiotics defines as "live microorganisms which when administered in adequate amounts confer a health benefit on the host," are a newly developed therapeutic option for wound healing [9]. Probiotic supplements given intraoperatively to diabetic rats showed quicker skin healing, most likely as a result of decreased inflammatory

response, improved neovascularization, and higher type I collagen deposition. Probiotic supplementation also improves glycemic management and inhibits weight loss in animal models.[9]The most widely used probiotic supplements are strains from other bacterial species (Propionibacterium acidilactici, Lactococcus lactis, Leuconostoc mesenteroides, Bacillus subtilis, Streptococcus thermophilus), yeasts (Saccharomyces boulardii), and members of the Lactobacillus spp. and Bifidobacterium genera[9]. Applying honey and turmeric topically speeds up the healing of wounds and is both safe and economical[13].vitamin C (VitC) or ascorbic acid (AscA), a major antioxidant and cofactor for collagen formation, is quickly depleted. In human or murine sepsis, parenteral vitamin C treatment promotes anti-inflammatory and pro-resolution effects while suppressing pro-inflammatory responses[14]. Blood cells, parenchymal cells, extracellular matrix, and soluble mediators are all involved in the intricate, dynamic, and interacting process of wound healing. The three stages of wound healing— tissue creation, remodeling, and inflammation—occur over time.4 For millennia, people have understood the connection between wound healing and nutrition. It is well recognized that inadequate intake of macronutrients, particularly protein, has a negative impact on wound healing. Equally vital are micronutrients, which are crucial components of cellular metabolism. The immune system and wound healing are significantly influenced by a number of vitamins and minerals; zinc, vitamin C, and vitamin A are particularly crucial.[7]

DISCUSSION

DFUs have a detrimental impact on patients' and their families' quality of life as well as their health and socioeconomic well-being. In order to avoid DFUs and enhance their clinical outcomes, nutrition can be extremely important. Patients with chronic wounds have higher metabolic demands due to increased cellular activity and inflammation in the healing wound; as a result, they consume more energy and nutrients. Individuals with uncontrolled diabetes have been found to have increased protein catabolism and a negative nitrogen balance. Diabetes patients, particularly those who are overweight or obese, are generally recommended to follow low-calorie/low-carb diets to better control their glycemic indices and associated problems, despite their increased need for energy sources and essential nutrients during the healing process..[4] It has also been observed that patients with DFUs who are overweight or obese consume notably less calories and nutrients through their diet. Loss of subcutaneous tissue, muscle atrophy, and delayed wound healing can all be consequences of inadequate calorie intake. In order to improve wound healing in DFUs, a positive nitrogen balance must be promoted by an adequate protein intake supplemented by non-protein energy sources. Protein is responsible for cell proliferation, collagen, and connective tissue synthesis, as well as the antibody synthesis required for immune system function [4]. When it comes to managing diabetes and its consequences, nutrition therapy is essential. Inadequate nourishment before to or during the healing process might impede the speed of wound healing and reduce its strength. Since it is necessary for wound healing, protein is one of the most important macronutrients. All phases of the healing process, including fibroblast proliferation, collagen synthesis, angiogenesis, and immunological function, depend on it. [3]Diabetic foot ulcers (DFUs) are known to heal more slowly when M1/M2-type macrophages are dysregulated. Therefore, healing requires reestablishing the proper balance between these macrophage subtypes.[12]

CONCLUSION

For patients with diabetic foot ulcers, proper dietary treatment is essential. Healing results can be greatly enhanced by concentrating on consuming enough protein, getting enough micronutrients, and keeping blood glucose levels steady. To further adapt dietary recommendations and interventions to the specific needs of each patient, more research is required.

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RESEARCH ARTICLE

Lattice Valued Picture Fuzzy Relations

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ABSTRACT

In this paper, Lattice Valued Picture Fuzzy Relations and their fundamental operations are defined. The properties of Lattice valued Picture Fuzzy Relations are investigated. Further, the composition of Lattice Valued Picture Fuzzy Relations are described with illustrations and their properties are examined.

Keywords: Picture Fuzzy Sets, Picture Fuzzy Relations, Lattice Valued Picture Fuzzy Sets, Lattice Valued Picture Fuzzy Relations, Composition of Lattice Valued Picture Fuzzy Relations

INTRODUCTION

Relations are beneficial for demonstrating correspondence between items. Mathematical theories have benefited greatly from crisp relations. Some issues, meanwhile, cannot be resolved by crisp relations. Thus, following the concept of the fuzzy set, Zadeh [7] further proposed defining fuzzy relations as an expansion of the classical relationships. Uncertainty cannot be modelled by fuzzy relations, although vagueness may. To overcome this, Intuitionistic fuzzy sets was defined by Atanassov [1]. Burillo and Bustince [2], [3] defined intuitionistic relations and discussed about their properties. Picture fuzzy relations were introduced by B.C. Cuong [4], who also investigated their characteristics. Tweena Evangelin P and A. Francina Shalini [6] defined Lattice Valued Picture Fuzzy Sets by inducing picture fuzzy sets to the theory of lattices. In Section 2, some basic definitions and properties have been presented. In Section 3, Lattice Valued Picture Fuzzy Relations and their basic operations are defined. In Section 4,

we define the composition of Lattice Valued Picture Fuzzy Relations and discuss their properties. The conclusion is given in Section 5.

PRELIMINARIES

Definition 2.1: *[5]* Let P be a non-empty ordered set. If x $\vee$ yand x $\wedge$ yexist for all $x, y \in P$, then P is called a lattice.

Definition 2.2: *[5]* We refer to a complemented and distributive lattice as a Boolean lattice.

Definition 2.3: *[4]*A picture fuzzy set $A = \{\langle \hat{a}, \mu_A(\hat{a}), \eta_A(\hat{a}), \nu_A(\hat{a})\rangle | \hat{a} \in \hat{X}\}$where $\mu_A(\hat{a}), \eta_A(\hat{a}), \nu_A(\hat{a}) \in [0,1]$ are called the positive, neutral and negative membership degrees of $\hat{a}$ in $\hat{X}$ andsatisfy the following condition: $\forall\, \hat{a} \in \hat{X}, \mu_A(\hat{a}) + \eta_A(\hat{a}) + \nu_A(\hat{a}) \leq 1$. Now $1 - (\mu_A(\hat{a}) + \eta_A(\hat{a}) + \nu_A(\hat{a}))$ could be called the degree of refusal membership of $\hat{a} \in \hat{X}$.

Definition 2.4: *[4]* A picture fuzzy relation is a picture fuzzy subset of $\hat{X} \times \hat{Y}$ (i.e)
$R = \{\langle(\hat{x}, \hat{y}), \mu_R(\hat{x}, \hat{y}), \iota_R(\hat{x}, \hat{y}), \vartheta_R(\hat{x}, \hat{y})\rangle | \hat{x} \in \hat{X}, \hat{y} \in \hat{Y}\}$ where$\mu_R : \hat{X} \times \hat{Y} \to [0,1]$, $\iota_R : \hat{X} \times \hat{Y} \to [0,1]$, $\vartheta_R : \hat{X} \times \hat{Y} \to [0,1]$ satisfy the condition $0 \leq \mu_R(\hat{x}, \hat{y}) + \iota_R(\hat{x}, \hat{y}) + \vartheta_R(\hat{x}, \hat{y}) \leq 1\ \forall\, (\hat{x}, \hat{y}) \in \hat{X} \times \hat{Y}$. *PFR* $(\dot{\mathcal{U}})$ is the set of all picture fuzzy relations in $\hat{X} \times \hat{Y}$.

Definition 2.5: *[6]*Consider the universe $\mho_1$and a nontrivial complete boolean lattice$\mathcal{L}$. A Lattice Valued Picture Fuzzy Set (LVPFS) $\mathcal{A}_{\mathcal{L}} = \{\langle \dot{a}, \zeta_{\mathcal{A}_{\mathcal{L}}}(\dot{a}), \eta_{\mathcal{A}_{\mathcal{L}}}(\dot{a}), \vartheta_{\mathcal{A}_{\mathcal{L}}}(\dot{a})\rangle | \dot{a} \in \mho_1\}$ where $\zeta_{\mathcal{A}_{\mathcal{L}}} : \mho_1 \to \mathcal{L}$ is positive membership degree, $\eta_{\mathcal{A}_{\mathcal{L}}} : \mho_1 \to \mathcal{L}$ is neutral membership degree and $\vartheta_{\mathcal{A}_{\mathcal{L}}} : \mho_1 \to \mathcal{L}$ is negative membership degree.
$\pi_{\mathcal{A}_{\mathcal{L}}}(\dot{a}) = (\zeta_{\mathcal{A}_{\mathcal{L}}}(\dot{a}) \vee \eta_{\mathcal{A}_{\mathcal{L}}}(\dot{a}) \vee \vartheta_{\mathcal{A}_{\mathcal{L}}}(\dot{a}))'$ is the refusal membership degree of $\dot{a}$ in $\mathcal{A}_{\mathcal{L}}$. LVPFS $(\mho_1)$ represents set of Lattice Valued Picture Fuzzy Sets in $\mho_1$.

Definition 2.6:*[6]*Let $\mathcal{A}_{1_{\mathcal{L}}}, \mathcal{A}_{2_{\mathcal{L}}} \in$ LVPFS $(\mho_1)$. Then

i. $\mathcal{A}_{1_{\mathcal{L}}} \subseteq \mathcal{A}_{2_{\mathcal{L}}}$ iff $\zeta_{(\mathcal{A}_{1_{\mathcal{L}}})}(\dot{a}) \leq \zeta_{(\mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}), \eta_{(\mathcal{A}_{1_{\mathcal{L}}})}(\dot{a}) \leq \eta_{(\mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}), \vartheta_{(\mathcal{A}_{1_{\mathcal{L}}})}(\dot{a}) \geq \vartheta_{(\mathcal{A}_{2_{\mathcal{L}}})}(\dot{a})$.

ii. $\mathcal{A}_{\mathcal{L}}{}^{c} = \{\langle \dot{a}, \vartheta_{\mathcal{A}_{\mathcal{L}}}(\dot{a}), \eta_{\mathcal{A}_{\mathcal{L}}}(\dot{a}), \zeta_{\mathcal{A}_{\mathcal{L}}}(\dot{a})\rangle | \dot{a} \in \mho_1\}$

iii. $\mathcal{A}_{1_{\mathcal{L}}} \cup \mathcal{A}_{2_{\mathcal{L}}} = \{\langle \dot{a}, \zeta_{(\mathcal{A}_{1_{\mathcal{L}}} \cup \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}), \eta_{(\mathcal{A}_{1_{\mathcal{L}}} \cup \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}), \vartheta_{(\mathcal{A}_{1_{\mathcal{L}}} \cup \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a})\rangle \mid \dot{a} \in \mho_1\}$ where

iv. $\zeta_{(\mathcal{A}_{1_{\mathcal{L}}} \cup \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}) = \zeta_{(\mathcal{A}_{1_{\mathcal{L}}})}(\dot{a}) \vee \zeta_{(\mathcal{A}_{2_{\mathcal{L}}})}(\dot{a})$, $\eta_{(\mathcal{A}_{1_{\mathcal{L}}} \cup \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}) = \eta_{(\mathcal{A}_{1_{\mathcal{L}}})}(\dot{a}) \wedge \eta_{(\mathcal{A}_{2_{\mathcal{L}}})}(\dot{a})$,
$\vartheta_{(\mathcal{A}_{1_{\mathcal{L}}} \cup \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}) = \vartheta_{(\mathcal{A}_{1_{\mathcal{L}}})}(\dot{a}) \wedge \vartheta_{(\mathcal{A}_{2_{\mathcal{L}}})}(\dot{a})$.

v. $\mathcal{A}_{1_{\mathcal{L}}} \cap \mathcal{A}_{2_{\mathcal{L}}} = \{\langle \dot{a}, \zeta_{(\mathcal{A}_{1_{\mathcal{L}}} \cap \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}), \eta_{(\mathcal{A}_{1_{\mathcal{L}}} \cap \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}), \vartheta_{(\mathcal{A}_{1_{\mathcal{L}}} \cap \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a})\rangle \mid \dot{a} \in \mho_1\}$ where
$\zeta_{(\mathcal{A}_{1_{\mathcal{L}}} \cap \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}) = \zeta_{(\mathcal{A}_{1_{\mathcal{L}}})}(\dot{a}) \wedge \zeta_{(\mathcal{A}_{2_{\mathcal{L}}})}(\dot{a})$, $\eta_{(\mathcal{A}_{1_{\mathcal{L}}} \cap \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}) = \eta_{(\mathcal{A}_{1_{\mathcal{L}}})}(\dot{a}) \wedge \eta_{(\mathcal{A}_{2_{\mathcal{L}}})}(\dot{a})$, $\vartheta_{(\mathcal{A}_{1_{\mathcal{L}}} \cap \mathcal{A}_{2_{\mathcal{L}}})}(\dot{a}) = \vartheta_{(\mathcal{A}_{1_{\mathcal{L}}})}(\dot{a}) \vee \vartheta_{(\mathcal{A}_{2_{\mathcal{L}}})}(\dot{a})$.

LATTICE VALUED PICTURE FUZZY RELATIONS

Definition 3.1: A Lattice Valued Picture Fuzzy Relation (LVPFR) is defined as

$$R_{\mathcal{L}} = \{\langle (\hat{\kappa}_1, \hat{\kappa}_2), \zeta_{(R_{\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2), \iota_{(R_{\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2), \vartheta_{(R_{\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2)\rangle \mid \hat{\kappa}_1 \in \mho_1, \hat{\kappa}_2 \in \mho_2\}$$

where$\zeta_{(R_{\mathcal{L}})} : \mho_1 \times \mho_2 \to \mathcal{L}$ is the positive membership degree, $\iota_{(R_{\mathcal{L}})} : \mho_1 \times \mho_2 \to \mathcal{L}$ is the neutral membership degree and $\vartheta_{(R_{\mathcal{L}})} : \mho_1 \times \mho_2 \to \mathcal{L}$ is the negative membership degree.
$\pi_{(R_{\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2) = (\zeta_{(R_{\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2) \vee \iota_{(R_{\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2) \vee \vartheta_{(R_{\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2))'$ is the refusal degree of $(\hat{\kappa}_1, \hat{\kappa}_2)$ in $R_{\mathcal{L}}$. The set of all Lattice Valued Picture Fuzzy Relations in $\mho_1 \times \mho_2$ is denoted by LVPFR $(\mho_1 \times \mho_2)$.

Example 3.2: Let $\mho_1 = \{\dot{p}_1, \dot{p}_2\}$ and $\mho_2 = \{\dot{m}_1, \dot{m}_2, m_3\}$ and the lattice $\mathcal{L}$ in figure 1.

$$R_{1_{\mathcal{L}}} = \{\langle(\dot{p}_1, \dot{m}_1), 15,1,5\rangle, \langle(\dot{p}_1, \dot{m}_2), 5,3,15\rangle, \langle(\dot{p}_1, \dot{m}_3), 1,15,3\rangle, \langle(\dot{p}_2, \dot{m}_1), 3,1,15\rangle,$$
$$\langle(\dot{p}_2, \dot{m}_2), 15,5,1\rangle, \langle(\dot{p}_2, \dot{m}_3), 5,1,3\rangle\}$$ is a LVPFR.

$[R_{\mathcal{L}}] = \begin{bmatrix}(15,1,5) & (5,3,15) & (1,15,3\\(3,1,15) & (15,5,1) & (5,1,3)\end{bmatrix}$

Definition 3.3: The complement of a LVPFR$R_{1_{\mathcal{L}}}$ is defined as

$\left(R_{1_{\mathcal{L}}}\right)^c = \{\langle(\hat{\kappa}_1,\hat{\kappa}_2),\zeta_{(R_{1_{\mathcal{L}}})^c}(\hat{\kappa}_1,\hat{\kappa}_2),\iota_{(R_{1_{\mathcal{L}}})^c}(\hat{\kappa}_1,\hat{\kappa}_2),\vartheta_{(R_{1_{\mathcal{L}}})^c}(\hat{\kappa}_1,\hat{\kappa}_2)\rangle|\ (\hat{\kappa}_1,\hat{\kappa}_2) \in \mho_1 \times \mho_2\}$where

$\zeta_{(R_{1_{\mathcal{L}}})^c}(\hat{\kappa}_1,\hat{\kappa}_2) = \vartheta_{R_{1_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2),$

$\iota_{(R_{1_{\mathcal{L}}})^c}(\hat{\kappa}_1,\hat{\kappa}_2) = \iota_{R_{1_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2),$

$\vartheta_{(R_{1_{\mathcal{L}}})^c}(\hat{\kappa}_1,\hat{\kappa}_2) = \zeta_{R_{1_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2).$

Example 3.4: The complement of $R_{\mathcal{L}}$ in example 3.2 is

$\left[\left(R_{1_{\mathcal{L}}}\right)^c\right] = \begin{bmatrix}(5,1,15) & (15,3,5) & (3,15,1)\\(15,1,3) & (1,5,15) & (3,1,5)\end{bmatrix}$.

Definition 3.5: Let$R_{1_{\mathcal{L}}}$ be a LVPFR from $\mho_1$ to $\mho_2$. The inverse of $R_{1_{\mathcal{L}}}$is a LVPFR from $\mho_2$ to $\mho_1$ is defined as

$\left(R_{1_{\mathcal{L}}}\right)^{-1} = \{\langle(\hat{\kappa}_2,\hat{\kappa}_1),\zeta_{(R_{1_{\mathcal{L}}})^{-1}}(\hat{\kappa}_2,\hat{\kappa}_1),\iota_{(R_{1_{\mathcal{L}}})^{-1}}(\hat{\kappa}_2,\hat{\kappa}_1),\vartheta_{(R_{1_{\mathcal{L}}})^{-1}}(\hat{\kappa}_2,\hat{\kappa}_1)\rangle|\ (\hat{\kappa}_2,\hat{\kappa}_1) \in \mho_2 \times \mho_1\}$where

$\zeta_{(R_{1_{\mathcal{L}}})^{-1}}(\hat{\kappa}_2,\hat{\kappa}_1) = \zeta_{R_{1_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2),$

$\iota_{(R_{1_{\mathcal{L}}})^{-1}}(\hat{\kappa}_2,\hat{\kappa}_1) = \iota_{R_{1_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2),$

$\vartheta_{(R_{1_{\mathcal{L}}})^{-1}}(\hat{\kappa}_2,\hat{\kappa}_1) = \vartheta_{R_{1_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2).$

Example 3.6: The inverse of $R_{1_{\mathcal{L}}}$ in example 3.2 is $\left[\left(R_{1_{\mathcal{L}}}\right)^{-1}\right] = \begin{bmatrix}(15,1,5) & (3,1,15)\\(5,3,15) & (15,5,1)\\(1,15,3) & (5,1,3)\end{bmatrix}$.

Definition 3.7: Let $R_{1_{\mathcal{L}}}$ and $R_{2_{\mathcal{L}}}$ be two LVPFRs from $\mho_1$ to $\mho_2$. Then,$R_{1_{\mathcal{L}}} \subseteq R_{2_{\mathcal{L}}}$ iff $\zeta_{R_{1_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2) \leq \zeta_{R_{2_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2), \iota_{R_{1_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2) \leq \iota_{R_{2_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2), \vartheta_{R_{1_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2) \geq \vartheta_{R_{2_{\mathcal{L}}}}(\hat{\kappa}_1,\hat{\kappa}_2)$
$\forall\ (\hat{\kappa}_1,\hat{\kappa}_2) \in \mho_1 \times \mho_2.$

Definition 3.8: Let $R_{1_{\mathcal{L}}}$ and $R_{2_{\mathcal{L}}}$ be two LVPFRs from $\mho_1$ to $\mho_2$. Then,

i. $R_{1_{\mathcal{L}}} \cup R_{2_{\mathcal{L}}} = \left\{\langle(\hat{\kappa}_1,\hat{\kappa}_2),\zeta_{(R_{1_{\mathcal{L}}} \cup R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2),\iota_{(R_{1_{\mathcal{L}}} \cup R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2),\vartheta_{(R_{1_{\mathcal{L}}} \cup R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2)\rangle \middle| (\hat{\kappa}_1,\hat{\kappa}_2) \in \mho_1 \times \mho_2\right\}$
where $\zeta_{(R_{1_{\mathcal{L}}} \cup R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) = \zeta_{(R_{1_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) \vee \zeta_{(R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2),\ \iota_{(R_{1_{\mathcal{L}}} \cup R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) = \iota_{(R_{1_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \iota_{(R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2),$
$\vartheta_{(R_{1_{\mathcal{L}}} \cup R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) = \vartheta_{(R_{1_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \vartheta_{(R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2).$

ii. $R_{1_{\mathcal{L}}} \cap R_{2_{\mathcal{L}}} = \left\{\langle(\hat{\kappa}_1,\hat{\kappa}_2),\zeta_{(R_{1_{\mathcal{L}}} \cap R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2),\iota_{(R_{1_{\mathcal{L}}} \cap R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2),\vartheta_{(R_{1_{\mathcal{L}}} \cap R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2)\rangle \middle| (\hat{\kappa}_1,\hat{\kappa}_2) \in \mho_1 \times \mho_2\right\}$
where $\zeta_{(R_{1_{\mathcal{L}}} \cap R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) = \zeta_{(R_{1_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \zeta_{(R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2),\ \iota_{(R_{1_{\mathcal{L}}} \cap R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) = \iota_{(R_{1_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \iota_{(R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2),$
$\vartheta_{(R_{1_{\mathcal{L}}} \cap R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) = \vartheta_{(R_{1_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2) \vee \vartheta_{(R_{2_{\mathcal{L}}})}(\hat{\kappa}_1,\hat{\kappa}_2).$

Example 3.9: Let $\mho_1 = \{\dot{p}_1,\dot{p}_2\}$ and $\mho_2 = \{\dot{m}_1,\dot{m}_2,\dot{m}_3\}$ and the lattice $\mathcal{L}$ in figure 1.
$R_{1_{\mathcal{L}}} = \{\langle(\dot{p}_1,\dot{m}_1),15,1,5\rangle,\langle(\dot{p}_1,\dot{m}_2),5,3,15\rangle,\langle(\dot{p}_1,\dot{m}_3),1,15,3\rangle,\langle(\dot{p}_2,\dot{m}_1),3,1,15\rangle,\langle(\dot{p}_2,\dot{m}_2),15,5,1\rangle,\langle(\dot{p}_2,\dot{m}_3),5,1,3\rangle\},$
$R_{2_{\mathcal{L}}} = \{\langle(\dot{p}_1,\dot{m}_1),3,5,1\rangle,\langle(\dot{p}_1,\dot{m}_2),15,1,5\rangle,\langle(\dot{p}_1,\dot{m}_3),1,3,15\rangle,\langle(\dot{p}_2,\dot{m}_1),5,1,15\rangle,\langle(\dot{p}_2,\dot{m}_2),3,1,5\rangle,\langle(\dot{p}_2,\dot{m}_3),15,3,5\rangle\}$
be LVPFRs from $\mho_1$ to $\mho_2$.

$[R_{1_{\mathcal{L}}}] = \begin{bmatrix}(15,1,5) & (5,3,15) & (1,15,3)\\(3,1,15) & (15,5,1) & (5,1,3)\end{bmatrix}$

$[R_{2_{\mathcal{L}}}] = \begin{bmatrix}(3,5,1) & (15,1,5) & (1,3,15)\\(5,1,15) & (3,1,5) & (15,3,5)\end{bmatrix}$

Then, $[R_{1_{\mathcal{L}}} \cup R_{2_{\mathcal{L}}}] = \begin{bmatrix}(15,1,1) & (15,1,5) & (1,3,3)\\(15,1,15) & (15,1,1) & (15,1,1)\end{bmatrix}$

$[R_{1_\mathcal{L}} \cap R_{2_\mathcal{L}}] = \begin{bmatrix} (3,1,5) & (5,1,15) & (1,3,15) \\ (1,1,15) & (3,1,5) & (5,1,15) \end{bmatrix}$

Theorem 3.10: Let $R_{1_\mathcal{L}}, R_{2_\mathcal{L}} \in LVPFR(\mathfrak{V}_1 \times \mathfrak{V}_2)$. Then,

i. $\left(R_{1_\mathcal{L}}^{-1}\right)^{-1} = R_{1_\mathcal{L}}$

ii. $\left(\left(R_{1_\mathcal{L}}\right)^c\right)^{-1} = \left(\left(R_{1_\mathcal{L}}\right)^{-1}\right)^c$

iii. $R_{1_\mathcal{L}} \subseteq R_{2_\mathcal{L}} \Rightarrow \left(R_{1_\mathcal{L}}\right)^{-1} \subseteq \left(R_{2_\mathcal{L}}\right)^{-1}$

Proof: The proof is clear from the definitions.

Theorem 3.11: Let $R_{1_\mathcal{L}}, R_{2_\mathcal{L}}, R_{3_\mathcal{L}} \in LVPFR(\mathfrak{V}_1 \times \mathfrak{V}_2)$. Then,

i. $R_{1_\mathcal{L}} \supseteq R_{2_\mathcal{L}}$ and $R_{1_\mathcal{L}} \supseteq R_{3_\mathcal{L}} \Leftrightarrow R_{1_\mathcal{L}} \supseteq R_{2_\mathcal{L}} \cup R_{3_\mathcal{L}}$

ii. $R_{1_\mathcal{L}} \subseteq R_{2_\mathcal{L}}$ and $R_{1_\mathcal{L}} \subseteq R_{3_\mathcal{L}} \Leftrightarrow R_{1_\mathcal{L}} \subseteq R_{2_\mathcal{L}} \cap R_{3_\mathcal{L}}$

Proof

i. $R_{1_\mathcal{L}} \supseteq R_{2_\mathcal{L}} \Leftrightarrow \zeta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \zeta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2), \iota_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \iota_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2), \vartheta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \leq \vartheta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2)$

$R_{1_\mathcal{L}} \supseteq R_{3_\mathcal{L}} \Leftrightarrow \zeta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \zeta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2), \iota_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \iota_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2), \vartheta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \leq \vartheta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2)$
$\zeta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \zeta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2)$ and $\zeta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \zeta_{R_{3_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \Leftrightarrow \zeta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \zeta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \vee \zeta_{R_{3_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \zeta_{(R_{2_\mathcal{L}} \cup R_{3_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2)$
$\iota_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \iota_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2)$ and $\iota_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \iota_{R_{3_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \Leftrightarrow \iota_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \iota_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \vee \iota_{R_{3_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \iota_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \wedge \iota_{R_{3_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \geq \iota_{(R_{2_\mathcal{L}} \cup R_{3_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2)$ $\vartheta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \leq \vartheta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2)$ and $\vartheta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \leq \vartheta_{R_{3_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \Leftrightarrow \vartheta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \leq \vartheta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \wedge \vartheta_{R_{3_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \leq \vartheta_{(R_{2_\mathcal{L}} \cup R_{3_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2)$ Thus, $R_{1_\mathcal{L}} \supseteq R_{2_\mathcal{L}}$ and $R_{1_\mathcal{L}} \supseteq R_{3_\mathcal{L}} \Leftrightarrow R_{1_\mathcal{L}} \supseteq R_{2_\mathcal{L}} \cup R_{3_\mathcal{L}}$.

ii. The proof is analogous to that of (i).

Theorem 3.12: Let $R_{1_\mathcal{L}}, R_{2_\mathcal{L}} \in LVPFR(\mathfrak{V}_1 \times \mathfrak{V}_2)$. Then,

i. $\left(R_{1_\mathcal{L}} \cup R_{2_\mathcal{L}}\right)^{-1} = \left(R_{1_\mathcal{L}}\right)^{-1} \cup \left(R_{2_\mathcal{L}}\right)^{-1}$

ii. $\left(R_{1_\mathcal{L}} \cap R_{2_\mathcal{L}}\right)^{-1} = \left(R_{1_\mathcal{L}}\right)^{-1} \cap \left(R_{2_\mathcal{L}}\right)^{-1}$

Proof:

i. $\zeta_{\left(\left(R_{1_\mathcal{L}}\right)^{-1} \cup \left(R_{2_\mathcal{L}}\right)^{-1}\right)}(\hat{\kappa}_2, \hat{\kappa}_1) = \zeta_{\left(R_{1_\mathcal{L}}\right)^{-1}}(\hat{\kappa}_2, \hat{\kappa}_1) \vee \zeta_{\left(R_{2_\mathcal{L}}\right)^{-1}}(\hat{\kappa}_2, \hat{\kappa}_1)$

$= \zeta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \vee \zeta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) = \zeta_{(R_{1_\mathcal{L}} \cup R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2) = \zeta_{\left(R_{1_\mathcal{L}} \cup R_{2_\mathcal{L}}\right)^{-1}}(\hat{\kappa}_2, \hat{\kappa}_1)$
$\iota_{\left(\left(R_{1_\mathcal{L}}\right)^{-1} \cup \left(R_{2_\mathcal{L}}\right)^{-1}\right)}(\hat{\kappa}_2, \hat{\kappa}_1) = \iota_{\left(R_{1_\mathcal{L}}\right)^{-1}}(\hat{\kappa}_2, \hat{\kappa}_1) \wedge \iota_{\left(R_{2_\mathcal{L}}\right)^{-1}}(\hat{\kappa}_2, \hat{\kappa}_1) = \iota_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \wedge \iota_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) = \iota_{(R_{1_\mathcal{L}} \cup R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2)$
$= \iota_{\left(R_{1_\mathcal{L}} \cup R_{2_\mathcal{L}}\right)^{-1}}(\hat{\kappa}_2, \hat{\kappa}_1)$
$\vartheta_{\left(\left(R_{1_\mathcal{L}}\right)^{-1} \cup \left(R_{2_\mathcal{L}}\right)^{-1}\right)}(\hat{\kappa}_2, \hat{\kappa}_1) = \vartheta_{\left(R_{1_\mathcal{L}}\right)^{-1}}(\hat{\kappa}_2, \hat{\kappa}_1) \wedge \vartheta_{\left(R_{2_\mathcal{L}}\right)^{-1}}(\hat{\kappa}_2, \hat{\kappa}_1) = \vartheta_{R_{1_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) \wedge \vartheta_{R_{2_\mathcal{L}}}(\hat{\kappa}_1, \hat{\kappa}_2) = \vartheta_{(R_{1_\mathcal{L}} \cup R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2) = \vartheta_{\left(R_{1_\mathcal{L}} \cup R_{2_\mathcal{L}}\right)^{-1}}(\hat{\kappa}_2, \hat{\kappa}_1)$ Thus, $\left(R_{1_\mathcal{L}} \cup R_{2_\mathcal{L}}\right)^{-1} = \left(R_{1_\mathcal{L}}\right)^{-1} \cup \left(R_{2_\mathcal{L}}\right)^{-1}$.

ii. The proof is analogous to that of (i).

COMPOSITION OF LATTICE VALUED PICTURE FUZZY RELATIONS

Definition 4.1: Consider $R_{1_\mathcal{L}} \in LVPFR(\mathfrak{V}_1 \times \mathfrak{V}_2)$ and $R_{2_\mathcal{L}} \in LVPFR(\mathfrak{V}_2 \times \mathfrak{V}_3)$. Then, the composition of $R_{1_\mathcal{L}}$ and $R_{2_\mathcal{L}}$ is a LVPFR from $\mathfrak{V}_1 \times \mathfrak{V}_3$ defined as
$R_{1_\mathcal{L}} \, o \, R_{2_\mathcal{L}} = \{\langle(\hat{\kappa}_1, \hat{\kappa}_3), \zeta_{(R_{1_\mathcal{L}} \, o \, R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_3), \iota_{(R_{1_\mathcal{L}} \, o \, R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_3), \vartheta_{(R_{1_\mathcal{L}} \, o \, R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_3)\rangle$

$|(\hat{\kappa}_1, \hat{\kappa}_3) \in \mho_1 \times \mho_3\}$
where $\zeta_{(R_{1_\mathcal{L}} o R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_3) = \vee_{\hat{\kappa}_2 \in \mho_2}[\zeta_{(R_{1_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2) \wedge \zeta_{(R_{2_\mathcal{L}})}(\hat{\kappa}_2, \hat{\kappa}_3)]$,
$\iota_{(R_{1_\mathcal{L}} o R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_3) = \wedge_{\hat{\kappa}_2 \in \mho_2}[\iota_{(R_{1_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2) \wedge \iota_{(R_{2_\mathcal{L}})}(\hat{\kappa}_2, \hat{\kappa}_3)]$,
$\vartheta_{(R_{1_\mathcal{L}} o R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_3) = \wedge_{\hat{\kappa}_2 \in \mho_2}[\vartheta_{(R_{1_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2) \vee \vartheta_{(R_{2_\mathcal{L}})}(\hat{\kappa}_2, \hat{\kappa}_3)]$.

Example 4.2: Consider $\mho_1 = \{\dot{p}_1, \dot{p}_2\}$, $\mho_2 = \{\dot{m}_1, \dot{m}_2, m_3\}$, $\mho_3 = \{\dot{x}_1, \dot{x}_2\}$ and the lattice $\mathcal{L}$ in figure 1.
Let $R_{1_\mathcal{L}} = \{\langle(\dot{p}_1, \dot{m}_1), 15,3,1\rangle, \langle(\dot{p}_1, \dot{m}_2), 1,15,3\rangle, \langle(\dot{p}_2, \dot{m}_1), 3,15,5\rangle, \langle(\dot{p}_2, \dot{m}_2), 1,3,5\rangle\}$and
$R_{2_\mathcal{L}} = \{\langle(\dot{m}_1, \dot{x}_1), 3,5,1\rangle, \langle(\dot{m}_1, \dot{x}_2), 15,3,5\rangle, \langle(\dot{m}_2, \dot{x}_1), 3,15,5\rangle, \langle(\dot{m}_2, \dot{x}_2), 1,3,15\rangle\}$
be LVPFRs from $\mho_1$ to $\mho_2$.

$$[R_{1_\mathcal{L}}] = \begin{bmatrix} (15,3,1) & (1,15,3) \\ (3,15,5) & (1,3,5) \end{bmatrix}$$

$$[R_{2_\mathcal{L}}] = \begin{bmatrix} (3,5,1) & (1,3,15) \\ (3,15,5) & (1,3,15) \end{bmatrix}$$

Then, $[R_{1_\mathcal{L}} o\, R_{2_\mathcal{L}}] = \begin{bmatrix} (3,1,1) & (15,3,5) \\ (3,1,5) & (3,3,5) \end{bmatrix}$.

Theorem 4.3: If$R_{1_\mathcal{L}} \in LVPFR(\mho_1 \times \mho_2)$ and $R_{2_\mathcal{L}} \in LVPFR(\mho_2 \times \mho_3)$, then
$(R_{1_\mathcal{L}} o\, R_{2_\mathcal{L}})^{-1} = (R_{2_\mathcal{L}})^{-1}\, o\, (R_{1_\mathcal{L}})^{-1}$.

Proof:
$\zeta_{((R_{1_\mathcal{L}} o\, R_{2_\mathcal{L}})^{-1})}(\hat{\kappa}_3, \hat{\kappa}_1) = \zeta_{(R_{1_\mathcal{L}} o\, R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_3)$

$$\begin{aligned}
&\zeta_{((R_{1_\mathcal{L}} o\, R_{2_\mathcal{L}})^{-1})}(\hat{\kappa}_3, \hat{\kappa}_1) = \zeta_{(R_{1_\mathcal{L}} o\, R_{2_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_3) \\
&= \vee_{\hat{\kappa}_2 \in \mho_2}[\zeta_{(R_{1_\mathcal{L}})}(\hat{\kappa}_1, \hat{\kappa}_2) \wedge \zeta_{(R_{2_\mathcal{L}})}(\hat{\kappa}_2, \hat{\kappa}_3)] \\
&= \bigvee_{\hat{\kappa}_2 \in \mho_2} [\zeta_{((R_{1_\mathcal{L}})^{-1})}(\hat{\kappa}_2, \hat{\kappa}_1) \wedge \zeta_{((R_{2_\mathcal{L}})^{-1})}(\hat{\kappa}_3, \hat{\kappa}_2)] \\
&= \bigvee_{\hat{\kappa}_2 \in \mho_2} [\zeta_{((R_{2_\mathcal{L}})^{-1})}(\hat{\kappa}_3, \hat{\kappa}_2) \wedge \zeta_{((R_{1_\mathcal{L}})^{-1})}(\hat{\kappa}_2, \hat{\kappa}_1)] \\
&= \zeta_{((R_{2_\mathcal{L}})^{-1}\, o\, (R_{1_\mathcal{L}})^{-1})}(\hat{\kappa}_3, \hat{\kappa}_1)
\end{aligned}$$

$$\iota_{\left((R_{1\ell}\, o\, R_{2\ell})^{-1}\right)}(\hat{\kappa}_3,\hat{\kappa}_1) = \iota_{(R_{1\ell}\, o\, R_{2\ell})}(\hat{\kappa}_1,\hat{\kappa}_3)$$
$$= \wedge_{\hat{\kappa}_2 \in \mathcal{U}_2}[\iota_{(R_{1\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \iota_{(R_{2\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)]$$
$$= \bigwedge_{\hat{\kappa}_2 \in \mathcal{U}_2}[\iota_{\left((R_{1\ell})^{-1}\right)}(\hat{\kappa}_2,\hat{\kappa}_1) \wedge \iota_{\left((R_{2\ell})^{-1}\right)}(\hat{\kappa}_3,\hat{\kappa}_2)]$$
$$= \wedge_{\hat{\kappa}_2 \in \mathcal{U}_2}[\iota_{\left((R_{2\ell})^{-1}\right)}(\hat{\kappa}_3,\hat{\kappa}_2) \wedge \iota_{\left((R_{1\ell})^{-1}\right)}(\hat{\kappa}_2,\hat{\kappa}_1)]$$
$$= \iota_{\left((R_{2\ell})^{-1}\, o\, (R_{1\ell})^{-1}\right)}(\hat{\kappa}_3,\hat{\kappa}_1)$$

$$\vartheta_{\left((R_{1\ell}\, o\, R_{2\ell})^{-1}\right)}(\hat{\kappa}_3,\hat{\kappa}_1) = \vartheta_{(R_{1\ell}\, o\, R_{2\ell})}(\hat{\kappa}_1,\hat{\kappa}_3)$$
$$= \bigwedge_{\hat{\kappa}_2 \in \mathcal{U}_2}[\vartheta_{(R_{1\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \vee \vartheta_{(R_{2\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)]$$
$$= \bigwedge_{\hat{\kappa}_2 \in \mathcal{U}_2}[\vartheta_{\left((R_{1\ell})^{-1}\right)}(\hat{\kappa}_2,\hat{\kappa}_1) \vee \vartheta_{\left((R_{2\ell})^{-1}\right)}(\hat{\kappa}_3,\hat{\kappa}_2)]$$
$$= \wedge_{\hat{\kappa}_2 \in \mathcal{U}_2}[\vartheta_{\left((R_{2\ell})^{-1}\right)}(\hat{\kappa}_3,\hat{\kappa}_2) \vee \vartheta_{\left((R_{1\ell})^{-1}\right)}(\hat{\kappa}_2,\hat{\kappa}_1)]$$
$$= \vartheta_{\left((R_{2\ell})^{-1}\, o\, (R_{1\ell})^{-1}\right)}(\hat{\kappa}_3,\hat{\kappa}_1)$$

Thus, $(R_{1_\ell}\, o\, R_{2_\ell})^{-1} = (R_{2_\ell})^{-1}\, o\, (R_{1_\ell})^{-1}$.

Theorem 4.4: Let $R_{1_\ell}, R_{2_\ell} \in LVPFR(\mathcal{U}_1 \times \mathcal{U}_2)$ and $R_{3_\ell} \in LVPFR(\mathcal{U}_2 \times \mathcal{U}_3)$. Then

i. $(R_{1_\ell} \cup R_{2_\ell})\, o\, R_{3_\ell} = (R_{1_\ell}\, o\, R_{3_\ell}) \cup (R_{2_\ell}\, o\, R_{3_\ell})$

ii. $(R_{1_\ell} \cap R_{2_\ell})\, o\, R_{3_\ell} = (R_{1_\ell}\, o\, R_{3_\ell}) \cap (R_{2_\ell}\, o\, R_{3_\ell})$

Proof:

i. $$\zeta_{(R_{1\ell} \cup R_{2\ell})\, o\, R_{3\ell}}(\hat{\kappa}_1,\hat{\kappa}_3) = \vee_{\hat{\kappa}_2 \in \mathcal{U}_2}\left(\left(\zeta_{(R_{1\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \vee \zeta_{(R_{2\ell})}(\hat{\kappa}_1,\hat{\kappa}_2)\right) \wedge \zeta_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right)$$
$$= \vee_{\hat{\kappa}_2 \in \mathcal{U}_2}\left(\left(\zeta_{(R_{1\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \zeta_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right) \vee \left(\zeta_{(R_{2\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \zeta_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right)\right)$$
$$= \bigvee_{\hat{\kappa}_2 \in \mathcal{U}_2}\left(\zeta_{(R_{1\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \zeta_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right) \vee \bigvee_{\hat{\kappa}_2 \in \mathcal{U}_2}\left(\zeta_{(R_{2\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \zeta_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right)$$
$$= \zeta_{(R_{1\ell}\, o\, R_{3\ell})}(\hat{\kappa}_1,\hat{\kappa}_3) \vee \zeta_{(R_{2\ell}\, o\, R_{3\ell})}(\hat{\kappa}_1,\hat{\kappa}_3)$$

$$\iota_{(R_{1\ell} \cup R_{2\ell})\, o\, R_{3\ell}}(\hat{\kappa}_1,\hat{\kappa}_3) = \bigwedge_{\hat{\kappa}_2 \in \mathcal{U}_2}\left(\left(\iota_{(R_{1\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \iota_{(R_{2\ell})}(\hat{\kappa}_1,\hat{\kappa}_2)\right) \wedge \iota_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right)$$
$$= \wedge_{\hat{\kappa}_2 \in \mathcal{U}_2}\left(\left(\iota_{(R_{1\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \iota_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right) \wedge \left(\iota_{(R_{2\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \iota_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right)\right)$$
$$= \bigwedge_{\hat{\kappa}_2 \in \mathcal{U}_2}\left(\iota_{(R_{1\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \iota_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right) \wedge \bigwedge_{\hat{\kappa}_2 \in \mathcal{U}_2}\left(\iota_{(R_{2\ell})}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \iota_{(R_{3\ell})}(\hat{\kappa}_2,\hat{\kappa}_3)\right)$$

$$= \iota_{\left(R_{1\mathcal{L}}\, o\, R_{3\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_3) \wedge \iota_{\left(R_{2\mathcal{L}}\, o\, R_{3\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_3)$$

$$\vartheta_{\left(R_{1\mathcal{L}} \cup R_{2\mathcal{L}}\right)\, o\, R_{3\mathcal{L}}}(\hat{\kappa}_1,\hat{\kappa}_3) = \bigwedge_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\left(\vartheta_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \vartheta_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \right) \vee \vartheta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \right)$$

$$= \wedge_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\left(\vartheta_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \vee \vartheta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \right) \wedge \left(\vartheta_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \vee \vartheta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \right) \right)$$

$$= \bigwedge_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\vartheta_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \vartheta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \right) \wedge \bigwedge_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\vartheta_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \vartheta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \right)$$

$$= \vartheta_{\left(R_{1\mathcal{L}}\, o\, R_{3\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_3) \wedge \vartheta_{\left(R_{2\mathcal{L}}\, o\, R_{3\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_3)$$

ii. The proof is analogous to that of (i).

Theorem 4.5: Consider $R_{1_\ell} \in LVPFR(\mathcal{U}_1 \times \mathcal{U}_2)$, $R_{2_\ell} \in LVPFR(\mathcal{U}_2 \times \mathcal{U}_3)$ and $R_{3_\ell} \in LVPFR(\mathcal{U}_3 \times \mathcal{U}_4)$. Then, $R_{1_\ell}\, o\, \left(R_{2_\ell} o\, R_{3_\ell}\right) = \left(R_{1_\ell} o\, R_{2_\ell}\right) o\, R_{3_\ell}$.

Proof:

$$\zeta_{R_{1\mathcal{L}}\, o\, \left(R_{2\mathcal{L}} o\, R_{3\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_4) = \bigvee_{\hat{\kappa}_3 \in \mathcal{U}_3} \left(\zeta_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \left(\bigvee_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\zeta_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \wedge \zeta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right) \right) \right)$$

$$= \mathrm{V}_{\hat{\kappa}_3 \in \mathcal{U}_3} \left(\mathrm{V}_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\zeta_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \left(\zeta_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \wedge \zeta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right) \right) \right)$$

$$= \mathrm{V}_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\left(\mathrm{V}_{\hat{\kappa}_3 \in \mathcal{U}_3} \left(\zeta_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \left(\zeta_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \right) \right) \wedge \zeta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right) \right)$$

$$= \mathrm{V}_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\zeta_{\left(R_{1\mathcal{L}}\, o\, R_{2\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_3) \wedge \zeta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right)$$

$$= \zeta_{\left(R_{1\mathcal{L}}\, o\, R_{2\mathcal{L}}\right)\, o\, R_{3\mathcal{L}}}(\hat{\kappa}_1,\hat{\kappa}_4)$$

$$\iota_{R_{1\mathcal{L}}\, o\, \left(R_{2\mathcal{L}} o\, R_{3\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_4) = \bigvee_{\hat{\kappa}_3 \in \mathcal{U}_3} \left(\iota_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \left(\bigvee_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\iota_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \wedge \iota_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right) \right) \right)$$

$$= \mathrm{V}_{\hat{\kappa}_3 \in \mathcal{U}_3} \left(\mathrm{V}_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\iota_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \left(\iota_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \wedge \iota_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right) \right) \right)$$

$$= \mathrm{V}_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\left(\mathrm{V}_{\hat{\kappa}_3 \in \mathcal{U}_3} \left(\iota_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \left(\iota_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \right) \right) \wedge \iota_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right) \right)$$

$$= \mathrm{V}_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\iota_{\left(R_{1\mathcal{L}}\, o\, R_{2\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_3) \wedge \iota_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right)$$

$$= \iota_{\left(R_{1\mathcal{L}}\, o\, R_{2\mathcal{L}}\right)\, o\, R_{3\mathcal{L}}}(\hat{\kappa}_1,\hat{\kappa}_4)$$

$$\vartheta_{R_{1\mathcal{L}}\, o\, \left(R_{2\mathcal{L}} o\, R_{3\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_4) = \bigvee_{\hat{\kappa}_3 \in \mathcal{U}_3} \left(\vartheta_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \left(\bigvee_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\vartheta_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \wedge \vartheta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right) \right) \right)$$

$$= \mathrm{V}_{\hat{\kappa}_3 \in \mathcal{U}_3} \left(\mathrm{V}_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\vartheta_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \left(\vartheta_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \wedge \vartheta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right) \right) \right)$$

$$= \mathrm{V}_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\left(\mathrm{V}_{\hat{\kappa}_3 \in \mathcal{U}_3} \left(\vartheta_{\left(R_{1\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_2) \wedge \left(\vartheta_{\left(R_{2\mathcal{L}}\right)}(\hat{\kappa}_2,\hat{\kappa}_3) \right) \right) \wedge \vartheta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right) \right)$$

$$= \mathrm{V}_{\hat{\kappa}_2 \in \mathcal{U}_2} \left(\vartheta_{\left(R_{1\mathcal{L}}\, o\, R_{2\mathcal{L}}\right)}(\hat{\kappa}_1,\hat{\kappa}_3) \wedge \vartheta_{\left(R_{3\mathcal{L}}\right)}(\hat{\kappa}_3,\hat{\kappa}_4) \right)$$

$$= \vartheta_{\left(R_{1\mathcal{L}}\, o\, R_{2\mathcal{L}}\right)\, o\, R_{3\mathcal{L}}}(\hat{\kappa}_1,\hat{\kappa}_4)$$

Thus, $R_{1_\ell}\, o\, \left(R_{2_\ell} o\, R_{3_\ell}\right) = \left(R_{1_\ell} o\, R_{2_\ell}\right) o\, R_{3_\ell}$.

CONCLUSION

In the current article, we have defined Lattice Valued Picture Fuzzy Relations and discussed their properties. The properties of composition of Lattice Valued Picture Fuzzy Relations have been studied. Using the concepts discussed in this study, future research can be done on problems related to decision-making.

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RESEARCH ARTICLE

A Study on the Role of Hr in Promoting Work-Life Balance for Employees

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ABSTRACT

This study examines the role of Human Resource (HR) management in promoting work-life balance among employees. It investigates how HR policies such as flexible work schedules, remote work, and wellness programs contribute to achieving a balance between work and personal life. Based on a survey of 110 employees, the research finds that such HR initiatives significantly enhance employee satisfaction and productivity. The study highlights the importance of effective communication of policies and personalized support, emphasizing HR's critical role in improving employee well-being and organizational performance. The findings suggest that organizations prioritizing work-life balance can foster a more engaged and productive workforce.

Keywords: Work-Life Balance, Human Resource Management, Employee Well-being, Flexible Work Policies, promoting work-life balance.

INTRODUCTION

Work-life balance is the state of managing personal life and work commitments effectively. In the current competitive landscape, it is essential for organizations to acknowledge the significance of employee well-being in order to maintain high levels of productivity and morale. Human Resource Management (HRM) plays a vital role in designing policies that support work-life balance initiatives. This study examines how HR functions contribute to maintaining a healthy work-life interface for employees. Key concerns include flexible scheduling, stress management, employee engagement, and wellness programs.

HR's role in promoting work-life balance

The Human Resources (HR) department plays a crucial role in creating a work environment that supports work-life balance. HR professionals implement policies, programs, and initiatives that help employees manage their professional and personal lives effectively. Some key HR strategies include:

1. Flexible Work Policies: HR introduces shift rotations, manageable work schedules, and remote work options where feasible.
2. Health and Wellness Initiatives: Providing access to medical check-ups, stress management programs, and wellness activities.
3. Employee Assistance Programs (EAPs): Offering counseling services and mental health support to employees.
4. Fair Leave Policies: Ensuring employees have adequate leave benefits, including paid time off, maternity/paternity leave, and emergency leave.
5. Workplace Culture and Engagement: Organizing team-building activities, celebrations, and open communication forums to foster a positive work environment.

NEED FOR THE STUDY

In the current fast-paced and demanding workplace, achieving a proper balance between professional duties and personal life has become more difficult for employees. High work demands, long hours, and continuous connectivity via digital devices often result in stress, burnout, and a decline in productivity.

Human Resource (HR) departments play a vital role in designing and implementing policies and practices that support employees in achieving work-life balance. The need for this study arises from the growing recognition that promoting work-life balance not only enhances employee well-being but also contributes to higher job satisfaction, improved employee retention, and organizational performance.

OBJECTIVES OF THE STUDY

- To gain a deeper understanding of the concept of work-life balance and its significance.
- To explore the role played by Human Resources in fostering work-life balance.
- To identify HR practices and policies aimed at supporting employees' personal and professional needs.
- To evaluate the effectiveness of these practices on employee satisfaction and productivity.
- To provide recommendations for improving work-life balance initiatives.

SCOPE OF THE STUDY

The study is limited to understanding the effectiveness of HR practices in promoting work-life balance within organizations. It focuses on the strategies adopted, the benefits observed by employees, and the organizational outcomes. While the study does not include industry-specific or company-specific data, it takes into account a general perspective applicable across various sectors. It is based on primary data collected from a sample size of 110 respondents.

A WELL-BALANCED WORK-LIFE DYNAMIC ENHANCES EMPLOYEE PRODUCTIVITY, SATISFACTION, AND OVERALL ORGANIZATIONAL SUCCESS

19th Century (1800s) – The Industrial Revolution

- Work-life balance was almost non-existent, with employees (including children)working long hours in factories.
- The focus was on maximizing production, and worker well-being was not a priority.
- Labor movements began advocating for better working conditions, leading to laws on working hours.

20th Century (1900s) – Labor Rights and Workplace Reforms

- 1920s-1930s: The concept of the 8-hour workday gained traction (e.g., Henry Ford introduced it in 1926).
- 1940s-1950s: The rise of corporate HR departments started addressing employee welfare.
- 1970s-1980s: The term "work-life balance" emerged as more women joined the workforce, leading to policies like maternity leave and flexible work schedules.

- 1990s: Companies began recognizing that employee well-being directly impacts productivity. HR started implementing employee assistance programs (EAPs), wellness initiatives, and family-friendly policies.

21st Century (2000s-Present) – Digital Age and Flexibility

- 2000s: Remote work and flexible schedules became more common with advancements in technology.
- 2010s: Mental health awareness increased, and HR played a significant role in promoting well-being programs.
- 2020s (Post-Pandemic Era): The COVID-19 pandemic accelerated the shift to remote and hybrid work. HR now focuses on flexible work arrangements, mental health support, and work-life integration to boost employee productivity and satisfaction.

CHALLENGES THAT EMPLOYEES FACE IN ACHIEVING WORK-LIFE BALANCE

While work-life balance is crucial for employee well-being, achieving it can be challenging due to several factors, including:

1. Long Work Hours: Numerous employees are expected to work extended periods of time, which can make it challenging for them to balance work and individual obligations.
2. Job Demands: Employees who work in high-stress or requesting jobs might find it trying to separate from work, bringing about work-related pressure, and trouble in overseeing individual responsibilities,
3. Lack of Flexible Work Arrangements: Employees who don't have the choice to work from home, work from home or work flexible hours might find it trying to balance work and individual obligations,
4. Job Insecurity: Employees who have an uncertain outlook on their jobs might focus on work over private obligations, prompting burnout and expanded pressure.
5. Personal Commitments: Individual responsibilities, like family obligations, really focusing on kids or older relatives, or seeking after schooling, can likewise make it trying for employees to balance work and individual life.
6. Technology: The accessibility of innovation, for example, cell phones and PCs has made it more straightforward for employees to work beyond conventional work hours, making it trying for employees to turn off from work.
7. Workplace Culture: Workplace culture that promotes long working hours and rewards those who work excessively can make it difficult for employees to maintain a work-life balance.

REVIEW OF LITERATURE

Numerous researchers have addressed the significance of work-life balance:

1. Greenhaus & Allen (2011) – Defined work-life balance as the level of satisfaction and good functioning at work and at home with minimum role conflict.
2. Clark (2000) – Proposed the Work/Family Border Theory which explains how individuals manage and negotiate the boundaries between work and family domains.
3. Friedman & Greenhaus (2000) – Highlighted the importance of organizational support in achieving balance.
4. Kossek et al. (2006) – Showed that flexible work arrangements significantly improve job satisfaction.
5. Hill et al. (2001) – Found that teleworking enhances work-life balance by reducing commuting stress.
6. Batt & Valcour (2003) – Suggested that supportive HR policies improve commitment and reduce turnover.
7. Allen (2001) – Found that managerial support is crucial in reducing work-family conflict.
8. Beauregard & Henry (2009) – Asserted that work-life balance practices positively impact organizational outcomes.
9. Byron (2005) – Conducted a meta-analysis showing that work-family conflict adversely affects job satisfaction.
10. Aryee et al. (2005) – Revealed that work-life balance programs enhance employee morale.

RESEARCH METHODOLOGY

- Research Design: Descriptive

- Sampling Technique: Simple Random Sampling
- Sample Size: 110 employees
- Data Collection Tool: Structured questionnaire using Likert scale (Strongly Agree to Strongly Disagree)Statistical Tools Used: Percentage analysis, t-test, U test, regression, correlation, F-test.

METHODS OF THE DATA COLLECTION

Primary Data Collection
Primary data refers to first-hand information collected directly from respondents. Since your study involves offline data collection, the methods used may include:

Questionnaires & Surveys
Structured or semi-structured questionnaires were used to collect responses directly from employees/customers.

Interviews
Face-to-face interviews helped gather detailed insights from respondents. Observations: Observing employee/customer behavior in real-time provided qualitative insights.

Secondary Data Collection
Secondary data refers to information that has already been collected and analyzed by other sources.

Company Reports & HR Policies
For understanding existing employee work-life balance initiatives.

Government Reports & Industry Studies
To compare industry trends and policies. Previous Research Papers & Articles: To support the findings with existing literature.

Sample Size
The study is conducted with a sample size of 102 respondents. This number was determined based on the feasibility of data collection and the need to obtain a representative sample of the population under study.

Sampling Technique
A sampling technique is the process used to select participants for the study. In this research, an appropriate method such as simple random sampling, stratified sampling, or convenience sampling is used, ensuring that the selected respondents accurately represent the target population.

Sampling Area
The sampling area refers to the geographical or organizational scope from which the respondents are selected. For this study, data was collected from employees to ensure relevant and valid findings.

Hypothesis
Main Hypothesis (H_1) and Null Hypothesis (H_0):
H_0 (Null Hypothesis)
HR policies and practices have no significant impact on employees' work-life balance, job satisfaction, or well-being.

H_1 (Alternative Hypothesis)
HR policies and practices significantly impact employees' work-life balance, leading to improved job satisfaction, reduced stress, and better personal well-being.

Sample Tests

DATA ANALYSIS AND INTERPRETATION

1.9.1 T-TEST

Null Hypothesis (H_0)

There is no significant difference in the average working hours per week between different genders.

Alternative Hypothesis (H_1)

There is a significant difference in the average working hours per week between different genders.

GENDER	69	41	0	0	0
DISTRIBUTION OF RESPOND BASED ON THEIR WORKING HOURS PER WEEK	0	110	0	0	0

X_1	X_1^2	X_2	X^2_2
69	4761	0	O
41	1681	110	12100
0	0	0	0
0	0	0	0
0	0	0	0
110	**6442**	**110**	**12100**

$N_1 = 2$

$\bar{X}1 = \frac{\sum X_1}{N_1}$ $\bar{X}2 = \frac{\sum X_2}{N_2}$

$\bar{X}1 = \frac{110}{2}$ $\bar{X}2 = \frac{110}{1}$

= 55 = 110

$S_1^2 = \sqrt{\frac{\sum X_1^2}{N_1} - \left(\frac{\sum X_1}{N_1}\right)^2}$

$= \sqrt{\frac{6642}{2} - \left(\frac{110}{2}\right)^2}$

$= \sqrt{3221 - 3025}$

$= \sqrt{196}$

$S_1^2 = 14$

$S_2^2 = \sqrt{\frac{\sum X_2^2}{N_2} - \left(\frac{\sum X_2}{N_2}\right)^2}$

$= \sqrt{12100 - 12100}$

$S_2^2 = 0$

$S = \sqrt{\frac{\sum S_1^2 N_1 + S_2^2 N_2}{N_1 + N_2 - 2}}$

$= \sqrt{\frac{14(2) + 0(1)}{2+1-2}}$

$= \sqrt{\frac{28}{1}} = \sqrt{28}$

S = 5.2915

$t = \frac{\overline{X_1} - \overline{X_2}}{S\sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$

$= \frac{55 - 110}{5.2915\sqrt{\frac{1}{2} + \frac{1}{1}}}$

$= \frac{55}{5.2915\sqrt{1.5}} = \frac{55}{20.4934}$

t = 2.6837
Degree of freedom = 2 + 1 - 2
= 1
6.314 > 2.6837
Tabulated value > calculated value .

CONCLUSION

Calculated value is greater then tabulated value. Therefore null hypothesis (H_0) is accepted. Hence, there is no significant difference in the average working hours per week between different genders.

U-TEST ANALYSIS

Null Hypothesis (H_0)

There is no association between marital status and the requirement to work beyond regular hours frequently.

Alternative Hypothesis (H_1)

There is an association between marital status and the requirement to work beyond regular hours frequently.

MARITAL STATUS	43	56	11	0	0
JOB REQUIRES TO WORK BEYOND REGULAR WORKING HOURS FREQUENTLY.	25	18	35	15	17

X_1	R_1	X_2	R2
43	7	25	5
56	8	18	4
11	1	35	6
0	-	15	2
0	-	17	3
N_1=3	R_1= 16	N_2 = 5	R_2 =20

N_1=3, R_1= 16 ,N_2 = 5 ,R_2 =20

U= $N_1(N_2) + N_1 \frac{(N_1+1)}{2} - R_1$

3(5) + $\frac{(3+1)}{2}$ - 16

U= 15+ $\frac{12}{2}$ - 16

= 21 - 16 = 5.

Var (U) $N_1 N_2 \frac{(N_{1+N_{2+1}})}{2}$

= 3×5 $\frac{(3+5+1)}{12}$

=15× $\frac{9}{12}$ = 11.25

E (U) = $\frac{N_1 N_2}{2}$

= $\frac{3\times5}{2} = \frac{15}{2} = 7.5$

Z = $\frac{U-E(U)}{\sqrt{Var\,U}}$

= $\frac{5-7.5}{\sqrt{11.25}}$

= $\frac{-2.5}{\sqrt{11.25}} = \frac{-2.5}{3.35}$

Z = 0.755

Table Value = 0.4494

Calculated Value > Tabulated Value

0.755 > 0.4494

CONCLUSION

Calculated value is greater then tabulated value. Therefore null hypothesis (H_0) is accepted. Hence, there is no significant difference in the average working hours per week between different genders.

CORRELATION ANALYSIS

Null Hypothesis (H_0)

There is no significant correlation between having dependents and the length of employment in the current company.

Alternative Hypothesis (H_1)

There is a significant correlation between having dependents and the length of employment in the current company.

MARITAL DEPENDENTS	72	38	0	0
SERVICE	10	33	29	38

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{n(\sum x^2)(n\sum y^2 - (\sum y)^2}}$$

X	**Y**	**X^2**	**Y^2**	**XY**
72	10	5184	100	720
38	33	1444	1089	1254
0	29	0	814	0
0	38	0	1444	0
110	**110**	**6028**	**3447**	**1974**

$$r = \frac{4 \times 1974 - 110 \times 110}{\sqrt{4 \times (6628) - (110)^2 \times (3447 - (110)^2}}$$

$$r = \frac{7896 - 12100}{\sqrt{4(6628 - 12100)(3447 - 12100)}}$$

$$r = \frac{4204}{4 \times (5472)(7627)}$$

$$= \frac{4204}{166.939776}$$

= 0.0002

CONCLUSION

The Coefficient of Correlation (r) is 0.0002. Since the degree of positive correlation is 0 to +0.25. Therefore, there is a very low degree of positive correlation.

REGRESSION ANALYSIS

Null Hypothesis (H_0)

Age group does not significantly predict stress due to work-life imbalance.

Alternative Hypothesis (H_1)

Age group significantly predicts stress due to work-life imbalance.

AGE	13	39	26	20	12
FEEL STRESSED DUE TO WORK-LIFE IMBALANCE.	48	26	24	12	0

Y= a+ bx

$b = \frac{n\sum xy-(\sum x)(\sum y)}{n\sum x}$

$a = \frac{\sum y-b(\sum x)}{n}$

X	Y	X^2	Y^2	XY
13	48	169	2304	624
39	26	1521	676	1014
26	24	676	576	624
20	12	400	144	240
12	0	144	0	0
110	**110**	**2910**	**3700**	**2502**

$b = \frac{n\sum xy-(\sum x)(\sum y)}{n\sum x^2-(\sum x)^2}$

$= \frac{5\times2502-(110)(110)}{5\times2910-(110)^2}$

$= \frac{12510-12100}{14550-12100}$

$= \frac{410}{2450}$

b= 0.1673

$\mathbf{a= \sum y - b\,(\sum xy)}$

$= \frac{110-0.1673(110)}{5}$

$= \frac{91.597}{5} = 18.3194$

Y= a + b x

=18.3194+0.1673x

F-TEST ANALYSIS

Null Hypothesis (H_0)

There is no significant difference in motivation and productivity due to work-life balance across different departments.

Alternative Hypothesis (H_1)

There is a significant difference in motivation and productivity due to work-life balance across different departments.

GOOD WORK LIFE BALANCE	63	23	24	0	0
DEPARTMENT	12	29	45	19	5

X	X^2	Y	Y^2
63	3969	12	144
23	529	29	814
24	576	45	2025
0	0	19	361
0	0	5	25
110	**5074**	**110**	**3396**

$\overline{X_2} = \frac{\sum X}{N_2}$

$\overline{X_2} = \frac{110}{3}$

$\overline{X_2}$ = 36.66

$\overline{\boldsymbol{Y_2}} = \frac{\sum \boldsymbol{X}}{\boldsymbol{N}}$

$\overline{Y_2} = \frac{110}{5}$

$\overline{Y_2}$= 22

$S_1 = \frac{\sum X^2}{N_{1-1}} S_2 = \frac{\sum Y^2}{N_{2-1}}$

$S_{1^2} = \frac{5074}{3-1} S_{2^2} = \frac{3396}{5-1}$

$S_{1^2} = \frac{5074}{2} S_{2^2} = \frac{3396}{4}$

$S_{1^2} = 2537 S_{2^2}$= 849

F= $\frac{2537}{849}$ = 2.9882

$V_{1=}$ N HIGH – 1 $V_{2=}$ N HIGH - 1

= 5-1 = 4 = 3-1 = 2

TABULATED VALUES = 6.94

2.9882< 6.94

CONCLUSION

The calculated value is 2.9882 which is lesser than tabulated value.hence, null hypothesis (Ho) is accepted.

FINDINGS

- Majority of employees are satisfied with HR's role in promoting work-life balance.
- Flexibility in working hours ranks highest in effectiveness.
- Female employees report higher stress due to work-life imbalance.
- Awareness of HR policies significantly affects satisfaction.
- Strong correlation between HR support and employee retention.

SUGGESTIONS

- Introduce more flexible work arrangements (e.g., hybrid models).
- Increase awareness campaigns on existing HR policies.
- Provide specialized support for women, especially post-maternity.
- Conduct regular wellness programs and stress audits.
- Use technology to monitor and support employee work-life patterns.

CONCLUSION

This study reinforces the crucial role HR plays in enhancing work-life balance. With the right policies and consistent implementation, HR departments can significantly improve employee morale, reduce turnover, and promote a more productive work environment. Tailored interventions and proactive communication are key to sustaining these initiatives.

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REVIEW ARTICLE

Structural Configurations and Optimization Strategies for Crane Mechanisms – A Review

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ABSTRACT

Crane mechanisms are critical components in various industrial applications, enabling the efficient lifting and transportation of heavy loads. This review examines contemporary advancements in crane mechanisms, reliability analysis, and optimization strategies. By synthesizing insights from multiple research papers, specific methodologies such as reliability block diagrams and metaheuristic optimization algorithms like Particle Swarm Optimization (PSO) are highlighted. Key findings include the superior performance of PSO in minimizing crane hook volume while maintaining load capacity and the critical role of project management tools in streamlining manufacturing workflows. Key gaps in current research are identified, such as the lack of standardized testing methods and the need for IoT integration, along with potential directions for future studies.

Keywords: Crane Mechanisms, Reliability Analysis, Optimization Strategies, Metaheuristic Algorithms, Structural Design

INTRODUCTION

Cranes are indispensable in modern industry, providing critical functionality in lifting, transporting, and placing heavy loads across construction sites, manufacturing plants, and logistics hubs. The evolution of crane mechanisms has paralleled the advancement of technology, incorporating sophisticated designs and control systems to enhance

safety, efficiency, and adaptability to varied tasks [1], [2], [5]. The complexity of crane systems arises from their multifunctional roles and the diverse environments in which they operate. For instance, bridge cranes and gantry cranes in industrial settings require precise load distribution and movement control, while mobile cranes deployed in construction must balance portability with lifting capacity. Each type of crane brings unique engineering challenges, including dynamic load handling, structural integrity, and operational safety [3], [4]. This review integrates findings from a wide array of studies to present a comprehensive overview of advancements in crane mechanisms. Key areas of focus include reliability analysis of crane components, optimization strategies for improving performance, and the integration of advanced project management methodologies. Special attention is given to recent innovations such as the application of metaheuristic algorithms for design optimization and the use of IoT technologies for real-time monitoring [6], [7]. By addressing the diverse challenges in crane operations—from mitigating component failures to enhancing material efficiency—this review aims to provide valuable insights for engineers, researchers, and industry professionals. The synthesis of existing research reveals gaps in knowledge and highlights opportunities for innovation, setting the stage for future advancements in this essential field of industrial engineering. Cranes play an essential role in industries such as construction, manufacturing, and logistics. The increasing complexity of crane systems demands robust mechanisms that are reliable, efficient, and optimized for specific applications. This review synthesizes findings from studies on various aspects of crane mechanisms, including reliability analysis, project management, and optimization methodologies, providing a comprehensive understanding of the field.

Overview of Crane Mechanisms

Crane mechanisms consist of several critical components, including lifting hooks, sheave blocks, ropes, and drum systems. The following subsections detail advancements in these components:

Lifting Mechanisms

Research emphasizes the reliability of crane lifting mechanisms to ensure safe operations. Structural configurations—ranging from single-rope systems to complex multi-component mechanisms—have been analyzed to minimize failure probabilities [8], [9]. These configurations include:

- **Single-Rope Systems**: These are simpler mechanisms often employed in smaller cranes, valued for their cost-effectiveness but limited in load capacity [10].
- **Multi-Rope Systems**: Designed for larger cranes, these configurations offer redundancy, enhancing reliability and safety by distributing the load across multiple ropes [11].
- **Integrated Safety Features**: Advanced configurations incorporate safety brakes and redundant supports, reducing the likelihood of catastrophic failures [12]. The choice of configuration significantly impacts operational safety, with more complex systems providing higher reliability but requiring more rigorous maintenance protocols.

Crane Hook Design

Optimization of crane hooks is a recurring theme, with studies employing metaheuristic algorithms such as Particle Swarm Optimization (PSO) and Harmony Search (HSA) to minimize volume while maintaining load capacity. This approach balances material efficiency and structural integrity [6], [13].

Reliability Block Diagrams

Reliability block diagrams (RBDs) are essential tools for analyzing the reliability of interconnected components. The study by Faltinová *et al.* (2018) demonstrated how RBDs can assess failure probabilities in different configurations, revealing critical points for design improvements [8].

Optimization Strategies in Crane Mechanisms

Optimization techniques have revolutionized the design and operation of crane systems. The following methods have been highlighted in the literature:

Metaheuristic Algorithms

Ten metaheuristic algorithms, including PSO and Crow Search Algorithm (CSA), have been compared for their efficiency in optimizing crane hook designs (Nancy & Stephen, 2022). PSO showed superior performance in minimizing the crane hook's volume while meeting load requirements. Specifically, PSO's advantages include:

- **Computational Efficiency:** PSO converges faster compared to other algorithms by efficiently exploring and exploiting the search space.
- **Accuracy:** The algorithm maintains high precision in reaching near-optimal solutions, making it suitable for minimizing complex design variables like crane hook volume.
- **Simplicity:** PSO requires fewer parameters for tuning, reducing the complexity of implementation and improving usability across diverse optimization problems.
- **Adaptability:** It is robust in handling non-linear and multi-dimensional optimization tasks, as demonstrated in crane mechanism applications. These features collectively make PSO a preferred choice for crane design optimization. Ten metaheuristic algorithms, including PSO and Crow Search Algorithm (CSA), have been compared for their efficiency in optimizing crane hook designs (Nancy & Stephen, 2022). PSO showed superior performance in minimizing the crane hook's volume while meeting load requirements.

Project Management Applications

Chauhan et al. (2018) investigated project management tools, such as Critical Path Method (CPM), to streamline the manufacturing of Electrical Overhead Travelling (EOT) cranes. This study identified areas for improvement, such as reducing material transportation costs and optimizing production workflows.[3]

Reliability-Centered Maintenance

Reliability-centered maintenance (RCM) strategies focus on preemptive measures to reduce downtime and enhance system longevity. These approaches are critical in minimizing operational risks in crane mechanisms [1]

Challenges and Research Gaps

Despite significant advancements, several challenges persist in the field:

1. **Standardization:** Lack of standardized testing methods for evaluating the reliability of crane components. For instance, Faltinová *et al.* (2018) highlighted discrepancies in testing methodologies across different crane systems, leading to inconsistent reliability assessments. [1]
2. **Material Innovation:** Limited exploration of advanced materials for improving crane hook durability and reducing weight. A case study on composite materials for crane hooks showed promise in reducing wear and tear but requires further validation [2]
3. **Dynamic Load Analysis:** Insufficient studies on the real-time dynamic behavior of crane systems under varying load conditions. For example, a study on bridge cranes indicated that fluctuating loads could cause unexpected system fatigue, underscoring the need for dynamic simulations.
4. **Integration of IoT:** Few studies address the integration of IoT technologies for real-time monitoring and predictive maintenance. Chauhan et al. (2018) demonstrated the potential of IoT in reducing operational downtime by tracking component health, yet its adoption remains limited due to high implementation costs.[3] These examples highlight the pressing need for more focused research to address these challenges effectively.

Despite significant advancements, several challenges persist in the field:

1. **Standardization:** Lack of standardized testing methods for evaluating the reliability of crane components.
2. **Material Innovation:** Limited exploration of advanced materials for improving crane hook durability and reducing weight.
3. **Dynamic Load Analysis:** Insufficient studies on the real-time dynamic behavior of crane systems under varying load conditions.
4. **Integration of IoT:** Few studies address the integration of IoT technologies for real-time monitoring and predictive maintenance.

Future Directions

Future research should focus on:

1. **IoT Integration:** Developing smart crane systems equipped with sensors for real-time data analysis and predictive maintenance. For instance, IoT-enabled sensors could monitor load distribution, alert operators to potential faults, and optimize maintenance schedules based on real-time data trends, reducing operational downtime and enhancing safety.
2. **Material Science Innovations:** Exploring lightweight, high-strength materials to improve crane efficiency. Practical implementations might include using composites or alloys that offer higher tensile strength with reduced weight, thereby decreasing energy consumption and wear on components.
3. **Dynamic Simulations:** Employing advanced simulation techniques to study the impact of dynamic loads on crane mechanisms. Tools like finite element analysis (FEA) can model stress distribution under varying operational conditions, providing insights into potential design optimizations.
4. **Sustainability:** Investigating environmentally friendly manufacturing processes and materials. This could involve adopting green technologies such as low-emission manufacturing methods and recyclable materials, contributing to sustainable development in the industry.

Future research should focus on

1. **IoT Integration:** Developing smart crane systems equipped with sensors for real-time data analysis and predictive maintenance.
2. **Material Science Innovations:** Exploring lightweight, high-strength materials to improve crane efficiency.
3. **Dynamic Simulations:** Employing advanced simulation techniques to study the impact of dynamic loads on crane mechanisms.
4. **Sustainability:** Investigating environmentally friendly manufacturing processes and materials.

CONCLUSION

This review consolidates findings from diverse studies, providing insights into the current state and future potential of crane mechanisms and optimization strategies. By addressing existing challenges and adopting innovative methodologies, the reliability, efficiency, and sustainability of crane systems can be significantly enhanced.

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RESEARCH ARTICLE

Breaking Colonial Dependence: Khwaja Abdul Hamied's Contribution to India's Pharmaceutical Revolution

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ABSTRACT

The Indian pharmaceutical industry, now a global leader in generic medicines, owes much to Khwaja Abdul Hamied, founder of Cipla in 1935. Determined to break India's dependence on foreign drug manufacturers, Hamied championed affordable, indigenous medicine production. His vision extended beyond business—he actively influenced policy, research, and self-reliance in critical pharmaceuticals. Amidst colonial constraints, he advocated for scientific innovation and industrial autonomy, ensuring essential medicines reached the masses. Hamied's efforts laid the foundation for India's pharmaceutical self-sufficiency, inspiring future policies like the Patent Act of 1970, which prioritized public health over monopoly profits. His legacy endures in India's transformation into the "pharmacy of the world," supplying affordable drugs globally. By fostering indigenous research and development, he not only revolutionized the industry but also strengthened India's healthcare infrastructure, proving that scientific progress and social responsibility could go hand in hand.

Keywords: Khwaja Abdul Hamied, Indian pharmaceutical industry, Cipla, Indigenous drug production, Pharmaceutical self-reliance, Affordable medicines

INTRODUCTION

Colonial rule in India entrenched dependence on Western pharmaceutical companies, which monopolized drug manufacturing and restricted access to essential medicines. Lacking indigenous production, India was forced to import expensive drugs, rendering healthcare inaccessible to a significant portion of the population. This

pharmaceutical dependence reinforced economic and medical vulnerabilities, leaving India reliant on foreign firms for life-saving treatments. Khwaja Abdul Hamied recognized this critical gap and founded Cipla in 1935 with a vision of pharmaceutical self-reliance. A chemist trained in Germany, Hamied combined scientific expertise, nationalist ideology, and entrepreneurial acumen to challenge foreign monopolies and establish an independent pharmaceutical industry. His efforts not only facilitated domestic drug production but also laid the foundation for India's emergence as a global leader in affordable medicine. This paper examines Hamied's pivotal role in dismantling colonial pharmaceutical dependence and fostering self-sufficiency. It explores his contributions to scientific research, policy advocacy, and indigenous drug manufacturing, which transformed India's healthcare landscape. By spearheading a movement for affordable and accessible medicines, Hamied's legacy endures in India's position as the "pharmacy of the world."

Colonial India and Pharmaceutical Dependence

During colonial rule, India lacked an indigenous pharmaceutical industry and relied heavily on Western drug **manufacturers**, who controlled production and pricing. British and European firms monopolized essential medicines, making them expensive and inaccessible to most Indians. The absence of domestic research and development further deepened this dependence, leaving the country vulnerable to public health crises and reinforcing economic subjugation through pharmaceutical imports.

British Monopoly on Pharmaceuticals

During British rule, India had no significant domestic pharmaceutical industry and remained heavily reliant on British and European drug manufacturers. These multinational corporations, including Glaxo, Burroughs Well come, and Bayer, monopolized drug production, ensuring that essential medicines remained costly and largely inaccessible to the Indian population. By leveraging restrictive patent laws, these firms eliminated competition, preventing local industries from developing independent manufacturing capabilities. The lack of indigenous pharmaceutical research and production exacerbated public health challenges, as life-saving drugs for diseases like malaria, tuberculosis, and cholera remained out of reach for millions. Additionally, colonial policies discouraged investment in local drug manufacturing, keeping India dependent on expensive imports. This pharmaceutical monopoly not only increased healthcare inequality but also reinforced India's economic subjugation. The pressing need for an independent pharmaceutical sector became evident, paving the way for reformers like Khwaja Abdul Hamied to challenge this colonial dependence.

The Absence of Indigenous Production

Unlike industrialized nations with well-established pharmaceutical sectors, colonial India faced significant structural barriers that hindered the development of an independent drug industry. The country lacked research infrastructure, domestic manufacturing capabilities, and policy support, forcing it to rely on expensive imports controlled by British and European firms. Restrictive patent laws further prevented Indian entrepreneurs from producing essential medicines, ensuring foreign monopolies remained unchallenged. This dependency was not merely an issue of economic exploitation but had devastating consequences for public health. Epidemics of malaria, tuberculosis, and cholera continued to ravage the population, with life-saving treatments priced beyond reach for most Indians. With no access to affordable medicine, mortality rates soared, and healthcare remained an unattainable luxury for the masses. Colonial pharmaceutical policies prioritized profit over public welfare, reinforcing India's medical and economic subjugation. The urgent need for self-reliance in drug manufacturing became evident, setting the stage for later reformers like Khwaja Abdul Hamied to challenge this dependence.

Khwaja Abdul Hamied: A Visionary of Pharmaceutical Independence

Scientific and Nationalist Ideals

Hamied, an accomplished chemist trained in Germany**,** returned to India with a vision to establish an indigenous pharmaceutical industry. Inspired by the Swadeshi movement**,** he believed that science should serve national interests, particularly in ensuring access to life-saving medicines. His dual identity as a scientist and nationalist positioned him as an ideal reformer.

Founding of Cipla (1935)

Khwaja Abdul Hamied's decision to establish a domestic pharmaceutical industry was driven by his strong belief in self-reliance and his frustration with India's dependence on foreign drug manufacturers. During British rule, India's pharmaceutical sector was entirely controlled by British and European multinational corporations, which not only kept medicine prices high but also restricted access to essential drugs. This monopoly ensured that most Indians, particularly the lower-income population, could not afford necessary treatments. Having pursued his doctoral studies in chemistry in Germany, Hamied was deeply influenced by the role of scientific research in national development. While studying under renowned chemist Carl Bosch, he recognized the importance of an independent pharmaceutical industry in ensuring healthcare accessibility. His time in Germany also exposed him to nationalist and anti-colonial movements, reinforcing his commitment to making India self-sufficient in medicine production. Upon returning to India, Hamied realized that pharmaceutical production in the country was practically nonexistent. The few existing firms were either distributors of foreign drugs or small-scale producers of basic medicinal compounds, incapable of competing with large multinational corporations. This gap in domestic drug manufacturing, combined with restrictive British policies, inspired Hamied to take bold action. He envisioned a scientifically advanced, independent Indian pharmaceutical company that could provide quality medicines at affordable prices.

Challenges in Establishing Cipla

In 1935**,** Hamied laid the foundation of Chemical, Industrial & Pharmaceutical Laboratories (Cipla) in Mumbai with the goal of manufacturing essential medicines domestically. However, this initiative was fraught with challenges.

1. **Financial Constraints:** Establishing a pharmaceutical company required significant capital investment, and financial institutions were reluctant to support indigenous businesses.British-controlled banks favored loans to European enterprises, making it difficult for Indian entrepreneurs to secure funding.Hamied had to rely on **personal savings, private investments, and contributions from nationalist supporters** who believed in his vision of self-reliance.
2. **Logistical and Technological Barriers:** The lack of domestic **pharmaceutical manufacturing expertise** meant that Cipla had to develop its own research and production capabilities from scratch.India did not have **modern laboratories, trained personnel, or access to advanced machinery**, forcing Cipla to import equipment at high costs.The British government imposed **import restrictions and tariffs** on essential raw materials, increasing the cost of production.
3. **Foreign Competition and Colonial Policies:**British and European firms, fearing competition, used their influence to prevent Cipla from obtaining manufacturing licenses.Hamied had to **negotiate with colonial authorities** to gain permission to produce specific drugs, a process designed to favor foreign companies.Cipla faced **intellectual property restrictions**, as many essential drugs were under patents held by Western firms.

Early Achievements and Breakthroughs

Despite numerous challenges, Khwaja Abdul Hamied remained resilient and determined, successfully establishing Cipla as a pioneering force in India's pharmaceutical industry. Securing resources, navigating colonial restrictions, and overcoming financial hurdles, he ensured that Cipla quickly became operational. Within a few years, the company made significant strides in domestic drug production, focusing on affordable, high-quality medicines for widespread diseases. Cipla developed innovative synthesis methods, bypassing foreign patents and reducing reliance on expensive imports. By prioritizing research and indigenous expertise, Hamied laid the foundation for India's pharmaceutical self-sufficiency, transforming Cipla into a key player in the country's healthcare revolution.

1. **Manufacturing Indigenous Medicines:** Cipla focused on producing drugs that were in high demand but remained largely inaccessible due to high import costs. The company developed alternative synthesis methods to manufacture essential medicines without violating British patents. Cipla successfully produced drugs for respiratory diseases, infections, and malaria**,** which were widespread in India.
2. **Investment in Research and Development (R&D):**Hamied prioritized scientific innovation, setting up one of India's first pharmaceutical research laboratories**.** He recruited and trained Indian scientists, fostering a culture

of domestic expertise in drug manufacturing**.** Cipla's early research efforts paved the way for future breakthroughs in medicine production.

3. **Policy Advocacy and Nationalist Support:** Hamied actively lobbied for policy changes that would promote indigenous drug manufacturing. He collaborated with nationalist leaders such as Mahatma Gandhi and Jawaharlal Nehru, who supported his vision of a self-reliant pharmaceutical industry. Cipla's success became a symbol of resistance against British economic dominance in India.

Policy Influence and the Path to Self-Reliance

The Patents Act of 1970

One of Hamied's lasting legacies was his contribution to India's patent policy. Before the 1970 reform**,** Indian companies could not legally produce patented drugs. This law enabled companies like Cipla to manufacture affordable, high-quality generics, paving the way for India's pharmaceutical dominance. The Patents Act of 1970 stands as a landmark policy that transformed India's pharmaceutical industry, enabling the country to become a global leader in generic drug production. Prior to 1970, India followed the patent laws inherited from the British colonial rule, specifically the Indian Patents and Designs Act of 1911. This system granted pharmaceutical companies product patents, giving them exclusive rights over their inventions for extended periods. As a result, multinational corporations (MNCs), mostly from Western countries, dominated the Indian pharmaceutical market, charging exorbitant prices for essential drugs. Due to these monopolistic practices, medicines remained inaccessible to a large segment of the Indian population, leading to concerns over public health and national self-sufficiency. Recognizing the need for change, the Indian government commissioned the Ayyangar Committee, led by Justice Rajagopala Ayyangar, to study the issue. The committee's findings highlighted the detrimental effects of the existing patent laws on India's healthcare sector and recommended a shift to process patents rather than product patents. This change would allow Indian companies to develop alternative methods to manufacture the same drugs without violating patents held by foreign corporations.

Impact of the Patents Act of 1970

The enactment of the Patents Act in 1970 marked a turning point for India's pharmaceutical industry. The law granted patents only for the process of manufacturing a drug, rather than the drug itself, significantly reducing the power of foreign pharmaceutical firms. This provision allowed Indian companies to reverse-engineer patented medicines and produce them at a fraction of the cost, making essential drugs more affordable and accessible. One of the primary beneficiaries of this law was Cipla, under the leadership of Dr. Yusuf Hamied. Cipla took full advantage of the new policy to develop and manufacture high-quality, low-cost generic medicines for various ailments, including life-threatening diseases such as tuberculosis, malaria, and HIV/AIDS. The company's efforts helped millions of people, not just in India but also in developing nations across Africa and Asia, who otherwise could not afford expensive patented medicines.

Expansion of Indigenous Drug Production

Cipla's success encouraged the establishment of public-sector pharmaceutical firms such as Hindustan Antibiotics Ltd. and Indian Drugs & Pharmaceuticals Ltd. This expansion played a crucial role in India's journey toward self-reliance in drug manufacturing. These government-backed enterprises not only ensured the widespread availability of essential medicines but also helped build the country's infrastructure for pharmaceutical research and development. The public-sector companies, in collaboration with private firms, contributed to the reduction of dependency on expensive imports and strengthened domestic production capabilities. As a result, India emerged as a key player in the global pharmaceutical market, producing high-quality, cost-effective medicines for both domestic and international consumption. The rise of indigenous drug production facilitated technological advancements, employment generation, and improved healthcare accessibility. Over the years, these developments positioned India as a world leader in affordable medicine production, reinforcing its reputation as the "pharmacy of the world."

Growth of the Generic Drug Industry

Today, India is a global leader in generic pharmaceuticals, supplying over 50% of global vaccine demand and 40% of U.S. generic drug imports. The groundwork laid by Hamied and the implementation of the Patents Act of 1970 allowed Indian pharmaceutical companies to emerge as competitive players in international markets. With a strong focus on research, development, and cost-effective production, India has built a robust pharmaceutical industry that continues to expand worldwide. Indian pharmaceutical giants such as Cipla, Sun Pharma, Dr. Reddy's Laboratories, and Lupin have established themselves as key exporters of generic medicines, meeting global healthcare needs at affordable prices. Their ability to manufacture high-quality generics while maintaining affordability has positioned India as an indispensable partner in global healthcare. Additionally, India's generic drug industry has played a crucial role in combating global health crises. During the COVID-19 pandemic, Indian pharmaceutical firms rapidly scaled up production of essential medicines and vaccines, ensuring their availability in both domestic and international markets. As demand for affordable healthcare solutions grows, India's generic drug industry remains at the forefront of addressing global medical challenges.

Growth of the Generic Drug Industry

Today, India is a global leader in generic pharmaceuticals, supplying over 50% of global vaccine demand and 40% of U.S. generic drug imports. The groundwork laid by Hamied and the implementation of the Patents Act of 1970 allowed Indian pharmaceutical companies to emerge as competitive players in international markets. With a strong focus on research, development, and cost-effective production, India has built a robust pharmaceutical industry that continues to expand worldwide. Indian pharmaceutical giants such as Cipla, Sun Pharma, Dr. Reddy's Laboratories, and Lupin have established themselves as key exporters of generic medicines, meeting global healthcare needs at affordable prices. Their ability to manufacture high-quality generics while maintaining affordability has positioned India as an indispensable partner in global healthcare. Additionally, India's generic drug industry has played a crucial role in combating global health crises. During the COVID-19 pandemic, Indian pharmaceutical firms rapidly scaled up production of essential medicines and vaccines, ensuring their availability in both domestic and international markets. As demand for affordable healthcare solutions grows, India's generic drug industry remains at the forefront of addressing global medical challenges.

India's Emergence as the 'Pharmacy of the World

The Patents Act of 1970 laid the foundation for India's rise as a global pharmaceutical powerhouse. Freed from restrictive product patents, Indian pharmaceutical companies invested in research and development (R&D) to create cost-effective processes for drug manufacturing. By the 1990s, Indian firms such as Cipla, Ranbaxy, Dr. Reddy's, and Sun Pharma had established themselves as major players in the international generic drug market. India's ability to produce affordable generics became particularly crucial in the early 2000s during the global HIV/AIDS crisis. Under Hamied's leadership, Cipla introduced a cost-effective triple-combination antiretroviral therapy for HIV/AIDS at less than a dollar a day, making life-saving treatment accessible to millions in Africa and other developing regions. This move challenged the pricing policies of Western pharmaceutical giants and cemented India's reputation as the "pharmacy of the world."

Challenges and Revisions to the Patent Law

Despite the benefits of the Patents Act of 1970, pressure from the World Trade Organization (WTO) and international pharmaceutical companies led to significant amendments in 2005, bringing India's patent laws in line with global intellectual property standards. The amendment reinstated product patents for pharmaceuticals, biotechnology, and agrochemicals, limiting the ability of Indian companies to freely manufacture generic versions of patented drugs. However, provisions such as compulsory licensing and Section 3(d) of the amended Act still allow India to prioritize affordability and access to essential medicines, ensuring that the core principles of the 1970 reform continue to be upheld.

Challenges and Future Prospects

Despite remarkable progress, the Indian pharmaceutical industry faces several challenges. Intellectual property rights (IPR) disputes remain a major concern, as international pressure mounts for stricter patent regulations. Additionally, regulatory barriers, both domestic and international, pose obstacles to market expansion. Competition from China, particularly in the supply of active pharmaceutical ingredients (APIs), further complicates growth prospects. To sustain its leadership in the global pharmaceutical industry, India must strengthen its research and development (R&D) capabilities, invest in innovative drug discovery, and refine industrial policies to support local manufacturers. Government initiatives to boost domestic API production and streamline regulatory frameworks will be critical. By addressing these challenges, India can continue to build on its legacy as the "pharmacy of the world" while ensuring accessibility and affordability in global healthcare.

CONCLUSION

Khwaja Abdul Hamied's vision, scientific acumen, and nationalist fervor played an instrumental role in breaking India's colonial dependence on pharmaceuticals. By founding Cipla, investing in R&D, and advocating for policy reforms, he laid the foundation for India's self-reliant pharmaceutical industry. His contributions extended beyond national boundaries, influencing global healthcare accessibility. As India continues to assert its position as the "pharmacy of the world,"Hamied's legacy remains a guiding force in ensuring that medicine remains a public good rather than a commercial monopoly.

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RESEARCH ARTICLE

Voluntary Migration and Psychological Resistance: Exploring Diaspora and Jewish Identity in Philip Roth's *Indignation*

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ABSTRACT

Philip Roth, a renowned literary figure of the United States is a third-generation Jew immigrant settled at Newark, New Jersey to share a special affinity to the place where he grew up and evidently proved his connection by elucidating the presence of Newark as an indispensable backdrop pervasively in his novels. Being a third generational Jew in the land where Christianity reined its stronghold, we observe that the author who tries to establish a cultural aspect of Jews despite practiced Atheism, perhaps to showcase his social responsibility against the bias that was showered during his stay at Newark which has largely influenced his novels and is articulated effectively through blurring the boundaries of Fiction and Non-Fiction. It shall be noted that the elements of Diaspora can be identified prominently in the Novel *Indignation*, one of the books from the collection, *Nemeses*, where the young protagonist of nineteen, Marcus faces discomfort in multiple facets for being displaced in a different state Ohio, at Wines burg College to carry out his higher studies. The incidents that unfold in the college premises of Marcus and his encounter with the rigid norms of the institution narrates to substantiate the application of the elements of Diaspora in the novel mentioned. The Modern Viewpoint of Diaspora emphasizes basically the habitual voluntary settlement in a foreign land for different purposes, yet the convincible

degree of stability and connectivity will always remain an interrogative space for the immigrants to get it answered. In view of the aforementioned details, this paper attempts to deconstruct the features of Diaspora through the intrigue and the corresponding situations represented in the novel *Indignation* by Roth.

Keywords: Diaspora, Displacement, Jewish Culture, Voluntary settlement, Immigrants.

The term Diaspora is often traced under the umbrella of post-colonial theory, elucidating the critical situations of the migrants, mostly trans-locating from a third-world country to the land of their colonizers ("Postcolonial Concepts"). In the introductory chapter of *Diaspora theory and Transnationalism*, Himadri Lahiri sheds light on the fact that Diaspora and Transnationalism often stand as synonyms which apparently contributes to the debates revolving around 'roots' and 'routes'(3). In fact, the former was well received with a specific meaning with regard to its Jewish contextual dispersion from their historic homeland to many parts of the world signifying the oppression and the moral degradation that arose during the process of dispersion. (Safran 83). The word then gradually became relatable to the process of trans-migrations in general, as the condition of displacement was sensed widely amidst the population of the world. It shall be observed that people usually migrate either as a large scale of movement or dispersal of a particular group of people/Voluntary choices (Lahiri 2). The mass migration is evidently witnessed in the war zone countries like Iraq and Syria, where refugees move from severe hostile conditions to a better place to set up their second homeland. The latter focuses on the voluntary interest of the group of people to uplift their condition as a personal preference. We shall note an important pointer that the host country/nation would not always be hospitable to welcome their guests as it may stir the existing peace prevailing in their respective nations, mainly with regard to the manifestations of culture, ethnic and religious ideologies that the migrants carry along. An attempt was given by Himadri Lahri with the definition of Diaspora considering the existing contributions to the same. Diaspora is a social formation outside the nation of origin. It is a phenomenon involving uprooting, forced or voluntary, of a mass of people from the 'homeland' and their 're-rooting' in the host-land(s). Diasporic subjects usually have a strong nostalgia for the land they have left behind and for its culture(s), but at the same time may, consciously and/or unconsciously, tend to accumulate or assimilate to the dominant cultures of the new space (4).

At the outset of applying the elements of Diaspora in the novel *Indignation*, it shall be observed the young protagonist Marcus, steps voluntarily to attend Winesburg, a small liberal Arts and Engineering College at Ohio, after his freshman year from 'Robert Treat', a college at Newark, New Jersey. The Voluntary shift of place from his homeland to Winesburg which is apparently five hundred miles away, brings in a lot of suffocation to Marcus, possibly because of his skeptical attitude in not being flexible to the situation given, for which he cost his own life towards the end of the plot. The examination of the Diaspora theory, though, rejects intra-state shifts as migrants encounter little resistance with respect to their social/cultural identity (Lahiri 4), we find that the situations encountered by Marcus encapsulate the similar issues of the contest between cultural and religious identity with regard to his Jewish background from Newark. It is also said that his education stands as a priority to escape the unsound concerns and abuses from his father. This leads the readers to speculate the taste of verbal accusations and constant drudgery that his father Mr. Messner, inadvertently gave his son during the freshman year at Robert Treat college, which forced him to voluntarily decide on a college, apparently, far from home (Father) for his sophomore year to have peace and concentration in his studies as Marcus has had ambitions of becoming a successful lawyer. This Psychotic condition with his father arouse lately as he turned to be an overprotective shield to save his son from the possibilities of ruination mostly in his overthinking head through the influences of fellow men around him. Especially, with the instance, that shares the interest of Eddie Pearlgreen, a fellow of the same age as Marcus, who ended up in pool games and stealing cars. With reference to the spoilt activities of other fellows, Mr. Messner would usually ask a round of questions regarding Marcus' whereabouts of a day which annoys him so much as he would have had aboded the public library to work on his assignment paper. "So there you are," he announced. "Yeah, strange, isn't

it? At home. I sleep here. I live here. I am your son, remember? "Are you? I've been everywhere looking for you." "Why? Why? Somebody, please, tell me why 'everywhere.'" "Because if anything were to happen to you if something were happen to you" "But nothing will happen. Dad, I am not this terror of the earth who plays pool, Eddie Pearlgreen! Nothing is going to happen"… "It's about the life, where the tiniest misstep can have tragic consequences." (12). Being a mature teen, Marcus made several attempts to solve the impending sensitive issue by talking on good terms with his father, but nothing actually worked but paved his way to enter Winesburg College. Little did he know that the constraint is pervasive and the virtue of tolerance is what he needed to acquire. Nevertheless, we observe that the shifting of place happens through a voluntary decision juxtaposed with the unpinning psychotic pressure from his father's baseless suspicions. Marcus, introduced to the new environment, was calm and determined to focus on his studies. He was let in a room to share it with three Jewish boys. Bertram Flusser was the notable one, as he was trying to make life, a challenging factor for his roommates. His tantrums are beyond one's control. Flusser is a man of music and he often plays Beethoven on his recorder only when his roommates are in sound sleep (21). Losing his temper, Marcus broke the recorder into pieces (23). This incident allowed Marcus to change his room as his mates were driving him nowhere but crazy. The shift in the room was notified to the Dean and corresponding documents were submitted to substantiate his decision which was approved by the officials. He was later partnered with Elwyn Ayers Jr., a third-year student inclined to take up his engineering major after his preliminary study. "Living with Elwyn was much like living alone. In his flat Ohio accent, he'd make a dry crack that would cut off conversation when I felt like taking a break from studying to talk for a few minutes" (30). However, Marcus was satisfied that he could finally concentrate on his purpose of aboding Winesburg for a couple of years. But things were not on good terms eventually with Elwyn, when he commented on Marcus's date Olivia, a 'cunt' (72) which enraged and spoilt the idea of continuing to stay with the third-year boy. This led him to seek residence at Neil Hall, the most detested room in the whole of Winesburg, almost living alone without a mate.

With the observations made with Marcus' attitude of resistance, it is evident to prove that the process of assimilation could not be derived from the narration. This leads us to a contesting platform to contemplate the factor of Home and how the protagonist conceived it. In fact, the place which Marcus claimed as his hometown, did not give him the space, he needed to breathe and that stood as a primary reason to shift his place to Winesburg. Thus, the definition of 'Home' and its spot of location shall be briefly discussed to understand the ideology behind the sense of belonging. Avtar Brah simplifies the conception of Home from two perspectives. One shall be a mythical state of desire, probably of a diasporic imagination, when there applies no chance of migrants returning to their geographical native land. "On the other hand, home is also a lived experience of a locality" (Brah 192). In the case of Marcus, he tries to figure the one which suits the rational conditions of living in an ideal place like home (his comfort area), but unfortunately, he could not spot one within the brief time that he shares on earth. Brah brings out an argument that "the question of home is intrinsically linked with the way in which processes of inclusion and exclusion operate and are subjectively experienced under given circumstances" (192). Marcus staunchly believed in the concept of Atheism and stood in his rational terms with people. He had a clarity that the existence of divine powers were distractions to human growth and he relied only on his effort and hard work to excel in his studies. In fact, the ideologies that Marcus adorned and imbibed were his comfort space and perhaps, that's the interior space he could identify as his home to rely on. Marcus and his thought on Atheism are strongly portrayed in the narration deeply influenced by the novelist Roth himself as he stood as an ardent atheist till his final breath. The heated conversation between the Dean of Winesburg and Marcus reveals the strong sketch of Marcus' character and his opinions allow the spectator to figure out his challenging spirit to assimilate in a foreign space that was bestowed on him. When questioned why he denies identifying himself as a Jew, he claims that he "Objected not because I was an observant Jew but because I was an ardent atheist" (80). Marcus, as we find was the man of his beliefs and would stand to his conventions at any cost. He believed in the irrelevance of mentioning his religion in his college application and never did. His father's profession was acknowledged just as Butchering but not tagged his religious name as a prefix,'Kosher'. "I'd be curious to know why you didn't write down 'Kosher, Marcus." "I didn't think that was relevant. If some entering student's father was a dermatologist or an orthopedist or an obstetrician, wouldn't he just write down 'Physician'? Or 'Doctor'? That's my guess anyway." (92). He continues with the argument that he had no intention to hide his religion but never felt the preference to practice one (93). Marcus enunciates the problem in a well-defined way while

asking about his problem of constant shifts to different rooms. He instinctively testifies his own behavior is "not the inability to adjust" but to keep himself away from the superfluous problems that are susceptible to distract him (98). Marcus makes his proclamations clear with proper substantiations and never left it a sweeping statement. While arguing against the religious practices, he quotes Bertrand Russell, a Nobel laureate, who is known for his famous essay titled "Why I Am Not a Christian" where he talks about different points of view like the first-cause argument, the argument from design, the moral argument for a deity and the argument for the remedying of injustice (102). "Religion he declares is based primarily and mainly on fear- fear of mysterious, fear of defeat, and the fear of death"(103). This greater influence on fighting against the concept of fear and upholding his ideologies on the pedestal apparently led him to fall from studies, ultimately in life. If at all, he adjusted or rather assimilated to the norms of the college, he would have sustained to become a powerful orator. He stood steadfast to be a resistance to the cultural norms of the college by denying to attend the Chapel under the prescribed curriculum, thus digging his own grave to perish in the Korean War, where he realized the loop of fatal circumstances to fight against. It was my job not to pluck the chickens but to eviscerate them. You silt the ass open a little bit and you stick your hand up and you grab the viscera and you pull them out. I hated that part. Nauseating and disgusting, but it had to be done. That's what I learned from my father and what I loved learning from him: that you do what you have to do. (5) Despite loving to learn the toughest lessons of adapting to the situation to fulfill one's duties, Marcus failed in following the same to land in the hands of death at an early age, nevertheless upheld his perceptions high in the plinth with an outstanding gesture. In the light of the discussion based on the novel *Indignation*, tracing the elements of Diaspora, it shall be attempted to claim that the factor of voluntary migration, resistance, and the endless loop of defining home was contested in the intrigue with reference to the character of Marcus and his ideas behind accustoming to the given context of living.

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RESEARCH ARTICLE

Gender Disparities in Energy Transition: Biogas Adoption in Rural West Bengal and its Impact on Sustainable Development

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ABSTRACT

Biogas presents a feasible way to supply rural communities in developing nations with sustainable and clean energy. However, despite the Government of India's numerous policy attempts, gender-based barriers continue to hinder the mainstream adoption of biogas. The study examines the gender disparities in household leadership and biogas adoption in West Bengal, which are indicative of broader socio-cultural dynamics. This article examined the gender-based situation regarding the access to biogas installation in rural West Bengal from the various district using the Khadi and Village Industries Commission database among 2000 sample households. The findings indicate that women are the primary consumers of culinary energy; however, only 28% of biogas beneficiaries are female, while 72% are male. The fact that 99% of household chiefs are male further compounded this trend, indicating that women's involvement in energy decisions is still restricted by socio-cultural norms. Notably, district such as South 24 Parganas and Birbhum have extreme male dominance, while Nadia has more equitable adoption rates. Malda has more female installations, suggesting targeted initiatives may eliminate gender discrepancies. The greener energy transition supports Sustainable Development Goals (SDGs) 5 (gender equality) and 7 (clean energy). Women's biogas participation improves health (SDG 3), food security (SDG 2), and education (SDG 4). Thus it need to targeted policies must encourage women's biogas participation for fair benefits and sustainable energy to ensure that household energy users, particularly women, benefit equally from the shift to renewable energy sources, women must be more involved in decision-making in biogas adoption.

Keywords: Gender, Biogas, Rural, Sustainable Development Goals, India

INTRODUCTION

Sustainable development aims to eliminate poverty, promote well-being, and safeguard the planet by 2030 [1]. However, achieving Sustainable Development Goal (SDG) 7—'universal access to affordable, reliable, and modern energy services' remains an unmet challenge for over 2.4 billion people who still lack clean cooking energy [2]. In India, for example, the World Energy Outlook (2017) reports that approximately 819 million people rely on traditional biomass cookstoves for their daily cooking needs [3, 4]. This reliance on biomass fuel is widespread in many low-income countries, where transitioning from conventional fuels to modern, cleaner energy sources is a significant challenge. In these contexts, biomass fuel accounts for about 95% of total energy consumption [5]. Collecting and gathering fuel wood is a labour-intensive, time-consuming activity disproportionately carried out by women, which increases the burden on women, exacerbating gender inequality, particularly in developing countries. The heavy reliance on traditional fuel further deepens the gender divide, as it directly impacts women's health, time, and labour. Countries with fast-growing economies, such as China and India, have begun focusing on reducing the use of biomass and increasing access to renewable energy sources [6]. Thus, transitioning from traditional biomass to clean and efficient bioenergy or other renewable energy forms is vital to addressing energy poverty. This transition in developing and least-developed countries would improve energy access and reduce gender inequities by lessening the burden on women. Gender inequality exacerbates poverty, particularly for women, who face limited access to education, employment, and social equity. Women's involvement in achieving SDG 7 is crucial, as it has the potential to drive and sustain social change. Addressing energy poverty and promoting the adoption of new technologies can significantly improve women's quality of life and contribute to gender equality. Therefore, incorporating women's roles and perspectives in domestic energy use is essential for developing effective energy policies supporting social progress and sustainable development [7]. The paper helps to explore the role of women in climate change and the adoption of biogas in the rural areas of the eastern region of India.

Potential of biogas adoption in India

India has the second-largest population in the world, and over 65% of its people rely on agriculture for a living, in addition to the country's massive cattle population. As a result, the Food and Agriculture Organization (FAO) analysis calculated that India has the potential for land for crops that may provide the energy needed for their everyday cooking needs by generating a lot of agricultural wastes and animal manure, which would be especially useful for rural residents. One of the critical contemporary energy services that can contribute to the growth of a country's economy is biogas, a sustainable energy source. In 2020, 38% of installed energy capacity will come from renewable sources, making India the third-largest producer of renewable energy [8, 9]. In terms of renewable energy installations worldwide, India ranks fifth, according to the Ministry of New and Renewable Energy (MNRE) report [10, 11]. India hopes to have achieve 227GW of renewable energy, already more than the 175GW by 2022, which set as part of the Paris Agreement (Figure 1) [12, 13]. The biogas digester with anaerobic digestion actively contributes to achieving the SDGs and the Paris Agreement's aims by reducing greenhouse gas emissions and promoting sustainable agriculture and energy generation through waste management [14]. By 2030, the government wants to install 450GW of renewable energy [15, 16]. Hence, with 45 lakh added since 2012, India now has the second-largest installation of biogas plants worldwide, behind China [17]. India has set a goal to install 6.5 lakh biogas units nationwide as part of its 12thfive-year plan [18]. India has the potential to install approximately 12 million household-type biogas plants, according to a recent estimation by the MNRE. However, only 4.75 million of the total potential biogas plants were installed as of March 31, 2014, by GoI [19, 20]. The estimated production of biogas in India in 2014-15 was approximately 20757 lakh cubic meters, which is equivalent to 6.6 crore domestic LPG cylinders (5% of total LPG consumption), accounts 2.53 lakh families benefitted through the production of biogas plants until 2015[21, 22]. Biogas is utilised by less than one percent of households in India for cooking purposes [23]. It will produce approximately 6.46 million cubic meters of biogas per day, equivalent to 70.90 million LPG cylinders and 8.20 million tonnes of biomass. It will reduce the annual carbon dioxide emissions by 615,000 tonnes [24]. India successfully installs 12 million family-sized biogas plants, it will reduce approximately 120 million tonnes of Carbon Dioxide (CO_2)annually [25]. In addition, it will be able to produce 8.75 billion cubic meters of biogas, which will generate

11.67 Gigawatt/hour of renewable energy for India by 2022 [26]. It also plays a critical role in enhancing soil fertility and reducing costs by substituting synthetic fertiliser with bio-fertilizer. This nutrient-rich organic fertiliser enhances crop yields and promotes sustainable agricultural production for an extended period [27, 28]. The implementation of biogas plants in Indian states has notable geographical variations, with certain states attaining high adoption rates and others falling behind because of infrastructure and socioeconomic obstacles. According to the total number of biogas plants in all Indian states as of June 30, 2020, there are notable regional differences in adoption (Figure 2). Maharashtra (924,111) is the highest, followed by Andhra Pradesh, Karnataka, Uttar Pradesh, and Gujarat, which have the most biogas plant installations [29], which is indicative of robust agricultural economies, large numbers of cattle, and efficient policy support for biogas energy. Although on a smaller scale, states like Odisha (271,809), Tamil Nadu, Punjab, and Kerala all exhibit significant improvements. States such as West Bengal (1,105), Manipur, and Jammu & Kashmir report fewer installations, probably because they relied on alternate energy sources, lack of knowledge, and land limits. India has installed a total of 5056159 biogas plants around overall states and union territories [30], demonstrating consistent development but also exposing inequalities impacted by geopolitical support, agricultural reliance, sociocultural influences, and geographical obstacles. In underperforming regions, especially in urban and geographically limited locations, our findings highlight the necessity of focused efforts to increase the adoption of biogas.

Women's movements in climate changing in Indian perspectives

Sustainable development requires collaborative efforts to construct a sustainable and resilient society. Renewable energy sources, including biogas, are necessary to mitigate pollution in India due to its substantial population and evolving energy requirements (7.9% from April 2016 to March 2017 and 8% from 2017-18) [31]. The primary factors that contribute to the transformation of the ecosystem are deforestation and the production of greenhouse gases as a result of the combustion of fuelwood. While the global average is 4.5 tonnes, India's per capita CO_2 emission is 1.8 tonnes [32]. India supported the Paris Agreement and committed to reducing the emissions intensity of its Gross domestic product (GDP) by 33-35% by 2030. Additionally, it will increase the capacity of fossil power to 40% from 28% in 2015 [33, 34]. Globally, 31% of geographical areas are covered by forest, according to the 2020 report of FAO and United Nations Environment Programme (UNEP) [35]. In India, the 2019 State of Forest Report estimated that 21.67% of geographical areas are covered by forest [36]. Singh and Gundimeda (2014) reported that the use of renewable energy sources has the potential to reduce 71 kg CO_2eq/Gigajoule biomass in India, thereby mitigating global warming [37]. According to the 2011 Forest Survey of India report, fuelwood meets the cooking and heating energy requirements of 40% of the world's population. Approximately 853.9 million people utilise firewood, and 199.6 million (23.4%) people collect biomass from forests [38].

Women who serve as change agents to advocate for environmental conservation and protection. On a global scale, numerous women's movements have emerged to protect the environment from the degradation of forests. The movement of women against deforestation is not only well-known in India, as well as worldwide. Amrita Bai, a Bishnoi woman from Khejarli village in Jodhpur, Rajasthan, was born on September 9, 1730. Amrita Bai and Bishnoi gave their lives to safeguard the khejari trees by hugging each tree from the soldiers of King Abhay Singh of Jodhpur. Amrita Bai and other Bishnoi villagers were among the 363 individuals who the soldiers murdered in the name of the sacred Khejarli during this movement. This movement resulted in the forest being dispersed on a large scale because the state declared the areas restricted and protected [39]. The Chipko Movement in 1972 in the Chamoli district of Uttar Pradesh provided the greatest inspiration. The movement was spearheaded by Chandi Prasad Bhatt and SunderlalBahuguna [40]. Bachchni Devi, Gauri Devi, and other women in the region are the foundation of this movement, as they are the most directly impacted by environmental deforestation. They are responsible for the protection of trees. Therefore, rural women took action to safeguard and preserve the environment and forests by embracing trees during the contractors' arrival in the region [41, 42]. The Chipko movement and the role of women became a significant historical eco-developmental movement worldwide. Women's involvement in this movement, which promoted ecofeminism in patriarchal societies, demonstrated solidarity in the struggle against environmental conservation [43]. The protection of natural resources from deforestation and ecological degradation has been a

critical component of numerous forest conservation movements in India, including the Appiko Movement (1983) and Jungle BachaoAndolan (1980s), which are led by local communities, particularly women [40]. Therefore, women are instrumental in developing policies that aim to safeguard against environmental exploitation and the exploitation of sustainable energy resources.

Gender issues in biogas adoption in India

Biomass is the primary source of cooking energy in India's rural areas, accounting for over 580 million people [44, 45]. Women and girls lacking fair access to modern energy services spend most of their time gathering fuel wood and cooking. As a result, the government has launched many efforts to encourage renewable energy, including biogas technology, which has significantly altered the energy sector while improving social fairness and well-being [46]. Biogas energy is connected to attaining sustainable development goals and human development by reducing poverty, empowering women, and encouraging sustainable modern energy for a less labour-intensive society that is more convenient and safer than traditional biomass [47-50]. One of the primary causes of low biogas technology adoption in developing nations' rural areas is gender disparity [51]. Access to better modern energy services significantly improves health, education, and livelihood opportunities by promoting gender equality [52]. According to the World Health Organization(WHO), 1.67 million people died in India in 2019, accounting for 17.8% of the country's total mortality [53]. Wassie and Adaramola discovered that biogas could replace solid biomass, such as 631.7 kg of fuel wood for cooking and 25 litres of kerosene for illumination each year [54]. Women spend up to 20 hours per week collecting fuel and 4 hours per day cooking with traditional biomass as part of their unpaid, unrecognised, and unaccounted-for care jobs, limiting their educational opportunities [55]. Women controlled the choice of family energy consumption. Thus, it is understandable that women-headed families are more likely to embrace biogas technology than male members [56–58]. However, one of the most important factors influencing the long-term viability of any development initiative is the lack of female participation. Women are one of India's most essential pillars of rural energy innovation, serving as change agents for climate mitigation and contemporary technology adaptation. In India, a lack of sufficient education and training for female household members is one of the most crucial issues in maintaining biogas digesters and their potential to improve economic prospects [59].

Women contribute 17% of GDP in India, which is significantly lower than the global average of 37% [60]. Jagriti, an NGO in northern India, claims that their clean contemporary energy efforts have decreased the working strain by 10 hours and allowed them to participate in commercial activity [61]. In India, the use of biogas varies greatly by state; West Bengal has one of the lowest installations (1,105 plants as of June 30, 2020). Although this tendency is influenced by a number of variables, including land limitations, preferences for alternative energy sources, and governmental restrictions, and the gender gap in biogas adoption continues to be a significant but frequently disregarded obstacle. The lack of adoption of biogas in this region is further exacerbated by a lack of gender-sensitive legislation. In order to ensure fair access to clean cooking solutions and to support sustainable energy transitions, it is imperative that this gender gap be addressed. The adoption of biogas in rural India has been the subject of numerous research; however, the gender-based adoption of biogas and its impact on SDGs and climate change agents have received very little attention. Furthermore, research has yet to be conducted on the gender-based adoption of biogas in rural areas. The paper aims to describe the current situation in rural West Bengal regarding the gender component of biogas adoption and discuss the connections between gender and the influence of biogas adoption on reaching SDGs. The study aims to increase sustainable renewable energy access in rural regions by presenting a detailed picture of biogas adoption in rural areas and gender differences in promoting biogas without any gender-based burden.

STUDY AREA AND METHODOLOGY

West Bengal is an agricultural state located in eastern India. The state has more than 88,752 m2/km of geographical area. It is located between 21°20' to 27°32' N latitude and 85°50' to 89°52' E longitude (Figure 3). According to the 2011 Indian Census, the state is divided into 19 districts and 341 Community Development blocks. West Bengal is India's fourth most populated state, having a population of 9.13 million. Except for Kolkata, rural areas reside around 68% of

the state's population. Rural areas have a higher sex ratio of 953 (944 in urban). The male population in rural areas is 51.22 percent, while females comprise 48.78 percent. West Bengal has the second-highest biogas density in rural India [62]. The West Bengal Renewable Energy Development Agency (WBREDA) is the state nodal agency for West Bengal under the Ministry of New and Renewable Energy, Government of India. This organisation strives to promote and improve renewable energy in West Bengal. WBREDA has set a target of 18000 domestic biogas plants by 2011, with approximately 11000 installed by December 2011 [63]. Thus, it is demonstrated that it is approximately 60%, indicating that biogas plant adoption is low in rural West Bengal. The Khadi and Village Industries Commission (KVIC) of West Bengal gathered the current data used in the paper between 2010 and 2011. The first study was conducted in 15 West Bengal districts, using 2000 homes as a sample that were registered in the KVIC database to establish a family-type 2 m^3 biogas plant. The Socio Economic and Caste Censusreport and census data were also sources of secondary data.

RESULTS AND DISCUSSIONS

Gender Disparities in Household Headship

The data illustrates pronounced gender disparities in household leadership in West Bengal, indicating a significant male predominance in headship, a tendency that aligns with both state and national averages (Table 1). At the national level, 87% of households are headed by males, whilst 13% are headed by females. The East Zone, encompassing West Bengal, exhibits a marginally elevated proportion of male-headed households at 89%, while female-headed households constitute merely 11%. In West Bengal, 88% of households are male-headed, whilst 12% are female-headed. This overarching trend exhibits small variations among districts, revealing regional distinctions in gender roles pertaining to household leadership. Districts with a predominance of male-headed families include South Twenty-Four Parganas (91%) and PurbaMedinipur (91%), reflecting a traditional and patriarchal framework in these areas, whereby women possess a diminished role in home decision-making. On the other hand districts with a greater proportion of women-headed households include Darjeeling (17.4%), which has the highest percentage, followed by Barddhaman (14%) and Jalpaiguri (14%). This indicates that these districts may exhibit marginally more progressive social dynamics, or it may represent economic migratory trends, wherein males work away from home, leaving women to oversee houses. Although some districts exhibit increased percentages of women taking on home headship, suggesting changes in traditional gender norms, the data generally highlights the continuation of male-dominated household leadership throughout West Bengal.

Gender disparities in biogas adoption across households

The adoption of biogas in West Bengal highlights a stark gender imbalance, revealing that men dominate both participation and decision-making in this cleaner energy transition. The adoption of biogas technology in West Bengal reveals significant gender-based disparities, with men overwhelmingly benefiting from and controlling household energy decisions despite the direct impact on women's daily lives. Figure 4a-4b represents the percentages of gender wise adoption pattern of biogas plants in the rural west Bengal. The results of biogas adoption in rural areas of West Bengal show a significant gender disparity, with 72% of beneficiaries being male (1,432) and only 28% female (568). Additionally, among household heads, an overwhelming 99% are male (1,977), while just 1% are female (23). These gendered patterns of biogas adoption suggest that the benefits of clean energy access are not equitably distributed between men and women. The study finds that there has been a large gender gap between male and women which is one of the key factors of adoption of biogas plants in rural Bengal. These findings suggest that men dominate decision-making related to energy technology adoption, even though women, as the primary users of household cooking energy, are most directly affected by the introduction of cleaner technologies like biogas. The low participation of women as beneficiaries and household heads may be due to socio-cultural norms that restrict their involvement in household decisions and access to financial resources. This gender imbalance points to the need for targeted policies that promote women's engagement in energy programs, as they stand to benefit the most in terms of health and time savings from biogas adoption.

Household dynamics and member relationships

The gender-wise distribution of biogas adoption in West Bengal reveals that sons are the primary beneficiaries, with a notable but secondary involvement of wives, indicating a need for greater inclusion of women in household energy decision-making (Figure 5). The gender-wise analysis of biogas adoption in West Bengal, based on the relationship of beneficiaries to household members, shows that 58% of the beneficiaries are sons (1,163), 27% are wives (542), and only 15% are household heads (290). This distribution highlights that sons, who are often seen as future decision-makers or inheritors in rural households, are the primary adopters of biogas. The relatively high percentage of wives as beneficiaries (27%) suggests that women are increasingly benefiting from biogas, likely due to their primary role in cooking and managing household chores [64]. However, with only 15% of the household heads directly involved as beneficiaries, it appears that decision-making around biogas adoption may be influenced by younger male members, reflecting both generational shifts and traditional gender roles. This dynamic underscores the need for policies that involve women more actively in decision-making processes, ensuring that the people most affected by household energy use have a greater say in adopting clean energy solutions. In conclusion, while sons are the primary beneficiaries of biogas adoption in West Bengal, the significant involvement of wives shows progress toward including women in energy access. However, more focused efforts are needed to fully empower women in household energy decisions and ensure equitable benefits.

Gender wise biogas adoption in various district of West Bengal

The gender-wise distribution of biogas installations across West Bengal for the year 2011-12 highlights significant disparities in the adoption of this sustainable technology. The analysis reveals that, in most districts, the number of biogas units installed by males surpasses that installed by females. For instance, in North 24 Parganas, there were 265 male installations compared to 205 female installations, indicating a skewed preference or access among men. Similarly, districts such as South 24 Parganas and Birbhum exhibit substantial gaps, with males having 116 and 146 installations, respectively, compared to 14 and 24 for females. This trend suggests that women in these districts face barriers in accessing or adopting biogas technology. Conversely, Nadia stands out with a relatively balanced gender distribution of biogas installations, showing 115 installations for females and 128 for males, which reflects a more equitable adoption rate. In districts like Cooch Behar and Darjeeling, where overall installation numbers are low, the gender gap is less pronounced, although Cooch Behar has an equal number of installations for both genders, and Darjeeling shows a higher number for males. In districts with very low installation numbers such as Howrah and Medinipur (West), the disparity is particularly stark, with females having only 2 and 8 installations, respectively. Malda, however, presents a unique case where the number of installations for females (26) exceeds that for males (12), possibly due to targeted outreach or local initiatives. These findings underscore the need for focused interventions to address gender disparities in biogas adoption. Factors such as limited access, awareness, and socio-economic constraints likely contribute to these imbalances.

To promote equitable access to clean energy, it is crucial to implement strategies that enhance outreach and support for female beneficiaries, addressing the underlying barriers that inhibit their participation in sustainable technology adoption. The analysis of biogas adoption by gender across different districts in West Bengal for the year 2011-12 reveals significant disparities. The data shows that certain districts exhibit a high male-to-female ratio in biogas installations, with South 24 Parganas, Bankura, and Purulia demonstrating particularly pronounced male dominance. For instance, in South 24 Parganas, the ratio is approximately 8.29, indicating a substantial gap between male and female installations. Conversely, districts like Cooch Behar and Malda show either a balanced or female-dominant adoption rate, with Cooch Behar having equal numbers of male and female installations and Malda reflecting a higher number for females. Some districts, such as Howrah, present a low male-to-female ratio of 0.50, suggesting a relatively higher female adoption. Districts like Nadia, Medinipur (West), and Murshidabad exhibit moderate disparities, with male dominance still evident but less pronounced. These trends highlight geographical and socio-cultural variations affecting biogas adoption, suggesting that targeted outreach programs and support structures are needed to address gender disparities. Increasing female-focused initiatives and understanding local barriers can help in promoting more equitable access to biogas technology across the region. The Figure 6 clearly reveals a gender difference in terms of percent participation among West Bengal's several districts. Men make a far larger percentage

than women in several areas. For instance, districts such South 24 Parganas, Bankura, Birbhum, and Purulia show significant gender variations (between 71% and 85%) in favour of male participation. Conversely, districts like Cooch Behar exhibit no gender disparity; both men and women participate equally. Remarkably, in areas like Howrah and Malda, women outnumber men with negative gender ratios of -33% and -36%, respectively, suggesting greater female participation. This gender gap most likely reflects deeper social and cultural factors in rural West Bengal, particularly in light of the acceptance of technology like biogas digesters, which depend on active involvement of women to guarantee larger society advantages. These realisations could point to areas where more concentrated efforts are required to eliminate gender gaps, especially in projects connected to energy and agriculture.

Relationship with biogas adoption and gender equality in achieving SDGs

Ensuring gender equality is essential for the effective realisation of the Sustainable Development Goals (SDGs), especially by engaging women in households that implement biogas digesters. The implementation of biogas technology contributes to the goals of SDG 5, which focusses on promoting gender equality and empowering women and girls. Additionally, it meets the clean energy requirements in rural regions, in accordance with SDG 7, which aims to provide access to affordable, reliable, sustainable, and modern energy for everyone. The biogas produced from these digesters functions as a clean cooking fuel, greatly diminishing dependence on conventional fuels and yielding bio-slurry that serves as an organic fertiliser. This shift supports sustainable agriculture by reducing reliance on chemical fertilisers. Furthermore, societal gender biases result in a disproportionate impact of poverty on women, as emphasised by Piana (2006) [65]. The economic advantages of biogas systems, including lower expenses related to LPG and alternative fuels, have the potential to mitigate poverty in rural areas, thereby contributing to the goal of eradicating poverty in all its manifestations. Furthermore, the use of bio-fertilizers improves crop yield and food security, playing a crucial role in addressing SDG 1, which aims to eliminate hunger and promote food security and better nutrition [66]. The adoption of biogas also tackles health issues, especially indoor air pollution, which predominantly impacts women and children. Substituting conventional biomass fuels with biogas leads to a notable decrease in the harmful smoke produced by wood burning. This reduction plays a crucial role in diminishing the occurrence of respiratory diseases and aligns with the objectives of SDG 3, which focusses on ensuring healthy lives and promoting well-being for everyone [67]. Additionally, the time conserved from gathering fuelwood can be allocated to educational pursuits, fostering equitable quality education for women in alignment with SDG 4 [68]. This extra time could allow women to participate in income-generating activities, thereby fostering economic growth and promoting decent work opportunities (SDG 8) [69]. Engagement in biogas initiatives elevates women's societal standing and equips them to address gender-based violence, aligning with the goals of SDG 10 aimed at diminishing inequality both within and among nations [70]. Furthermore, biogas systems play a crucial role in reducing the environmental consequences of deforestation and greenhouse gas emissions, aligning with SDG 13, which highlights the need for immediate action to address climate change and its effects [71]. In the end, creating women's biogas user groups can serve as a community service project that promotes environmental stewardship and gender equality while also accelerating the shift from traditional to modern, sustainable lifestyles.

CONCLUSION

West Bengal's patriarchal family leadership and biogas adoption patterns show that men dominate decision-making. West Bengal's 88% male-headed families are dominated in regional and societal level. In South Twenty-Four Parganas and PurbaMedinipur, where 91% of families are led by men, gender norms limit women's household decisions. Darjeeling (17.4% female-headed households) may be changing due to economic considerations like male migration or societal dynamics. Biogas adoption statistics show a gender gap of 72% male and 28% female. Women, who use cooking fuel most, are excluded from decision-making, and 99% of biogas adopters are male-headed homes. Gender-based household energy decisions are reflected in the primary adopters, 58% sons and 27% spouses. Even though clean cooking solutions benefit women most, this trend shows their marginalisation from energy decisions. The data show that socio-cultural and economic constraints prohibit women from adopting biogas technology. Few districts, like Malda, have female adoption outnumber male adoption. The gender gap requires focused efforts to

increase female energy decision-making and renewable energy access. To bridge these gaps, gender-sensitive policies and actions are needed. Health, economics, and sustainability can improve by empowering women in energy decisions. SDGs 5 (gender equality), 7 (clean energy), and 3 (excellent health and well-being) support biogas uptake. However, addressing gender energy access disparities and involving women, as key household energy consumers, in the shift to cleaner energy technologies will be necessary to achieve these goals. In conclusion, gender-based barriers must be removed and women must be fully involved in energy initiatives for biogas adoption in rural West Bengal to be fully realised. This will improve the lives of women and their families and help achieve poverty reduction, food security, and environmental sustainability.

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Table 1. Gender-wise differences in households and population across districts in west Bengal.

District Name	Total Households	Total Population	Male	Female	Male headed Households (%)	Women headed Households (%)
Darjeeling	2,79,770	1309512	664584	644808	83%	17.4%
Jalpaiguri	7,61,422	3400984	1748167	1652678	86%	14%
Cooch Behar	6,35,046	2670225	1391000	1278964	88%	12.3%
Malda	8,02,673	3820114	1964722	1854706	88%	12%
Murshidabad	14,90,524	6801254	3486604	3313100	88%	12.3%
Birbhum	7,58,961	3221127	1653190	1567581	87%	13%
Burdwan	12,50,095	5503907	2835478	2668097	86%	14%
Nadia	10,36,142	4387294	2274513	2112428	88.4%	12%
North 24 Parganas	11,83,056	5026419	2597491	2428330	89%	11%
Hoogly	9,20,643	3996736	2055084	1941308	87%	13%
Bankura	7,24,878	3423296	1759232	1663685	87%	13%
Purulia	5,36,972	2780989	1427449	1353379	87%	13%
Howrah	7,08,849	3243000	1675534	1567340	87%	13%
South 24 Parganas	15,23,398	6877633	3558964	3315672	91%	9%
Medinipur (West)	11,92,518	5335598	2737080	2597729	88.4%	11.6%
Medinipur (East)	10,59,248	4763259	2469775	2292968	91%	9%
All India Total	17,97,87,454	886692406	459450569	426987079	87%	13%
East Zone Total	4,73,07,665	233233971	121047781	112045205	89%	11%
State Total	1,57,56,750	70768255	36482898	34275226	88%	12%

Source: Census 2011 (https://www.census2011.co.in)

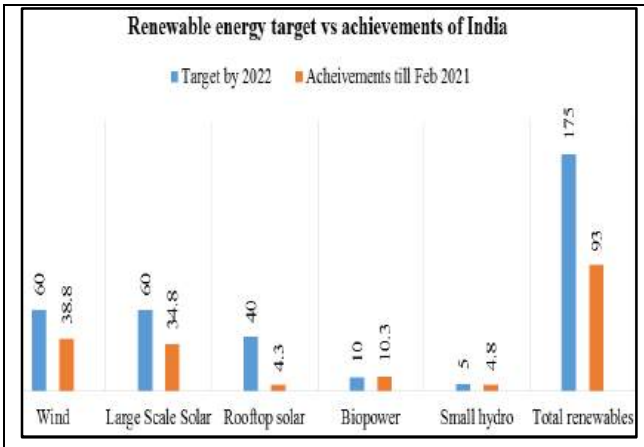


Figure 1. Current status of renewable energy installation progress of India.

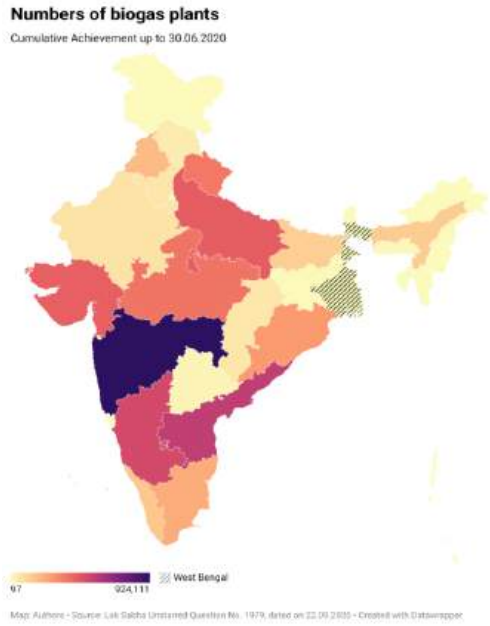


Figure 2: State-wise cumulative installed biogas plants



Figure 3.Study area map (West Bengal, India).

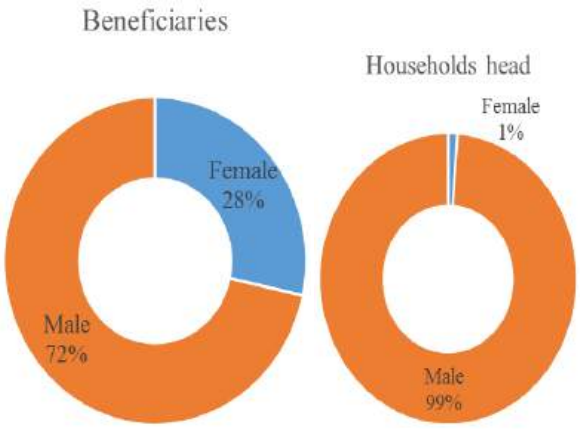


Figure 4. KVIC data of distribution of biogas plants in West Bengal (2010-11). Sources: KVIC 2010-2011

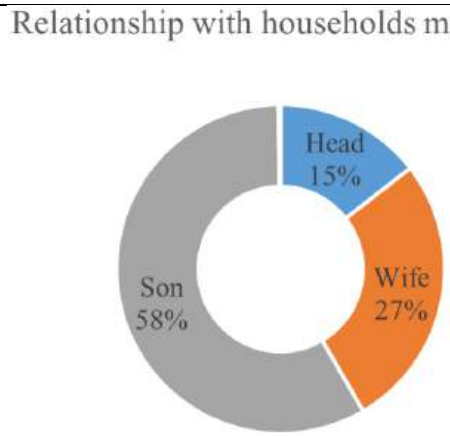


Figure 5: KVIC data of distribution of biogas plants in West Bengal (2010-11) Sources: KVIC 2010-2011

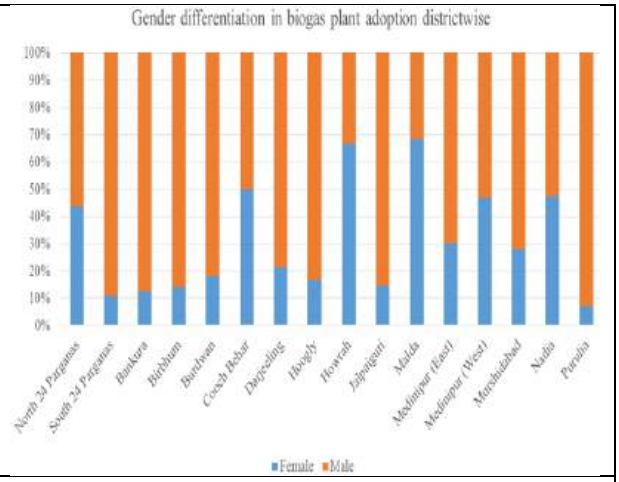


Figure 6. Percentages of adoption of biogas plants gender wise. Source: KVIC 2010-2011

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RESEARCH ARTICLE

Climate Change and its Effects on Agricultural Productivity: An Analytical Study

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ABSTRACT

Climate modification poses a major threat to agriculture, impacting food security, water resources, and rural livelihoods. Karnataka, India, with its reliance on rain-fed farming, is particularly vulnerable to climate variability. Irregular rainfall, prolonged droughts, rising temperatures, and extreme weather events increasingly affect crop yields and livestock health. This study analyses climate data from 2011 to 2020, highlighting rising temperatures and their effects on soil quality, groundwater levels, and agricultural productivity. Greenhouse gas emissions are identified as a key driver, influencing crop, livestock, and fisheries sectors. The paper explores adaptation and mitigation strategies such as efficient water management, crop diversification, soil conservation, and climate-resilient policies. It also emphasizes the role of technology remote sensing, precision farming, and AI-based weather forecasts in building agricultural resilience. Policy recommendations include enhanced government support, farmer education, and investment in climate-resilient infrastructure. The study offers treasured insights for developing sustainable, climate-adaptive agricultural practices in Karnataka.

Keywords: Climate change, agriculture, temperature variation, precipitation, adaptation strategies, mitigation, and food security.

INTRODUCTION

Climate change Involves long-term Shifts in global temperatures, rainfall patterns, and atmospheric situations, primarily caused by human activities such as burning fossil fuels, deforestation, and industrial emissions. These activities increase greenhouse gas levels, leading to rising temperatures and extreme weather events. Natural factors, including volcanic eruptions and solar radiation changes, also play a role in climate fluctuations. One of the most significant sectors affected by climate change is agriculture, as it is highly dependent on environmental conditions. Rising temperatures negatively impact crop production, particularly heat-sensitive crops like wheat, rice, and maize, reducing yields in many regions. While some areas may benefit from longer growing seasons, others experience significant agricultural losses due to excessive heat and unpredictable weather. Water scarcity is another major challenge, as increased evaporation leads to reduced soil moisture and frequent droughts, making irrigation more difficult. Additionally, changes in climate create favourable conditions for pests and crop diseases, leading to higher agricultural losses. Soil degradation is another consequence, with intense rainfall causing erosion and nutrient depletion, making it harder to sustain crop productivity. Extreme weather events, including storms, floods, and heat waves, further disrupt farming activities, damaging crops and infrastructure. Coastal agricultural regions are particularly vulnerable to rising sea levels, leading to saltwater intrusion and a reduction in arable land. Livestock farming also suffers as heat stress lowers productivity, reducing milk and meat yields, while poor pasture quality and limited water availability threaten animal health and reproduction. These challenges ultimately affect food security, leading to supply shortages and rising food prices. Small-scale farmers are especially vulnerable to economic instability, forcing some to abandon agriculture altogether. To mitigate these impacts, farmers and policymakers are adopting sustainable agricultural practices, such as conservation farming, agro forestry, and crop diversification. The development of drought-resistant and climate-resilient crop varieties is also crucial. Efficient water management techniques, including rainwater harvesting and drip irrigation, help optimize water use. Additionally, improved pest and disease control strategies, along with government policies and financial support, can enhance agricultural resilience. Addressing climate change through such adaptive measures is essential to ensuring global food security and the sustainability of agricultural systems. Climate change has emerged as a pressing environmental and socio-economic issue, with far-reaching consequences on agriculture.

Karnataka, predominantly rain-fed, experiences severe droughts, erratic rainfall, and increasing temperatures, all of which negatively affect crop yield and livestock production. Studies indicate that continued greenhouse gas emissions will exacerbate these effects, threatening food security and rural livelihoods. Agriculture is highly sensitive to climate variability, and any disruption in temperature and precipitation patterns directly impacts food production, soil fertility, and water availability. Karnataka, with 68% of its farmland dependent on monsoons, is particularly vulnerable to climate-induced stress. The state has witnessed a rise in extreme weather events, including prolonged dry spells, unseasonal rains, and flash floods, which have disrupted farming cycles and reduced productivity. The Intergovernmental Panel on Climate Change (IPCC) highlights that global temperatures have increased by more than 1°C since pre-industrial times, with projections indicating further warming. This trend has severe implications for Karnataka, where studies predict a temperature rise of 1.5–2°C by 2030. Additionally, the region's changing rainfall patterns threaten water security, with some districts experiencing a deficit while others face excess precipitation leading to floods. A decline in annual rainfall coupled with rising temperatures has also intensified groundwater depletion, increasing the risk of droughts and reducing irrigation potential. Beyond direct impacts on crops, climate change also influences livestock health, pest outbreaks, and soil degradation. The heat stress on cattle has led to decreased milk production, while rising temperatures have expanded the range of agricultural pests and diseases. Soil erosion, salinity, and loss of organic matter further degrade land quality, reducing its long-term productivity. Moreover, increased carbon dioxide levels can impact crop nutrition, leading to lower protein content in staple crops such as rice and wheat, affecting food security and nutrition. Economic consequences are also significant, as unpredictable weather patterns create instability in agricultural markets. Crop failures lead to income losses for farmers, increasing their reliance on government subsidies and alternative employment. Small and marginal farmers, who constitute a majority of Karnataka's agricultural workforce, are particularly vulnerable, facing challenges such

as rising input costs, declining yields, and financial insecurity. The socio-economic stress caused by climate change has also led to rural-to-urban migration, as farmers seek better livelihood opportunities in cities.This paper aims to analyse climate change projections, its historical impact on agriculture, and possible adaptation strategies to mitigate risks. It explores technological interventions, policy frameworks, and community-based resilience strategies that can help Karnataka's agricultural sector adapt to climate change while ensuring sustainable food production and rural livelihoods. Additionally, the study emphasizes the importance of government policies and international cooperation in fostering sustainable agricultural practices and climate resilience.

LITERATURE REVIEW

Venkateshwarlu, B. (2017): This study examines the effects of climate change on India's agricultural sector, highlighting that rising temperatures and irregular rainfall patterns have led to significant reductions in crop yields. Projections indicate that, without adaptation measures, rain fed rice yields could decrease by 20% by 2050 and 47% by 2080. Similarly, wheat yields may decline by 19.3% by 2050 and 40% by 2080. These reductions could result in approximately a 1.5% loss in India's GDP, emphasizing the need for adaptive farming techniques to counteract these challenges. **Economic Times Government (2024):** This report assesses the vulnerability of India's agricultural districts to climate change, categorizing 109 districts as 'very highly' vulnerable and 201 as 'highly' vulnerable. The study projects significant yield reductions in key crops by 2050 and 2080 if adaptation measures are not adopted. For instance, rainfed rice yields could decrease by 20% in 2050 and 47% in 2080, while wheat yields may decline by 19.3% in 2050 and 40% in 2080. The report underscores the importance of implementing climate-resilient agricultural practices to mitigate these impacts. **International Fund for Agricultural Development (2020):** This analysis explores the global economic consequences of climate change on agriculture, predicting that climate change could push 100 million people into poverty by 2030, with nearly half of these cases resulting from its impacts on agriculture. The report highlights that climate-induced agricultural decline exacerbates existing conflicts and has the potential to trigger new ones as resources become scarcer. The findings call for urgent investment in rural development to enhance resilience against climate-related challenges. **Economic Times Government (2024):** This report evaluates the vulnerability of India's agricultural districts to climate change, identifying 109 districts as 'very highly' vulnerable and 201 as 'highly' vulnerable. The assessment indicates that, without adaptation measures, rainfed rice yields could decrease by 20% by 2050 and 47% by 2080, while wheat yields may decline by 19.3% by 2050 and 40% by 2080. The report emphasizes the necessity of implementing climate-resilient agricultural practices to mitigate these adverse effects. **Down To Earth (2020):** This article discusses the global impact of climate change on agriculture, projecting that it could push 100 million people into poverty by 2030, with nearly half of these cases attributed to its effects on agriculture. The report highlights that climate-induced agricultural decline exacerbates existing conflicts and has the potential to trigger new ones as resources become scarcer. The findings underscore the urgency of investing in rural development to enhance resilience against climate-related challenges.

Reuters (2025): This article reports on a legal case where a Peruvian farmer is suing a German energy firm over its contribution to global greenhouse gas emissions, linking the company's emissions to the accelerated melting of local glaciers. The case highlights the broader implications of climate change on agriculture, as glacier melt water is crucial for irrigation in the region. The outcome of this case could set a legal precedent for holding polluting companies accountable for their environmental impact globally. **The Guardian (2025):** This article examines China's Loess Plateau project, an ambitious environmental initiative launched in 1999 to address severe soil erosion and loss of vegetation. The project implemented measures such as banning tree-cutting and overgrazing, providing grain and cash subsidies, and converting farmland to sustainable uses. As a result, vegetative cover increased by 25%, and soil erosion significantly reduced, demonstrating the effectiveness of large-scale environmental restoration efforts in mitigating the impacts of climate change on agriculture. **Choudhary, T. F., & Gupta, M. (2024):**this study examines the impact of climate change on crop production in india (1970-2020) using the panel ARDL method. It finds that long term increases in maximum temperature reduce crop yields, while higher carbon dioxide levels boost production and in short term maximum temperature and precipitation positively affect crop yields but minimum

temperature has a negative impact. The research highlights the need for adoptive strategies to address these complex climate effects. **Kuar, R., & Gautam, H. R. (2014):** This research explores the impact of climate change on agricultural productivity in India, emphasizing that temperature, sunlight, and water are critical drivers of crop growth. The study projects that wheat yields could decline by 5-10% with every 1°C increase in temperature, and overall crop yields might decrease by up to 30% in South Asia by the mid-21st century. Additionally, India could experience a 40% decline in agricultural productivity by the 2080s, highlighting the urgency for effective adaptation and mitigation strategies. **The Guardian (2025):** This article explores China's Loess Plateau project, Launched in 1999 to combat severe soil erosion and vegetation loss. key measures included restricting deforestation and overgrazing, offering subsidies and converting farmland to sustainable uses. **Reuters (2025):** This article reports on a legal case where a Peruvian farmer is suing a German energy firm over its contribution to global greenhouse gas emissions, linking the company's emissions to the accelerated melting of local glaciers. The case highlights the broader implications of climate change on agriculture, as glacier melt water is crucial for irrigation in the region. The outcome of this case could set a legal precedent for holding polluting companies accountable for their environmental impact globally. **Bellow, K. (2025):** This opinion piece discusses the intensifying effects of climate change, including rising temperatures leading to the melting of polar ice caps, sea-level rise, and freshwater scarcity. It emphasizes that higher temperatures increase evaporation, making water more scarce, which poses significant challenges for agriculture. The article calls for immediate action to conserve water through emission reductions, conservation efforts, and support for sustainable policies, underscoring that the planet's survival depends on decisions made today

METHODOLOGY

This study employs with a quantitative data to analyze the impact of climate change on agriculture in Karnataka. Secondary data is gathered from government reports, scientific studies, and climate knowledge portals, focusing on temperature trends, rainfall patterns, and agricultural productivity from 2011 to 2020. Statistical analysis is conducted to assess correlations between climatic variations and crop yields, soil conditions, and water availability. Geographic Information System (GIS) mapping is employed to visualize climate trends and identify vulnerable agricultural zones. Spatial analysis links climate variability with soil health, water availability, and crop productivity. Climate models and predictive analytics are used to forecast future scenarios and assess potential impacts on various farming systems The study also reviews national and state-level climate adaptation policies, analyzing government initiatives and agricultural programs to evaluate their effectiveness. Consultations with policymakers, experts, and extension officers help identify policy gaps and areas for improvement. By integrating empirical data, statistical modeling, and policy analysis, this research offers a comprehensive assessment of climate change impacts on agriculture in Karnataka. The findings aim to support evidence-based strategies for enhancing resilience, informing decisions by farmers, researchers, and policymakers.

NEED FOR THE STUDY

Given the increasing frequency of extreme weather events and their detrimental impact on agriculture, it is essential to understand the extent of climate change and devise appropriate coping mechanisms. This study provides critical insights into climate-induced agricultural challenges and suggests viable adaptation and mitigation strategies.

OBJECTIVES

1. To analyse the effect of climate change on agricultural productivity in Karnataka.
2. To examine temperature trends over the past decade.
3. To identify adaptation strategies that can enhance agricultural resilience.
4. To explore mitigation techniques that reduce climate risks

Impact of Climate Change

Climate change has far-reaching consequences for natural ecosystems, human livelihoods, and global resources. Some of the major impacts are:

Glacier Retreat

Most of the world's alpine glaciers are rapidly losing mass due to rising global temperatures. In glacier-fed regions, river flow may initially increase due to melting but will decline sharply as glaciers shrink.

Melting of glaciers and polar ice caps

Ice loss from Greenland and West Antarctica Projections indicate sea levels may rise between 0.8 and 2.4 meters by 2100, threatening low-lying nations like Bangladesh, the Maldives, Seychelles, and coastal areas worldwide.

Coral Bleaching

Increased sea temperatures stress corals, causing them to expel symbiotic algae and turn white—a process known as bleaching. Prolonged bleaching weakens coral reefs, making them more susceptible to mortality. In 1998, over 70% of corals in the Lakshadweep and Andaman-Nicobar Islands were affected by a major bleaching event.

Rising Sea Levels

Sea level rise is driven by three primary factors intensified by climate change: Thermal expansion of seawater as it absorbs heat (accounting for ~80% of global heat absorption)

Groundwater Depletion

Climate change affects groundwater both directly through altered precipitation patterns and indirectly via surface water interactions. Extended dry periods and increased evaporation contribute to declining groundwater tables.

Agricultural Disruption

Changes in climate disrupt crop cycles, reduce yields, shrink cultivable coastal land, and alter crop physiology. While higher temperatures may accelerate growth in some crops, they often reduce overall productivity, impacting farmer incomes and food security.

Extreme Weather Events

Global warming has intensified extreme temperatures, with hotter summers and colder winters. This results in more frequent and severe droughts, floods, hurricanes, and cyclones, threatening agriculture and infrastructure. Prolonged dry seasons, for example, have severely affected rice and maize production.

Spread of Pests and Diseases

Climate change is altering the geographic distribution of pests and diseases, pushing them toward higher altitudes and latitudes. This has led to increased outbreaks among both terrestrial and marine species, posing threats to biodiversity, agriculture, and public health.

Ocean Acidification

Rising CO_2 levels are increasing ocean acidity. When CO_2 dissolves in seawater, it forms carbonic acid, which disrupts marine ecosystems. According to the Global Biodiversity Outlook, ocean water is now 30% more acidic than it was before the industrial era, endangering marine life such as shellfish and corals.

Climate change impact on agriculture

Climate change has both positive and negative impacts on agriculture. While some effects may enhance productivity in specific conditions, the majority pose significant challenges to the sector. Key impacts include are:

Livestock (Animals)

Heat waves negatively affect livestock, especially cattle and buffaloes. Milk production may decline by 10–30% during the first lactation and by 5–20% in later stages. Heat stress can also delay growth, puberty, and reproductive maturity in crossbred animals.

Aquaculture (Fish)

Fish farming is disrupted by rising temperatures and changing water conditions. Shallow pond fish deaths, altered migration patterns, and shifts in breeding cycles are becoming more common due to temperature and seasonal variations.

Crop Yield

Warmer Temperatures: Increased heat may speed up crop growth but reduce yields, as crops mature faster, shortening the seed development phase. Elevated CO_2 Levels: Some crops (e.g., wheat and soybeans) may benefit from higher CO_2, with yield increases of up to 30%. However, crops like corn show limited gains (under 10%).

Extreme Weather

More frequent floods and droughts damage crops and reduce harvests. Pests, Weeds, and Diseases Warmer, wetter conditions and elevated CO_2 levels promote the growth of weeds, pests, and fungi, exposing crops to new threats and increasing the risk of infestations.

Seed Quality

Climatic stress during the growing season affects seed characteristics such as germination, viability, and appearance. Poor seed quality reduces crop yields and market value, threatening farmer income.

Nutritional Quality of Crops

Higher CO_2 levels have been shown to reduce the protein, iron, and zinc content of many staple crops, while increasing carbohydrate levels, negatively affecting food nutrition.

Soil Health

Climate change impacts soil composition, organic content, and structure. Reduced vegetation cover, intensified erosion, and sedimentation due to erratic rainfall and land-use changes degrade soil quality.

Water Resources

Agriculture, the largest consumer of surface water in India, faces mounting pressure from altered rainfall patterns, declining groundwater levels, melting glaciers, and increased evaporation, all of which stress the water supply system.

Crop Duration and Flowering

High temperatures during the flowering phase (anthesis) can drastically reduce seed formation. Even short heat spells (above 32–36°C) during this critical 1–3 day window can significantly lower crop yields.

TEMPERATURE CHANGE DUE TO CLIMATE CHANGE

Due to climate change, global temperatures are rising, with the planet's average surface temperature now about 1.1 degrees Celsius (1.9 degrees Fahrenheit) warmer than in the late 1800s, leading to more repeated and intense heat waves, droughts, and other extreme weather events.

Mean temperature of India and Karnataka from 2011 to 2020

From seeding to harvesting, the temperature is critical for crop growth. Climate change is hurting crop productivity in a variety of ways, including decreased agricultural product quality, the appearance of numerous insects and diseases in crops, and so on. The mean temperature of India and Karnataka from 2011 to 2020 is explained in Table No. 01 Source: https://climateknowledgeportal.worldbank.org/country/india The mean temperature of India and Karnataka is shown in Table No. from 2011 to 2020. The growth rate of India's mean temperature has been on a downward trend for the past six years but has been on a positive trend for three years, namely 2014, 2015, and 2016. India's mean temperature has ranged between -0.5964 and 1.5276 degrees Celsius. The growth rate of India's mean temperature has abruptly surged in 2016, with a 1.52672 increase over the previous year 2015. The maximum mean

temperature in Karnataka was 26.67 degrees Fahrenheit in 2019- and 26.16-degrees Fahrenheit in 2011. The trend of Karnataka's mean temperature growth rate is in the range of 0.87 to -0.7.

Minimum Temperature of India and Karnataka from 2011 to 2020

The coolest and hottest temperatures recorded in India and Karnataka are referred to as temperature. In agriculture, a uniform minimum temperature is necessary for growing various stages of crops and reaping the greatest yield for certain crops.

Minimum Temperature of India and Karnataka from 2011 to 2020

Source: https://climateknowledgeportal.worldbank.org/country/india

From 2011 to 2020, the minimum temperature in India and Karnataka is shown in the table. The growth rate of India's minimum temperature has been declining for the past six years, with values of -0.2644, -0.7953, -0.5163, -0.8303, -0.2616, -0.787 in 2012, 2013, 2017, 2018, 2019, and 2020, respectively. Karnataka had the greatest minimum temperature of 21.28 degrees in 2019 and the lowest minimum temperature of 20.78 degrees in 2011. The changing minimum temperature trends in India and Karnataka cause a great deal of disruption in agricultural farming techniques. The greatest temperature measured over a given period is referred to as the maximum temperature. It is a contentious term all across the world. It is a result of agricultural operations in many ways, such as soil and air moisture levels, crop cultivation cycle phases, crop cultivation of specific crops, and so on. From 2011 to 2020, the maximum temperature recorded in India and Karnataka is shown in the table. Maximum Temperature of India and Karnataka from 2011 to 2020 Source: https://climateknowledgeportal.worldbank.org/country/india. From 2011 to 2020, the maximum temperature recorded in India and Karnataka is depicted in the table. In 2016, the greatest temperature growth rate unexpectedly jumped to 1.2974. From 2017 to 2020, the growth rate of India's highest temperature has been on a downward trend. For the two years 2015 and 2016, the increase rate of maximum temperature in Karnataka was stagnant at 0.16.

Temperature Trends

Data analysis indicates a rise in Karnataka’s average temperature between 2011 and 2020, impacting crop yields and livestock health.

Precipitation Patterns

Rainfall patterns have become increasingly erratic, leading to droughts and water scarcity in major agricultural zones.

Soil and Crop Productivity

Prolonged dry spells have led to soil degradation, reducing nutrient availability and affecting overall crop quality.

Livestock Impact

Heat stress has resulted in decreased milk production and affected cattle reproductive health.

RESULTS AND DISCUSSION

Impact on Temperature and Rainfall Patterns Data analysis from 2011 to 2020 indicates a steady rise in average temperatures across Karnataka, with some regions experiencing an increase of up to 2°C. Rainfall patterns have become more erratic, with some districts experiencing prolonged droughts, while others have recorded extreme precipitation events leading to floods. These changes have disrupted traditional agricultural cycles, reducing productivity and increasing uncertainty for farmers. Effects on Crop Yield and Soil Quality The rise in temperature and erratic rainfall has adversely affected crop yields, particularly staple crops such as rice, wheat, and maize. Increased heat stress has shortened growing seasons, leading to lower yields. Soil degradation due to excessive heat and reduced moisture retention has also been observed, resulting in declining soil fertility and increased dependency

on chemical fertilizers. Livestock and Fisheries Vulnerability Heat stress has negatively impacted livestock, leading to reduced milk production and lower reproductive efficiency in cattle. Additionally, water scarcity has affected the availability of quality fodder, leading to nutritional deficiencies. In fisheries, rising water temperatures have altered breeding cycles and fish population dynamics, impacting the livelihoods of communities dependent on aquaculture. Economic and Social Consequences Climate change has intensified financial instability among farmers, with declining yields leading to lower incomes and increased debt burdens. Small and marginal farmers are the most affected, as they have limited resources to adapt to changing conditions. Migration from rural to urban areas has increased as farming becomes less viable, leading to socio-economic imbalances in rural communities. Adaptation and Mitigation Strategies To combat the adverse effects of climate change on agriculture, farmers have adopted various adaptation strategies, Shifting to drought-resistant crop varieties, Implementing improved water conservation techniques, such as rainwater harvesting and micro-irrigation, Diversifying income sources through integrated farming systems and agro forestry, Using precision agriculture and AI-based weather forecasting to optimize resource utilization.

Policy Interventions and Recommendations

Government policies and programs aimed at building climate resilience in agriculture have had mixed results. While initiatives such as crop insurance schemes and climate-resilient seed distribution have provided some relief, their implementation and accessibility remain challenges. Strengthening agricultural extension services, enhancing farmer education on climate-smart practices, and increasing investments in sustainable infrastructure are essential for long-term adaptation.

SUGGESTIONS

Ways to decrease climate modification: Farmers are among the most vulnerable to climate change, facing escalating challenges while being expected to maintain or improve productivity. Its impact can be reduced through three key strategies: Monitoring, Mitigation, Adaptation

Monitoring

The process of watching and comprehending the atmosphere, ocean, and other components of the earth system is known as climate monitoring. This is accomplished through measuring and documenting temperature, wind speed, humidity, rainfall, pressure, and a variety of other variables, as well as forecasting the current and future global climate scenarios.

Mitigation

climate mitigation involves reducing greenhouse gas emission to slow climate changewithout it even with adaptation, the risks of severe and lasting impacts remain high early mitigation offers greater benefits than the risks it may pose.

Adaptation

it is a key strategy to cope with climate change, involving proactive steps to reduce harm and make use of potential opportunities. When planned early it can save lives and reduce the cost (European commission). The ability to do this effectively is called as adaptive capacity.

Adaptation to climate change in agriculture

Climate is a crucial factor directly affecting agricultural productivity. The effectiveness of adaptation strategies largely depends on the ability to respond to changing conditions. Farmers can adopt several adaptive approaches to manage the unpredictable impacts of climate change:

Agro biodiversity

Greater genetic diversity in crops and ecosystems enhances resilience to climate stress. Drought-tolerant and stress-resistant crop varieties can help maintain productivity**.** Preserving genetic resources and diversifying farming systems such as integrating crops with livestock are proven methods to boost adaptability.

Localization over Globalization

For countries like India, where much of the population is rural, shifting toward localized farming systems can support sustainability. This involves optimizing local resources and modifying agronomic practices like crop selection, sowing schedules, input use, and irrigation techniques.

Agricultural Insurance

Expanding and improving insurance products helps farmers manage income risks from climate-related disruptions. Insurance provides financial protection against crop losses and enhances overall resilience.

Fertilizer and Nutrient Management

Efficient use of fertilizers reduces environmental stress and production risks. Adapting fertilizer practices can also lessen the negative impacts of climate change and improve soil health.

Drought Management

Droughts are a severe threat under climate change. Effective strategies include: Drought-tolerant crop varieties, Improved irrigation and water-use efficiency, Rainwater harvesting, Community-based adaptation initiatives

Land Use and Management

Long-term adaptation requires optimizing land use for new climate conditions. This includes adopting advanced technologies, improving land management, and enhancing water-use practices to sustain productivity.

Peri-Urban Irrigation with Treated Water

Urban wastewater, if properly treated, can be safely reused for irrigating peri-urban agriculture. This reduces water stress and supports urban food systems, provided contamination risks are managed.

Government interventions

Without complementary governance measures addressing legal, legislative, and institutional concerns, the technical intervention will be ineffective and unsustainable. Enhancing the value derived from freshwater resources necessitates the development of appropriate policy and management mechanisms. Strengthening governance, improving knowledge and information, collecting data, monitoring, and evaluation, boosting human and institutional capacity, and establishing integrated water resources management systems with the watershed as the management

1. **Water Management:** Rainwater harvesting and efficient irrigation systems should be implemented to combat water scarcity.
2. **Crop Diversification:** Farmers should shift to drought-resistant crop varieties to ensure stable yields under changing climatic conditions.
3. **Policy Interventions:** Government incentives for climate-smart agriculture can encourage the adoption of sustainable practices.
4. **Technological Innovations:** The use of AI and remote sensing tools can help farmers optimize irrigation and fertilizer application.

CONCLUSION

Climate change presents significant challenges to agriculture in Karnataka, influencing temperature, rainfall, soil conditions, and overall crop yield. The study highlights the urgent need for mitigation and adaptation measures to sustain agricultural productivity. Climate-resilient policies, technological advancements, and effective water management strategies can help farmers adapt to changing climatic conditions. Given the increasing severity of climate change, a multi-stakeholder approach is necessary to address these challenges. Government policies should focus on strengthening climate adaptation measures, including investment in research for drought-resistant crop varieties, improved irrigation techniques, and financial support for affected farmers. Strengthening early warning systems and weather forecasting will help farmers plan better and reduce risks associated with unpredictable climatic conditions. Furthermore, farmers need greater access to knowledge and resources that enable them to implement sustainable practices. Capacity-building programs, extension services, and financial incentives should be enhanced to encourage the adoption of climate-smart agriculture. Future research should focus on region-specific solutions to improve climate resilience in agriculture. Long-term studies on soil health, water conservation, and carbon sequestration in agriculture are essential to developing a sustainable framework for mitigating the impacts of climate change. Collaborative efforts between scientists, policymakers, and farming communities will be critical in ensuring food security and economic stability in the face of a changing climate.

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Table:1 Mean temperature of India and Karnataka from 2011 to 2020

Years	India	GR	Karnataka	GR
2011	24.82		26.16	
2012	24.77	-0.2015	26.39	0.8792
2013	24.64	-0.5248	26.18	-0.7958
2014	24.77	0.5276	26.41	0.87853
2015	24.89	0.48446	26.46	0.18932
2016	25.27	1.52672	26.51	0.18896
2017	25.15	-0.4749	26.59	0.30177
2018	25	-0.5964	26.44	-0.5641
2019	24.94	-0.24	26.67	0.86989
2020	24.8	-0.5613	26.51	-0.5999

Table: 2 Minimum Temperature of India and Karnataka from 2011 to 2020

Years	India	GR	Karnataka	GR
2011	18.91		20.78	
2012	18.86	-0.2644	21.01	1.10683
2013	18.71	-0.7953	20.8	-0.9995
2014	18.86	0.80171	21.03	1.10577
2015	19.01	0.79533	21.07	0.1902
2016	19.37	1.89374	21.12	0.2373
2017	19.27	-0.5163	21.21	0.42614
2018	19.11	-0.8303	21.06	-0.7072
2019	19.06	-0.2616	21.28	1.04463
2020	18.91	-0.787	21.13	-0.7049

Table : 3 Maximum Temperature of India and Karnataka from 2011 to 2020

Years	India	GR	Karnataka	GR
2011	30.78		31.59	
2012	30.73	-0.162	31.82	0.73
2013	30.61	-0.39	31.62	-0.6
2014	30.73	0.392	31.84	0.7
2015	30.83	0.3254	31.89	0.16
2016	31.23	1.2974	31.94	0.16
2017	31.07	-0.512	32.03	0.28
2018	30.94	-0.418	31.88	-0.5
2019	30.86	-0.259	32.1	0.69
2020	30.73	-0.421	31.94	-0.5

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RESEARCH ARTICLE

Interval Valued Fuzzy Pseudo Intrinsic Bi-Magic Graphs

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ABSTRACT

An Interval Valued Fuzzy Graph G is supposed to be pseudo intrinsic bi-magic graph if it includes mock constant λ_m which is distinct from intrinsic super constant. This research article intends at introducing some kinds of pseudo intrinsic bi-magic graph like evenly divisible, disjoint, double & poly pseudo intrinsic bi-magic graph and further determining the strength of the above-mentioned graphs.

Keywords: Interval Valued Fuzzy Graph, Intrinsic constant; mock constant; pseudo intrinsic edge-magic; evenly divisible- double; disjoint & poly pseudo intrinsic edge-magic; strength.
Mathematical Classification Subject: 05C72,05C78.

INTRODUCTION

Graph theory is a very important tool to represent many real-world problems. Nowadays, graphs do not represent all the systems properly due to the uncertainty or haziness of the parameters of systems. For example, a social network may be represented as a graph where vertices represent accounts (persons, institutions, etc.) and edges represent the relation between the accounts. If the relations among accounts are to be measured as good or bad according to the frequency of contacts among the accounts, fuzziness should be added to representation. This and many other problems motivated to define fuzzy graphs. The first definition of a fuzzy graph was introduced by Kaufmann in 1973. Rosenfeld [14] first introduced the concept of fuzzy graphs. After that fuzzy graph theory becomes a vast research area. Applications of fuzzy graph include data mining, image segmentation, clustering, image capturing, networking, communication, planning, scheduling, etc. Crisp graph and fuzzy graph both are structurally similar. But when there is an uncertainty on vertices and/or edges then fuzzy graph has a separate importance. Since the world is full of uncertainty so the fuzzy graph occurs in many real-life situations. A fuzzy graph contains many

properties like crisp graph due to generalization of crisp graphs, but it diverges at many places. A crisp graph G is an order pair of vertex-set V and edge set E such that E ⊆ V × V. In addition, v = |V| is said to order and e = |E| is called size of the graph G respectively. In a crisp graph, a bijective function ϱ :V ∪ E → N that produced a unique positive integer (To each vertex and/or edge) is called a labelling [16]. Enomoto, H et al introduced the notion of magic graph that the labels vertices and edges are natural numbers from 1 to |V| +|E| such that sum of the labels of vertices and the edge between them must be constant in entire graph [8]. Numerous other authors have explored diverse types of different magic graphs [1], [9] & [15]. In 1987, Bhattacharya succeeded in developing the connectivity notions between fuzzy bridge and fuzzy cut nodes [7].The subject of edge magic labelling of graphs had its origin in the work of Kotzig and Rosa on what they called magic valuations of graphs [12]. These labelling are currently referred to as either edge magic labelling or edge-magic total labelling. Fuzzy graphs are generalization of graphs. In graphs two vertices are either related or not related to each other. Mathematically, the degree of relationship is either 0 or 1. In fuzzy graphs, the degree of relationship takes values from [0, 1]. A fuzzy graph has ability to solve uncertain problems in a wide range of fields. In [13], Nagoorgani et. al. introduced the concepts of fuzzy labelling graphs, fuzzy magic graphs. Ju and Wang gave the definition of interval valued fuzzy graph in [10]. Akram et al. [2–6] introduced many new concepts of bipolar fuzzy graphs, interval valued line fuzzy graphs, and strong intuitionistic fuzzy graphs. In this paper we have developed the concept of interval valued fuzzy pseudo intrinsic edge magic graphs using its composite strength. Also, we discussed some kinds of pseudo intrinsic edge magic graph like evenly divisible, disjoint, double & poly pseudo intrinsic edge-magic graph and further determining the strength of the above mentioned graphs.

PRELIMINARIES

Definition 2.1.
A **fuzzy graph** G=(A, B) is a pair of functions A:V →[0, 1] and B:VxV →[0, 1] where for all u, v∈V, we have B(u, v) ≤ Min{A(u), A(v)}

Definition 2.2.
By an **interval-valued fuzzy graph** G of a graph $G*$, we mean a pair $G = (A, B)$, where $A = [A^-, A^+]$ is an interval-valued fuzzy set on V and $B = [B^-, B^+]$ is an interval-valued fuzzy relation on E such that
$B^-(xy) \leq \min(A^-(x), A^-(y))$,
$B^+(xy) \leq \min(B^+(x), B^+(y))$, for all $xy \in E$. Throughout this paper, $G*$ is a crisp graph, and G is an interval-valued fuzzy graph.

Definition 2.3.
An interval $[\mu - \delta, \mu + \delta]$ is said to be an δ-neighborhood of any membership value for any δ satisfying the following conditions.
1. $\delta \geq \min\{\mu_A(x), \mu_B(xy)\}$
2. $\delta \leq 1 - \max\{\mu_A(x), \mu_B(xy)\}$
3. $\delta \geq or \leq d(\mu(x), \mu(y))$ Where $d(\mu(x), \mu(y)) = |\mu(x) - \mu(y)|$ and $\mu(x), \mu(y)$ are the membership of vertices or edges

Definition 2.4.
A path P is called a cycle if $V_1 = V_n$ for n ≥ 3, then a cycle is called a fuzzy cycle. If it contains more than one weakest arc.

Definition 2.5.
A bijection ω is a function from the set of all nodes and edges of to [0, 1] which assign each nodes $A^\omega(V_i)$, $A^\omega(V_j)$ and edges $B^\omega(V_i, V_j)$ a membership value such that $B^\omega(V_i, V_j) \leq \text{Min}\{A^\omega(V_i), A^\omega(V_j)\}$ for all $V_i, V_j \in V$ is called fuzzy labeling.

Definition 2.6.
A graph is said to be fuzzy labeling graph if it has a fuzzy labeling and it is denoted by G^{ω}.

Definition 2.7.
A fuzzy labeling graph G is said to be fuzzy perfect intrinsic labeling if $f : A \rightarrow [0 ,1]$ and $f : B \rightarrow [0 ,1]$ is bijective such that the membership values of edges are {z, 2 z 3 z, ..., ∈ Z} and vertices are {(ε + 1)z, (ε + 2)z, ...(ε + υ)z} where ε + υ = N is the total number of vertices and edges and let z = 0.1 for N > 6.

Definition 2.8
The Bi-magic constant in an Interval Valued Fuzzy Perfect Intrinsic Bi-Magic Graph(IVFPIBMG) is said to be mock constant 'λ_m = [m- m+]′ if m- is equal to $_{A-}(x) + _{B-(xy)} + _{A-}(y)$ and m+ is equal to $_{A+}(x) + _{B+(xy)} + _{A+}(y)$ for some x ,y ∈ V with $\lambda_s \neq \lambda_w$.

Definition 2.9
An interval valued fuzzy graph is said to be an Interval Valued Fuzzy pseudo intrinsic Bi-magic graph if it contains a mock constant 'λ_m = [m- m+] ′ which is denoted by 'G_p = [Gp- Gp+]'

Theorem 2.10
Any fuzzy graph can be converted into an interval valued fuzzy labeling graph.

Interval Valued Fuzzy evenly divisible pseudo intrinsic edge bi-magic graph.
Definition 3.1
Let G be an interval valued fuzzy pseudo intrinsic edge bi-magic graph. If the mock constant 'λ_m' is evenly divisible then G is said to be evenly divisible.

Definition 3.2
Let G be an interval valued fuzzy pseudo intrinsic edge bi-magic graph. If the mock constant occurs twice that for all $\lambda_{mi} = \lambda_{mj}$ for all i≠j, then G is said to be a double interval valued fuzzy pseudo intrinsic edge bi-magic graph.

Definition 3.3
Let G be an interval valued fuzzy pseudo intrinsic edge bi-magic graph. If $\lambda_{mi} \neq \lambda_{mj}$ for all i≠j, then the graph G is said to be a disjoint interval valued fuzzy pseudo intrinsic edge bi-magic graph.

Definition 3.4
Let G be an interval valued fuzzy pseudo intrinsic edge bi-magic graph. If $\lambda_{mi} \neq \lambda_{mj} \neq \lambda_{mjk} \neq$…. for all i≠j≠k….. then G is said to be a poly pseudo interval valued fuzzy intrinsic edge bi-magic graph.

Theorem 3.5
An interval valued fuzzy cycle C_n is an evenly divisible pseudo intrinsic edge bi-magic graph for n= 4.
Proof: Let 'Cn' be an interval valued fuzzy cycle with even number of vertices. By our assumption, let n = 4
A-(v1)+A-(v1v2)+A-(v2) = 0.048+0.038+0.068=0.154= c-
A+(v1)+A+(v1v2)+A+(v2) = 0.052+0.042+0.072=0.166= c+
A-(v2)+A-(v2v3)+A-(v3) = 0.068+0.028+0.058=0.154= c-
A+(v2)+A+(v2v3)+A+(v3) = 0.072+0.032+0.062=0.166= c+
A-(v3)+A-(v3v4)+A-(v4) = 0.058+0.018+0.078=0.154= c-
A+(v3)+A+(v3v4)+A+(v4) = 0.062+0.022+0.082=0.164= c+
A-(v1)+A-(v1v4)+A-(v4) = 0.078+0.008+0.048=0.134= m-
A+(v1)+A+(v1v4)+A+(v4) = 0.082+0.012+0.052=0.146= m+
Here λ_m = [m- m+] ′ = [0.134 0.146] which is evenly divisible. By definition 3.1, the graph 'Cn' is an evenly divisible interval valued fuzzy pseudo intrinsic edge bi-magic graph.

Theorem 3.6:
A fuzzy cycle 'Cn' is a double pseudo intrinsic edge-magic graph for n=5.

Proof: Let 'Cn' be a fuzzy cycle with odd number of vertices. By our assumption, we consider n = 5
A-(v1)+A-(v1v2)+A-(v2) = 0.098+0.008+0.58=0.164= c-
A+(v1)+A+(v1v2)+A+(v2) = 0.102+0.012+0.062=0.176= c+
A-(v2)+A-(v2v3)+A-(v3) = 0.058+0.038+0.068=0.164= c-
A+(v2)+A+(v2v3)+A+(v3) = 0.062+0.042+0.072=0.176= c+
A-(v3)+A-(v3v4)+A-(v4) = 0.068+0.018+0.078=0.164= c-
A+(v3)+A+(v3v4)+A+(v4) = 0.072+0.022+0.082=0.176= c+
A-(v4)+A-(v4v5)+A-(v5) = 0.078+0.048+0.088=0.214= m1-
A+(v4)+A+(v4v5)+A+(v5) = 0.082+0.052+0.092=0.226= m1+
A-(v5)+A-(v1v5)+A-(v1) = 0.088+0.028+0.098=0.214= m2-
A+(v5)+A+(v1v5)+A+(v1) = 0.092+0.032+0.102=0.226= m2+
Here, two mock constants occur $_{m1}$ = [m1- m1+]′ = [0.214 0.226] &
$_{m2}$ = [m2- m2+]′ = [0.214 0.226]
By definition 3.2, the given fuzzy cycle graph with five vertices is a double pseudo intrinsic edge- magic graph.

Theorem
A fuzzy n-pan graph is a disjoint pseudo intrinsic edge-magic graph for n = 5.

Proof
Let G be a fuzzy n-pan graph with n =5.
Apply fuzzy intrinsic edge- magic labelling, we get
A-(v1)+A-(v1v2)+A-(v2) = 0.108+0.008+0.098=0.214= m1-
A+(v1)+A+(v1v2)+A+(v2) = 0.112+0.012+0.102=0.226= m1+
A-(v2)+A-(v2v4)+A-(v4) = 0.098+0.018+0.118=0.234= c-
A+(v2)+A+(v2v4)+A+(v4) = 0.102+0.022+0.122=0.246= c+
A-(v3)+A-(v3v4)+A-(v4) = 0.118+0.028+0.088=0.234= c-
A+(v3)+A+(v3v4)+A+(v4) = 0.122+0.032+0.092=0.246= c+
A-(v4)+A-(v4v5)+A-(v5) = 0.118+0.038+0.078=0.234= c-
A+(v4)+A+(v4v5)+A+(v5) = 0.122+0.042+0.082=0.246= c+
A-(v5)+A-(v5v6)+A-(v6) = 0.078+0.048+0.068=0.194= m2-
A+(v5)+A+(v1v5)+A+(v1) = 0.082+0.052+0.072=0.206= m2+
A-(v1)+A-(v1v6)+A-(v6) = 0.068+0.058+0.108=0.234= c-
A+(v5)+A+(v1v5)+A+(v1) = 0.072+0.062+0.112=0.246= c+
Here, two mock constants occur $_{m1}$ = [m1- m1+]′ = [0.214 0.226] &
$_{m2}$ = [m2- m2+]′ = [0.194 0.206]
By definition 3.3, the given fuzzy n-pan graph is a disjoint pseudo intrinsic edge- magic graph.

Theorem 3.8
Every fuzzy perfect intrinsic edge-magic graph is not always a pseudo intrinsic edge-magic graph and vice-versa.

Strength of evenly divisible, double, disjoint & poly pseudo intrinsic edge-magic graph
Definition 4.1
Let E be a fuzzy evenly divisible pseudo intrinsic edge-magic graph. Then the strength of E is denoted by αe and is defined as the twice of the mock constant, $\alpha e = 2\ \lambda m$.

Assessment 4.1.1
Evaluate the strength of fuzzy evenly divisible pseudo intrinsic edge-magic for cycle graph with n=4. By theorem 3.5, we get λ_m = [0.134, 146] and by above definition, strength of the given graph is $\alpha_e = 2\,\lambda_m = 2$[m- m+] =2[0.134, 0.146] = [0.268, 292] .

Definition 4.2
Let D be a fuzzy double pseudo intrinsic edge-magic graph. Then the strength of D is denoted by αd and is defined as $\alpha_d = \lambda_m$, $(\lambda_m = \lambda)$ for all i and j.

Assessment 4.2.1
Evaluate the strength of fuzzy double pseudo intrinsic edge-magic for cycle graph with n=5. By theorem 3.6, we focused double pseudo intrinsic edge magic graph with two mock constants which are equal. $\lambda_1 = \lambda_2$ = [0.214, 0.226] = λ_m
By above definition, Strength of the mentioned graph is
α_d = [0.214, 0.226], m1- m1+= [m2- m2+] for all i ≠ j.

Definition 4.3
Let T be a fuzzy disjoint pseudo intrinsic edge-magic graph. Then the strength of T is denoted by α_t and is defined as $\alpha_t = \lambda_{mi} + \lambda$ for all i ≠ j.

Assessment 4.3.1
Evaluate the strength of fuzzy disjoint pseudo intrinsic edge-magic for n-pan graph. By theorem 3.7, we discussed n-pan graph with n=5.
Here, $_{m1}$ = [m1- m1+] ′ = [0.214 0.226] & $_{m2}$ = [m2- m2+] ′ = [0.194 0.206]
Through the above definition, strength of the above mentioned graph is
$\alpha_t = \lambda_m + \lambda j$
for all $i \neq j$. = [0.214 0.226] +[0.194 0.206] = [0.214 + 0.194, 0.226+0.206]
α_t = [0.408, 0432]

Definition 4.4:
Let P be a fuzzy poly pseudo intrinsic edge-magic graph. Then the strength of T is denoted by α_p and is defined as $\alpha p = \lambda m + \lambda + \lambda j k + \ldots$ *for all* $i \neq j \neq k \neq \ldots$

CONCLUSION

The research article has taken the ideas like the evenly divisible, double, disjoint and poly pseudo intrinsic bi-magic interval valued fuzzy graphs. This paper has assessed the strength of concern graphs like fuzzy cycle with odd and even number of vertices & n-pan graph. In future, the attention would be on poly pseudo intrinsic bi-magic interval valued fuzzy graphs with additional examples.

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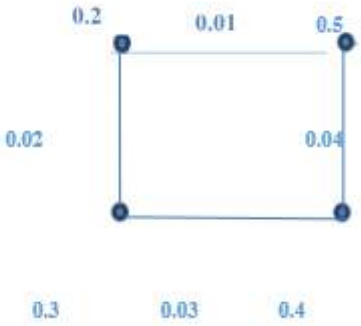


Fig: 1 Fuzzy Labelling

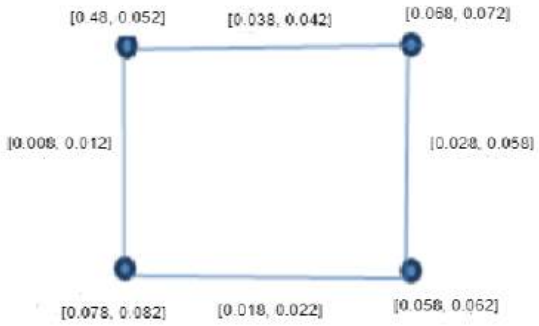


Fig: 2

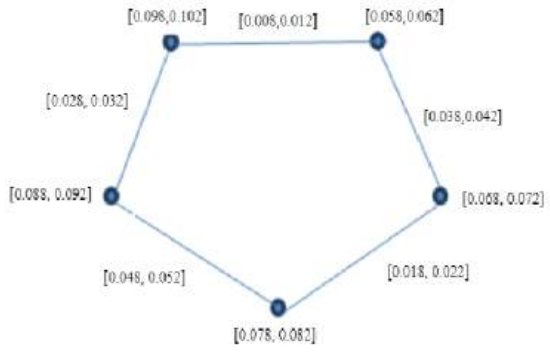


Fig:3

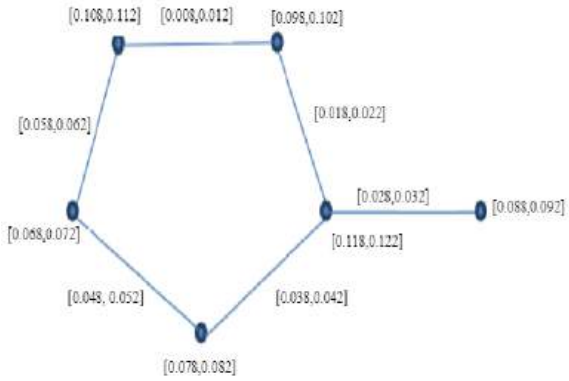


Fig:4

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RESEARCH ARTICLE

A Study on Employee Job Satisfaction

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ABSTRACT

In this study, different factors that affect job satisfaction are considered from personal attributes, motivational elements, and organizational aspects. To understand the dynamics of workplace contentment, the research is based on theoretical perspectives such as the Fulfilment Theory, Equity Theory, and Two-Factor Theory. A sample size of 130 employees was selected through random sampling method through a structured methodology using surveys, statistical analysis, correlation studies. Employees care about fair compensation, career growth, recognition, work life balance and a positive corporate culture and these are findings. Some people were generally content with most of these things, however, stress management, sick leave policies and more clearly defined career progression need improvement. It then bases its suggestions on how to multiply the career development initiatives, create a transparent recognition system, increase flexibility in the workplace and improve communication between employees and management. Turnover rates are lower and engagement is higher and the organization is more successful if there is a positive work environment.

Keywords: Employee Job Satisfaction, Workplace Engagement, Organizational Success, Career Growth, Work-Life Balance, Motivation, Compensation, Recognition, Job Security.

INTRODUCTION

This study investigates the determinants of employee satisfaction, the theories of how it works, and how it influences organizational performance. This research follows a structured approach to analyse the employee perspectives in order to identify the areas which contribute to workplace happiness and those which require intervention. With this understanding, organisations can develop better policies, create favourable working environment and implement strategies to promote employee engagement.It also importantly contributes to mental and emotional well-being on

account of which job satisfaction is important. The study also explores modern trends of job satisfaction, such as remote work, flexible schedule, wellness programs for employees, and the impact of technology on job roles. Nowadays, work environments are becoming more flexible, and organizations have to keep up with the changing needs of the employees and enhance job satisfaction levels. Through the application of theoretical frameworks, research findings, and practical recommendations, this study offers ideas on how organisations can create happier and more productive workforce that will benefit both the employees and employers. The understanding of the job satisfaction can enable organizations to be on a path towards sustainability by creating a culture of motivation, development, and wellbeing.

Definition and Meaning

Employee contentment and fulfilment in their work are often defined as job satisfaction. According to Robbins and Judge, it is a positive feeling about a job that results from an evaluation. Several important motivational theories, namely, Maslow's Hierarchy of Needs and Herzberg's Two-Factor Theory, focus on intrinsic and extrinsic factors that influence employee satisfaction.

Objectives of the Study

The purpose of this study is to examine the level of employee job satisfaction and factors that influence the workplace engagement, motivation and performance of employees. The aim of the study is to contribute useful ideas that will aid organizations in cultivating a motivated workforce, as well as increasing employee well-being and ultimately business success.

Theoretical Background of Job Satisfaction

Several theories have attempted to define and explain job satisfaction, helping organizations develop better workplace strategies.

Fulfilment Theory

It proposes that when employees' expectations around their roles and rewards match reality, they are satisfied. Those whose work rises to their aspirations enjoy high levels of job satisfaction; others find themselves discontent with a disconnect between their expectations and the reality of working conditions.

Discrepancy Theory

Discrepancy theory states that the level of satisfaction is determined by the discrepancy between what an employee believes they should be getting and what they are actually getting. As long as the rewards / benefits equal /exceed expectations, the employees are likely to be satisfied. But if they don't, disappointment develops.

Equity Theory

Employees, according to the equity theory, continuously measure their inputs and outputs to their coworkers. If they feel there's injustice—as in a situation where they put in the same level of effort but get paid less or are given lesser opportunities than others—they could feel dissatisfied. Particularly to keep motivation and engagement, a fair and transparent reward system is important.

Two-Factor Theory

Frederick Herzberg — a psychologist known for his two-factor, or motivator-hygiene theory of human behaviour. Hygiene factors to avoid dissatisfaction Motivation factors that contribute to satisfaction. Absence of hygiene factors leads to dissatisfaction, but their presence alone does not guarantee satisfaction without motivators present as well.

Factors Influencing on Job Satisfaction

Employee job satisfaction is shaped by an interplay of personal characteristics, motivational aspects, and organizational factors.

Personal Factors

Age also is a factor in career stability, and mid-career employees often report a higher satisfaction with their jobs than younger employees. Another factor that the people we spoke also attributed to positive job experiences is gender equality and workplace inclusivity. Educational levels impact expectations. Employees with advanced education demand clearer career paths and financial compensation. For instance, marital status may also affect satisfaction – employees with families tend to value workplace stability and benefits more.

Motivational Factors

Employee motivation is the internal drive to do something. Salary and benefits are among the most important motivational factors, as they help to maintain financial security and risk control. To improve engagement, career growth opportunities provide employees with clear development roadmaps. Recognition and praise uplift spirits, reaffirming a sense of accomplishment in employees. Flexible hours and remote working arrangements are good examples of work-life balance systems that allow employees to navigate the competing demands of work and home.

Organizational Factors

One of the most significant contributors to employee satisfaction is the work environment. Employees performing their jobs without added stress or physical discomfort is made possible by a safe and comfortable workplace. Corporate culture encourages collaboration, teamwork, and inclusion. Investing in performance management, training and development programs help employees grow.

METHODOLOGY AND RESEARCH DESIGN

The study is descriptive research by using structured surveys and statistical analysis of the employee job satisfaction. The study follows a systematic approach to achieve accuracy, reliability and meaningful insights.

RESEARCH DESIGN

The approach this research takes is quantitative, in order to understand how different factors affect job satisfaction. A broad perspective of employee's sentiments towards their workplace is incorporated into the design through structured survey methods, statistical analysis, and correlation studies.

Data Collection Methods

For this study data was collected from both primary and secondary source. Direct responses of employees through surveys and questionnaires is Primary Data. Secondary Data: Organizational reports, previous studies, academic literature and industry benchmarks.The questionnaire was administered to employees in a structured manner to ensure a broad range of perspectives. Career growth, salary satisfaction, job stress, workplace environment, work-life balance, medical benefits and recognition programs were the questions covered.

Sampling Size and Technique

130 employees, from all roles and experience level, were randomly sampled. This helps to ensure that the study includes a diverse range of people of different career stages and therefore findings are more representative.

Statistical Analysis Methods

The study also used several statistical techniques to interpret the responses and to gain meaningful insights.

- Correlation Analysis: Evaluated relationships between job satisfaction and work conditions.
- T-Test & U-Test: Found significant differences in satisfaction level of different employee groups.
- Predicted factors for Job Satisfaction through Regression Analysis.
- F-Test: Assessed variance in satisfaction across different demographics.

This combination of these methods led to comprehensive and accurate findings to help better understand the patterns in employee satisfaction.

Data Analysis and Interpretation

The sample size was 130 employees from different levels of experience. Key findings include:

- Employees are predominantly mid-career professionals with 52% of them in the 35 - 50 age group.
- This suggests that there is a higher representation of men at 58%.
- 72% of employees were satisfied with work hours.
- Upto 76% have positively rated the opportunities to use skills.
- 67 % of employees found flexibility in work life balance.
- 85%of employees liked the existence of medical facilities.
- 66% of the employees were willing to recommend their workplace.

Statistical analysis also provided some insights into employee job satisfaction by implementing various techniques (Eg, correlation analysis, T-tests, U-tests, and F-tests) Here are some of the key statistics obtained from employees:

Correlation Analysis

Correlation is a statistical measure that describes the strength and direction of a relationship between two variables. This study aims to investigate the relationship between the number of working hours and the corresponding results achieved. Null Hypothesis (H_0): There is no significant correlation between working hours and job results.
Alternative Hypothesis (H_1): There is a significant correlation between working hours and job results.

Working hours(x)	51	43	5	19	12
Results of job(y)	57	55	4	5	9

Solution

X	Y	X^2	Y^2	XY
51	57	2601	3249	2907
435	55	1849	3025	2365
5	4	25	16	20
19	5	361	25	95
12	9	144	81	108
$\sum X=130$	$\sum Y=130$	$\sum X^2 = 4980$	$\sum Y^2=6369$	$\sum XY = 5495$

n = 5

$$r = \frac{n\sum xy - \sum x \sum y}{\sqrt{(n\sum x^2 - (\sum x)^2)(n\sum y^2 - (\sum y)^2)}}$$

$$= \frac{5 \times 5495 \ - \ (130 \times 130)}{\sqrt{(5 \ \times 4980 \ - 130^2)(5 \times 6369 \ - 130^2)}}$$

$$= \frac{27475 \ - \ 16900}{\sqrt{(24900 \ - 16900)(31980 \ - 16900)}}$$

$$= \frac{10575}{\sqrt{(8000)(15080)}}$$

$$= \frac{10575}{\sqrt{120640000}}$$

$$= \frac{10575}{10988}$$

r = 0.963

CONCLUSION

The calculated correlation coefficient is r = 0.963, which is very close to +1. This indicates a very strong positive correlation between the number of working hours and job results.

T-Test Results

A t-test is a statistical method used to compare the means of two groups and determine whether the differences between them are significant or due to random chance.

Null Hypothesis (H_0): There is no significant correlation between career growth (X) and motivational factors (Y).

Alternative Hypothesis (H_1):There is a significant positive correlation between career growth (X) and motivational factors (Y).

Career growth (x)	42	32	22	19	15
Motivational Factors (y)	46	35	15	14	20

Solution

X	Y	X^2	Y^2
42	46	1764	2116
32	35	1024	1225
22	15	484	225
19	14	361	196
15	20	225	400
∑X=130	∑Y=130	$\sum X^2 = 3858$	$\sum Y^2 = 4162$

Find the $\bar{X}_x$ and $\bar{X}_y$

$$\bar{X}_x = \frac{42+32+22+19+15}{5} = \frac{130}{5} = 26$$

$$\bar{X}_y = \frac{46+35+15+14+20}{5} = \frac{130}{5} = 26$$

$N_1 = 5$

$N_2 = 5$

Find the s_x^2 and s_y^2

$$s_x^2 = \sqrt{\frac{\Sigma x^2}{N_1} - \left(\frac{\Sigma x}{N_1}\right)^2}$$

$$= \sqrt{\frac{3858}{5} - \left(\frac{130}{5}\right)^2}$$

$$= \sqrt{\frac{3858}{5} - (26)^2}$$

$$= \sqrt{771.6 - 676}$$

$$= \sqrt{95.6}$$

$$= 9.777$$

$$s_y^2 = \sqrt{\frac{\Sigma y^2}{N_2} - \left(\frac{\Sigma y}{N_2}\right)^2}$$

$$= \sqrt{\frac{4162}{5} - \left(\frac{130}{5}\right)^2}$$
$$= \sqrt{\frac{4162}{5} - (26)^2}$$
$$= \sqrt{832.4 - 676}$$
$$= \sqrt{156.4}$$
$$= 12.505$$

Find the S

$$S = \frac{s_1^2 N_1 + s_2^2 N_2}{N_1 + N_2 - 2}$$
$$= \frac{9.777 \times 5 + 12.505 \times 5}{5 + 5 - 2}$$
$$= \frac{48.885 + 62.525}{8}$$
$$= \frac{111.41}{8}$$
$$= 13.926$$

Find the t value

$$t = \frac{\overline{x_1} - \bar{x}_2}{s\sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$$
$$= \frac{26 - 26}{13.926\sqrt{\frac{1}{5} + \frac{1}{5}}}$$
$$= \frac{0}{13.926\sqrt{\frac{1}{5} + \frac{1}{5}}}$$
$$= 0$$

Degree of freedom = r + c – 2
= 2 + 5 – 2
= 5

Table value = 2.015

CONCLUSION

Calculated Value <Table Value
0 < 2.015
the calculated value 0 is less than the table value 2.015, fail to reject the null hypothesis (H_0). This means that there is no significant difference in the data.

U-Test Results

The U test, also known as the Mann–Whitney U test, is a non-parametric statistical test used to determine whether there is a significant difference between two independent groups. The test works by ranking all the values from both groups together and then calculating a U statistic based on the sum of these ranks. This statistic is then used to determine whether the observed differences between the groups are statistically significant.

Null Hypothesis (H_0):There is no significant relationship between age and employee satisfaction with the sickleave policy.

Alternative Hypothesis (H_1):There is a significant relationship between age and employee satisfaction with the sickleave policy.

Age (x)	21	68	41	-	-
Sick leave policy(y)	37	42	13	22	16

Solution

Find R_1 and R_2

Data: 21, 68, 41, 37, 42, 13, 22, 16

Data in ascending order: 13, 16, 21,22, 37, 41, 42, 68

Rank for data: 1,2,3,4,5,6,7,8

$R_1 = 3 + 6 + 8 = 17$

$R_2 = 1 + 2 + 4 + 5 + 7 = 19$

Find U_1 and U_2

$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$

$= 17 - \frac{3(3+1)}{2}$

$= 17 - \frac{3(4)}{2}$

$= 17 - \frac{12}{2}$

$= 17 - 6$

$= 11$

$U_2 = R_2 - \frac{n_2(n_2+1)}{2}$

$= 19 - \frac{5(5+1)}{2}$

$= 19 - \frac{5(6)}{2}$

$= 19 - \frac{30}{2}$

$= 19 - 15$

$= 4$

$U = 4$

Find Table Value

$N_1 = 3$

$N_2 = 5$

Level of significance = 5% = 0.05

Table value = 0

CONCLUSION

Calculated value > table value

4 > 0

The calculated U value was found to be 4, which is greater than the table value of 0. Since the calculated value exceeds the critical value, the null hypothesis is rejected. This indicates that there is a statistically significant difference in the perception of the sick leave policy among employees of different age groups.

F-Test Results

F test can be defined as a test that uses the f test statistic to check whether the variances of two samples (or populations) are equal to the same value. To conduct an f test, the population should follow an f distribution and the

samples must be independent events. On conducting the hypothesis test, if the results of the f test are statistically significant then the null hypothesis can be rejected otherwise it cannot be rejected.

Null hypothesis (H_0): There is no significant different between understanding about job role and different experience level. Alternative hypothesis (H_1): There is significant different between understanding about job role and different experience level.

Experience(x)	37	46	29	18	-
Understanding about job role(y)	52	66	0	7	5

Solution

x	Y	x^2	y^2
37	52	1369	2704
46	66	2116	4356
29	0	841	0
18	7	324	49
-	5	-	25
∑x=130	∑y=130	$\sum x^2 = 4650$	$\sum y^2 = 7134$

$N_1 = 4$

$N_2 = 5$

Find the $\bar{X}_1$ *and* $\bar{X}_2$

$$\bar{X}_1 = \frac{130}{4} = 32.5$$

$$\bar{X}_2 = \frac{130}{5} = 26$$

Find the s_1^2 *and* s_2^2

$$s_1^2 = \frac{\sum x^2}{N_1} - (\bar{x}_1)^2$$

$$= \frac{4650}{4} - (130)^2$$

$$= 1162.5 - 16900$$

$$= -15737.5$$

$$s_2^2 = \frac{\sum y^2}{N_2} - (\bar{x}_2)^2$$

$$= \frac{7134}{4} - (130)^2$$

$$= 1426.8 - 16900$$

$$= -15473.2$$

Find the S_1^2 *and* S_2^2

$$S_1^2 = \frac{N_1 s_1^2}{N_1 - 1}$$

$$= \frac{4 \times -15737.5}{4 - 1}$$

$$= \frac{-62.950}{3}$$

$$= -20983.333$$

$$S_2^2 = \frac{N_2 s_2^2}{N_2 - 1}$$

$$= \frac{5 \times -15473.2}{5 - 1}$$

$= \frac{-77366}{4}$
$= -19341.5$

Find the F value
$F = \frac{S_1^2}{S_1^2} = \frac{-20983.333}{-19341.5} = 1.0$

degree of freedom
$(N_1 - 1, N_2 - 1)$
$(4 - 1, 5 - 1)$
$(3,4)$
Table value= 6.59

CONCLUSION

Calculated value < Table value
1.085<6.59
calculated F-value (1.085) is much smaller than the table value (6.59), this suggests no significant difference between the variances of the two groups being compared.

FINDINGS AND SUGGESTIONS

Findings
The study also provided some significant findings when it comes to employees' job satisfaction, showing strengths alongside areas in need of attention. Overall, a large portion of employees believe that they feel happy at work: feeling good about their job, working conditions, and corporate culture. They reported fair compensation, career growth, and recognition were also important drivers of motivation and long-term desire to stay with the organization. The first key observation is that employees feel engaged when they can use their skills and abilities effectively. Maximizing skills: 73 percent of all respondents said they were generally satisfied with their opportunities to apply their skills, but a significant minority indicated that their talents were being underused. Some said they had concerns about clarity around career development and promotions. Although a large proportion of employees enjoy training and development initiatives, there is room for improved career progression frameworks among this group as well. Meaning, employees have a tendency to like a work-life balance, where they have the flexibility to balance their work with their own life needs/commitments. However, a significant number of respondents reported work hours and leave policies could be better aligned with well-being. In the same vein, job-related stress issues continue to afflict some workers, with a small percent of employees stating in a recent survey that they were unhappy due to pressures of workload and presence of high expectations. Similarly, recognition and motivation were found to be important factors according to their relevance to satisfaction. Workers appreciate recognition for their work, and those who feel valued tend to report greater job satisfaction. On the flip side, some employees feel like their hard work does not get noticed and the presence of structured recognition programs would help. As far as motivators that employees think drive engagement, monetary incentives, promotions, and appreciation initiatives are the ones that seem to matter to them. Most employees also praise the presence of medical benefits and workplace safety, stating that they trust that their employer cares about their health and physical safety. Technology was available and worked well enough, but some employees wanted faster solutions for tech issues; Summary Overall, employees are happy with their job roles and work environment. However, satisfaction levels could improve with better stress management, visibility on career progression, work-life balance programs and recognition programs. Organizations that proactively respond to these challenges will likely experience increased employee engagement, productivity and retention over the long term.

Suggestions

- Career development plans should be structured by organisations.
- Well-deserved recognition based on merit creates motivation and enhances performance.
- Make Safety a Priority and Leverage Technology to Boost Satisfaction
- Improved work-life balance policies lead to decreased stress levels.

CONCLUSION

Organizational success is heavily driven by job satisfaction, and job satisfaction influences performance, productivity, and employee retention. The study shows that employees who feel valued, recognized, and supported are more engaged in their roles and as a result of that a healthier work environment and better efficiency. On the contrary, if a worker is dissatisfied, he can result in higher turnover rates, workplace conflicts, stress, low morale, etc. The findings suggest that employees are very keen on receiving fair compensation, career development, recognition and a good work culture. The impact of these areas on companies that prioritise them is in the direct impact on workforce motivation and commitment. A crucial role in increasing employee happiness are also job security, effective leadership, and well-established work life balance policies. Thus, to be able to continuously monitor employee satisfaction and to adjust the policies or to create the atmosphere conducive to the well-being of the employee, organizations can always keep an eye on the feedback mechanisms. Clear promotion pathways, performance based rewards and an effective workplace support system can help employees remain motivated and engaged. In the long term, employee satisfaction is all about loyalty, higher efficiency and a thriving organizational culture. Motivated workforce is the backbone of a business and organizations that invest in employee's well-being enjoy long term benefits in the form of higher job performance, better teamwork as well as sustained company growth.

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RESEARCH ARTICLE

Pathogens on Inanimate Surfaces in Tertiary Care Hospital : Prospective Study

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ABSTRACT

The environment within intensive care units (ICUs) is critical, with surfaces being regularly touched by both healthcare workers and patients. This frequent contact turns these surfaces into potential sources of infection, posing significant risks to patient safety and health outcomes. A prospective study design was employed, focusing on identifying the variety and spread of bacterial contamination across different surfaces frequently handled by healthcare workers. The study involved collecting 600 swabs from various surfaces within the ICU & wards of a tertiary hospital. These surfaces included bed rails, bedside tables, medical equipment, and other commonly touched areas. It was found that a significant proportion, 38.01%, harbored pathogens. Among these, the bacterium Staphylococcus aureus was the most prevalent, particularly on aluminum surfaces. This is especially concerning because S. aureus can cause a variety of infections, from minor skin issues to serious, life-threatening diseases, particularly in people with weakened immune systems. We found high levels of bacterial contamination on frequently touched objects, including many potential pathogens and normal bacteria. S. aureus was the most found bacterium.

Keywords: Health care worker, ICU surface, Cleaning and disinfectant, Staphylococcus aureus

INTRODUCTION

Nosocomial infections refer to diseases acquired by patients while receiving medical care in a healthcare facility. These infections are associated with prolonged hospital stays and are a significant risk factor for increased infection rates, leading to serious health complications[1]. Healthcare-associated infections (HAIs) are significant global health challenges that impact millions of patients within healthcare systems worldwide. Literature has long acknowledged the occurrence and adverse consequences of HAIs. Unfortunately, the incidence of HAIs continues to rise at a concerning pace [2]. The rate of healthcare-associated infections (HAIs) in the combined hospitals was 250 cases per 100,000 acute occupied bed-days [3]. According to the International Nosocomial Infection Control Consortium, the prevalence of HAIs in India is about 9.06 infections per 1,000 ICU patient days [4]. The profound effects of healthcare-associated infections (HAIs) extend to hospital mortality, prolonged hospital stays, and additional medical expenses. A study had suggested that the contaminated environment plays an important role in the transfer of the infection as several pathogens persist in the environment. Health care associated infection is one of the common causes of mortality and morbidity among hospitalized patients[5-6]. The patient environment comprises the immediate area surrounding a patient that can be accessed by both the patient and healthcare workers (HCWs) during care. This includes spaces within curtains, equipment, medical devices, furniture, telephones, personal belongings, and bathrooms in acute care settings. In intensive care units (ICUs), the patient environment extends to the entire room or bed space, along with all items and equipment within it. In multi-bedroom setups, it specifically covers the area enclosed by an individual's curtain[6]. Many strains of bacteria have been reported to the area where frequently touched site and surface near-patient patients such as bed rails, tray tables, telephones, bedside tables, patient chairs, nurse call buttons, doorknobs, push plates, bed rails, faucet handles, and IV pole are highly contaminated. These surfaces, often referred to as high-touch surfaces, play a critical role in the transmission of infections within healthcare settings[7-8].Both Gram-positive and Gram-negative pathogens often contaminate hospital surfaces, with Staphylococcus aureus being among the most common. It can be found on floors and door handles even after disinfection and can spread through fomites, causing infections. Nosocomial pathogens like MRSA, VRE, Pseudomonas spp., and Acinetobacter spp. are notably stable in hospital environments[9].Cleaning and disinfection of hospital environment surfaces are common measures to prevent the transmission of bacteria. But many bacteria persist within an hour even after cleaning and disinfecting the surfaces[10].Microorganisms vary in their resistance to disinfectants, so agents must be chosen carefully for their effectiveness. The study aimed to assess bacterial contamination on frequently touched but often overlooked surfaces used by healthcare workers, patients, and visitors.

METHODOLOGY

This prospective study was conducted to evaluate the distribution of microbial flora on high-contact surfaces & determine the pattern of bacterial contamination according to surfaces material. The study was undertaken at CHARUSAT Healthcare and Research Foundation (CHRF), Anand ,Gujarat, India for five months. The hospital is a 200 bedded tertiary care hospital having medical ward , surgical ward &Intensive care unit providing variety of care to patient. The domestic staff performed daily routine cleaning wet mopping during the morning between 6am to 10 am and deep cleaning during the night between 9pm to 11pm times. Patient's bed side rails, Patient's bed remote control, Cardiac monitors , Patient's bedside table, Cardiac table, Treatment trolley, Ventilators are wiped twice a day with 70% Isopropyl alcohol swabs. But there is no practice to disinfect the Surfaces like, Door handles, Computer keyboard, Patient's cubicle curtains: facing towards the patient's side Light switches, Nurses chair arm, Nurses phone , Patient files, IV stand. To determine the pattern of bacterial contamination according to surface materials all inanimate surfaces are classified into Aluminum surface, Wooden Surface, Plastic surface, Paper surface, &Fabric surface

Specimen collection

A total of 600 samples were collected from various surfaces like Patient's bed side rails Patient's bed remote control, Patient's cubicle curtains, Patient's bedside table, Cardiac table Cardiac monitors, Door handles, Computer keyboard, Light switches, Nurses chair arm, Nurses phone, Treatment trolley, Patient files, IV stand, Ventilators. Most of these sites are accessible and commonly used by patients, visitors, and healthcare professionals. The sample was collected through Sterile swabs wet in distilled water were used for sample collection by rubbing over the test surface. The study included the most frequently occupied departments, such as the Intensive Care Unit and Medical and Surgical wards. Swabs used for sampling were approximately 1.5 cm long.

Microbiological Analysis

Swab sampling was done from each predetermined surface area. The swabs were cultured in Nutrient and chocolate agar contact plates (diameter- Petri) to identify the bacterial colony. All plates were incubated at 37degree C at 24 hours and 48 hours.

Ethical consideration:

There is no human participation in the present study hence ethical approval is not required.

RESULTS

Environmental sampling is essential for detecting microbial contamination in different settings, including healthcare facilities, laboratories, and public spaces. In this study, 600 surface samples were collected from various locations to evaluate bacterial contamination and identify potential pathogens. Microbiological analysis revealed bacterial growth in 229 samples (38.1%), showing that over one-third of the tested surfaces were contaminated. Meanwhile, 371 samples (61.83%) exhibited no bacterial growth under the given culture conditions (Table 1).Further testing of the 229 contaminated samples led to the successful isolation of 184 distinct bacterial strains

Bacterial Contamination and Distribution Across Surface Samples

The microbiological analysis of surface samples revealed a significant presence of bacterial contamination across various sites. Among the identified bacterial species, Staphylococcus aureus emerged as the most predominant bacterium, isolated from 14 distinct locations (Table 2). A detailed examination of S. aureus distribution indicated that the highest contamination was observed on door handles, where 26.7% (27/101) of the isolates were recovered. Other frequently contaminated surfaces included switch buttons (14%; 14/101), IV stands and bedside rails (12%; 12/101 each), and computer keyboards (9%; 9/101). These findings highlight the high-risk nature of frequently touched surfaces in facilitating microbial transmission.

Prevalence of Gram-Negative Bacteria

In addition to S. aureus, Gram-negative bacteria such as Acinetobacter species and Escherichia coli (E. coli) were also identified. Notably, light switches exhibited contamination with multiple bacterial species, including S. aureus, E. coli, Klebsiella pneumoniae (K. pneumoniae), Staphylococcus epidermidis (S. epidermidis), as well as bacteria belonging to the genera Enterococcus and Acinetobacter. The presence of these pathogens suggests that electrical switches serve as critical reservoirs for bacterial transmission, necessitating targeted cleaning interventions.

Surface Material and Bacterial Contamination

Further analysis of contamination patterns across different departmental surfaces indicated that *S. aureus* was the most frequently isolated bacterium on aluminum surfaces (Table 2). Additionally, both aluminum and plastic surfaces harbored a diverse range of bacterial species, underscoring the potential role of these materials in sustaining microbial growth. The widespread presence of bacteria on these surfaces highlights the need for strict infection control measures, including routine disinfection and improved hand hygiene compliance among healthcare workers and visitors.

DISCUSSION

Hospitals are environments where bacteria can easily spread, increasing the risk of infections, particularly among vulnerable patients. Some of the most problematic bacteria found in healthcare settings include Clostridium difficile, Klebsiella pneumoniae, Acinetobacter species, Escherichia coli, Enterobacter species, Pseudomonas aeruginosa, and Staphylococcus aureus. These pathogens often persist on environmental surfaces, making them potential sources of hospital-acquired infections (HAIs) (11). Contaminated surfaces don't just affect patients and healthcare workers—they can also contribute to the spread of bacteria into the broader community.

Contamination of Frequently Touched Surfaces

Hospital equipment and everyday objects that are frequently touched by healthcare workers, patients, and visitors often harbor bacteria. This study found that S. aureus was particularly prevalent on door handles, which are used constantly throughout the day. Among the sampled door handles, 26.7% (27 out of 101) were contaminated with S. aureus, highlighting the potential for bacterial transmission. A similar study by Saadi, Somia et al. found that 15.7% of door handles in hospital departments tested positive for S. aureus (12). Door handles are frequently touched, especially when staff members enter or leave a department or during shift changes. This study, conducted in active hospital wards and ICUs at CHARUSAT Hospital, observed that healthcare workers often wash their hands at the end of their shift before leaving their departments. However, they may unknowingly recontamination their hands by touching door handles when exiting. Interestingly, many do not wash their hands again after using the door handles, which can contribute to the spread of bacteria within the hospital and beyond. In addition to S. aureus, E. coli (4%) and Acinetobacter species (1%) were also found on door handles—both of which are known to cause hospital-acquired infections. This finding aligns with research by Oluwatoyin Bola Famojuro et al., who discovered E. coli (12.5%) and Acinetobacter species (4.2%) on door handles in Olabisi Onabanjo University Teaching Hospital (13).

IV Stands: A Hidden Reservoir of Bacteria

IV stands, which are frequently used by both healthcare workers and visitors, were also found to be contaminated. Out of 45 IV stand samples collected in this study, 27% (12 out of 45) tested positive for S. aureus. This contamination rate is lower than the findings of Dharm Raj Bhatta et al., who reported a much higher contamination rate of 58% (8 out of 14) (14). Since IV stands are regularly handled during patient care, they can serve as reservoirs for bacterial transmission. These results underscore the need for regular and thorough disinfection of IV stands to prevent the spread of infections.

Computer Keyboards as a Potential Source of Infection

Another major concern is the contamination of computer keyboards, which healthcare workers use daily to input patient data. Unlike smooth surfaces, keyboards have many crevices, making them difficult to clean and disinfect effectively. In this study, 20% (9 out of 45) of the collected keyboard samples tested positive for S. aureus. This finding is consistent with research by Ramphal et al., which showed that frequently touched hospital surfaces—such as floors, beds, furniture, doorknobs, and light switches—are often not adequately disinfected (15). Given the role of computer keyboards in daily hospital operations, regular cleaning with appropriate disinfectants is crucial to minimizing contamination.

Bacterial Persistence on Different Surface Materials

The study also examined bacterial contamination on various surface materials, including aluminum, polyester, plastic, and wood. It was found that S. aureus was most commonly detected on aluminum surfaces. This observation supports the findings of KH, Saka, AA, Akanbi, Obasa, Tope, Raheem, Ra, and Oshodi, Adebola, who reported that S. aureus remained the dominant pathogen on aluminum surfaces even after four hours (9). The ability of bacteria to persist on different materials suggests that specific cleaning protocols may be needed for different surfaces to ensure effective disinfection.

CONCLUSION

We concluded that the ICU surfaces are contaminated with staphylococcus aureus is found among frequent touched surface like Light switches, door handle, IV stand, computer keyboard and treatment trolley which is a potential source of illness and infection among ICU patients therefore effective hand hygiene, regular cleaning and disinfection should be focused on the highly bacterial contaminated surfaces or frequent touch surface.

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Table 1- Occurrence of pathogens on surface area

Surface sampling (n=600)	Number of samples	Percentage
Growth detected	229	38.1%
No growth detected	371	61.83%

Table 2: pathogens isolated from different types of surfaces 0*- No Growth

Name of bacteria	Aluminum	Wooden	Plastic	Paper	Polyester
Staphylococcus Aureus	46	9	36	6	4
E coli	8	0	4	4	1
K. pneumoniae	1	0	12	3	0
S. epidermidis	2	1	3	1	1
Enterococcus species	4	3	13	1	0
Acinetobacter species	8	1	8	1	2

Table 3- pathogens isolated from surfaces 0*- No Growth

SURFACE AREAS	S. Aureus	E coli	K. pneumoniae	S. epidermidis	Enterococcus species	Acinetobacter species	Total bacterial contamination on each surface
Bed side rails (n=55)	11(20%)	2(4%)	0	1 (2%)	3 (5%)	2 (4%)	19
Bed remote control (n=33)	2 (6%)	0	0	0	3(5%)	4 (12%)	9
Cubicle curtains (n=20)	4 (20%)	1(5%)	1 (5%)	1 (5%)	0	2 (10%)	9
Bedside table (n=12)	3(25%)	0	0	1 (8%)	0	1 (8%)	5
Cardiac table (n=40)	4 (10%)	0	0	0	3 (8%)	0	7
Cardiac monitors (n=22)	0	0	2 (9%)	0	1 (5%)	0	3

Door handle (n=81)	27 (33%)	3 (4%)	0	0	0	1 (1%)	31
Computer keyboard (n=45)	9 (20%)	2 (4%)	4 (9%)	0	1 (2%)	1(2%)	17
Light switches (n=70)	14(20%)	1(1%)	3 (4%)	1(1%)	2 (3%)	1(1%)	22
Nurses chair arm (n=35)	2 (6%)	0	1 (3%)	0	0	1(3%)	4
Nurses phone (n=30)	2 (7%)	1(3%)	0	2 (7%)	2 (7%)	1 (3%)	8
Treatment trolley (n=40)	2 (5%)	0	1 (3%)	0	1 (3%)	2 (5%)	6
Patient files (n=32)	6 (19%)	4 (13%)	3 (9%)	1 (3%)	1 (3%)	1 (3%)	16
IV stand (n=45)	12 (27%)	3 (7%)	0	1 (2%)	0	3 (7%)	19
Ventilators (n=40)	3 (8%)	0	2 (5%)	0	4 (10%)	0	9
Number of occurrences of bacterial growth	101	17	17	8	21	20	184

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RESEARCH ARTICLE

DFT Analysis, Drug Likeness Prediction and Target Prediction of 1-(2,4-Dichloro-5-Fluorophenyl) Ethenone Prop-2-en-1-one

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ABSTRACT

By using DFT calculations, optimization, bond parameters, mulliken charges, electrostatic regions, global descriptive parameters and hyper conjugations with its stabilisation energies have been calculated for the titled compound. The titled compound has been prepared by microwave irradiation method to achieve less reaction time and good yield. IR and NMR spectra have been recorded for its confirmation of formation. The calculated parameters have been good agreement with literature values and the present molecule has been predicted as it may act as good NLO material due to its higher polarizabilities and dipole moments than standard NLO material (Urea). The ADMETox predictions have been carried out in order to compile its drug-liking behaviour followed by target predictions are screened.

Keywords: 1-(2,4-dichloro-5-fluorophenyl)ethenone, IR & NMR spectra, DFT calculation, Druglikeness and Target prediction

INTRODUCTION

Chalcones or 1,3-diarylprop-2-en-1-ones are versatile compounds in medicinal chemistry, known for their diverse biological activities [1], including antibacterial [2], antiviral [3] and anticancer [4] properties. Their synthesis often involves the Claisen-Schmidt condensation method, leading to various derivatives with enhanced efficacy. Recent

studies utilize computational techniques like Density Functional Theory (DFT), molecular docking, and ADMET (Absorption, Distribution, Metabolism, Excretion, and Toxicity) analysis to explore their potential further. DFT calculations are employed to predict the electronic properties of chalcones, aiding in the design of more effective derivatives. Chalcones are a class of flavonoids characterized by a three-carbon α,β-unsaturated carbonyl system. They serve as precursors to flavonoids and are found in various plants, contributing to their medicinal properties. The most common method for synthesizing chalcones is the Claisen-Schmidt condensation, which involves the reaction of acetophenones with aldehydes. Chalcones exhibit significant antibacterial properties, making them potential candidates for developing new antibiotics. Some chalcone derivatives have shown effectiveness against viral infections, including those caused by HIV and influenza. IR and NMR spectra are used to identify and formation of chalcone moiety. These compounds generally predicted to show better ADMET properties leading to good drug-liking behaviour [5]. The molecular docking studies extended their biological potent in well manner due to its interactions with various enzymes. Molecular docking technique is used to evaluate the binding affinity of chalcones to various biological targets, providing insights into their mechanism of action.

MATERIAL AND METHODS

The compounds used in the synthesis of the present chalcone were purchased from Aldrich and used without purification. Melting point was determined on the ESICO microcontroller based melting point apparatus (230V) and is uncorrected. The IR spectra were taken ona JASCO FT/IR-4700 spectrometer. 1H and 13C-NMR were recorded on the Bruker Avance 400 MHz FT-NMR spectrometer in $CDCl_3$. We performed thin-layer chromatography using silica gel Merck 60 F-254.

Synthesis of (E)-3-(4-(benzyloxy)phenyl)-1-(2,4-dichloro-5-fluorophenyl)prop-2-en-1-one

The present compound was synthesized through a microwave-assisted technique, selected for its efficiency in terms of shorter reaction times and superior yield, as indicated by existing methods in the literature. To begin, 4-benzyloxybenzaldehyde and 1-(2,4-dichloro-5-fluorophenyl)ethanone were combined in equal proportions and dissolved in 20 mL of absolute ethanol, with a few drops of 10% NaOH solution added [6] (**Scheme 1)**. The reaction mixture was then exposed to microwave irradiation at 640 W for 2 minutes, and the reaction's progress was monitored by TLC. Following the completion of the reaction, the resulting product was poured into ice-cold water, filtered, and recrystallized from hot ethanol.

RESULTS AND DISCUSSION

IR spectral analysis

The intense peak at 1649.80 cm^{-1} is due to νCO stretching. The carbonyl peak [7]was observed at a lower wave number than a normal ketone carbonyl peak in the infrared spectra due to the existence of a ketonic carbonyl group conjugated with the olefinic carbon-carbon double bond. The olefinic group (-C=C-) is observed at 1585.2 cm^{-1}. The aryl CH stretches are observed at 3064-2915cm^{-1} and the bending vibration at 1090.55cm^{-1}indicated the CH=CH out of plane modes. The CH *in-plane* and *out of plane* modes are observed at 1120.44 cm^{-1} and 735.71cm^{-1}. The stretching at 1249.65cm^{-1} responds the C-O-C stretching.

NMR spectral analysis

The ^{1}H-NMR spectrum of titled compound is illustrated in Figs. 2 and 3. The NMR analysis was taken by dissolving the sample in $CDCl_3$ with TMS as an internal standard. The NMR spectrum confirms the present chalcone formation. The proton H_α appears as a doublet (δ 6.967 and J=16Hz) represent the hydrogen atom available next to the C=O in the 1 H-NMR spectra [8]. Another doublet at δ 7.537ppm with J=16Hz representing the adjacent H atom H_β. These values correspond to the double-bond trans that is generally appeared in natural chalcones [7]. The δ value of Hα and H_β is slightly shifted; this is due to the conjugation effect with the aromatic rings and C=O [9]. The proton shifts

at 5.119ppm indicated the methylene protons. The three aromatic ring protons appear in different positions 6.992-7.540ppm. In the ^{13}C-NMR spectrum (Fig. 3), the C=O chemical shift appeared at 191.16ppm, relative to other carbon atoms due to environmental factor and increased electro negativity of the oxygen atom [10]. The methylene group was appeared at δ 70.17ppm.The carbon resonates at 123.19ppm responded to C_α and chemical shift value at 147.06ppm responded the C_β carbon of vinyl group. The chemical shift at 161.44ppm corresponded to high electronegative fluorinated carbon. All the remaining aryl carbons appeared at 115.46ppm to 136.22ppm in ^{13}C NMR spectra.

DFT analysis

Molecular geometry

The 4BPMP molecule was analyzed in the current examination using the density functional theory method with a B3LYP/6-311++G(d,p) basis set to build up different structural and chemical parameters. 4BPMP is a non-planer molecule with C1 point group symmetry, as predicted by the DFT analysis. Fig. 1 depicts the optimized molecular structure. The bond length (Table-1) for C=O (22O-19C) is 1.256 Å. This is typical for a double bond between carbon and oxygen in a carbonyl group, indicating a strong bond and a planar structure due to conjugation. The C=C bonds (e.g., 20C-21C at 1.355 Å and 4C-5C at 1.381 Å) are slightly longer than a typical C=C bond (usually around 1.33 Å), likely due to conjugation with the carbonyl and possibly the effects of steric hindrance and electronic interactions with substituents. The C-Cl bonds (e.g., 41Cl-6C at 1.804 Å) are longer than typical C-H or C-C bonds due to the larger atomic radius of chlorine and the presence of electro negativity. The C-F bond (3C-19C at 1.509 Å) is relatively short, reflecting the strong bond between carbon and fluorine, and the high electro negativity of fluorine, which pulls electron density towards itself. Bond lengths such as 2C-3C (1.401 Å) and 10C-11C (1.404 Å) reflect standard C-C single bonds. The length is slightly increased in conjugated systems like this, where the bond can be partially double-bonded due to electron delocalization. The bond angles around conjugated bonds like 4C-5C-6C (121°) and 1C-2C-3C (122°) reflect the sp^2 hybridization of carbon atoms, where bond angles are close to 120°, typical for trigonal planar geometry. The bond angles are largely influenced by sp^2 hybridization (around 120°), with slight deviations due to the presence of electronegative substituents (Cl, F, O). The conjugation between the carbonyl and vinyl groups tends to keep the molecule planar, aiding in efficient electron delocalization. The dihedral angle for19C-20C-21C-14C is calculated as 180° which indicates the E-conformation of themolecule.

FMO's Study

According to the Frontier Molecular Orbital (FMO) theory, the reactivity of molecules is primarily governed by the interaction between the Highest Occupied Molecular Orbital (HOMO) and the Lowest Unoccupied Molecular Orbital (LUMO) of the reacting species [11]. The energy of the HOMO (E_{HOMO}) is often associated with a molecule's ability to donate electrons. Molecules with higher E_{HOMO} values typically have a stronger tendency to donate electrons to an electron-accepting species with a lower LUMO energy [12]. The energy gap (ΔE) between the HOMO and LUMO is an important indicator of molecular reactivity, particularly in interactions with biological systems such as amino acid residues in proteins. A smaller ΔE indicates higher reactivity, which often correlates with an increased inhibition efficiency (IE). Molecules with smaller energy gaps are generally more polarizable and exhibit higher chemical reactivity, making them more likely to be classified as "soft" molecules with lower kinetic stability. As shown in Table-2, in our study, the compound under investigation displays a lower ΔE value, which suggests increased reactivity and a higher likelihood of interacting with biological systems. The pictorial representation of HOMO and LUMO are given in Figure-2. The global softness (σ) and absolute hardness (η) values for this molecule were calculated to be 0.563 eV and 1.777 eV, respectively. The chemical potential (π) of an electron relates to its ease of removal and is closely tied to the molecule's electronegativity. The global electrophilicity index provides insight into a molecule's ability to accept electrons, with values greater than 1.5 eV indicating strong electrophilic character. In this case, the global electrophilicity index of the investigated compound is 5.738 eV, suggesting that the molecule behaves as a strong electrophile. This finding supports the notion that the compound is likely to undergo nucleophilic attack, emphasizing its potential reactivity in biological interactions.

Dipole moments and hyperpolarizabilities

The organic NLO material demonstrates significant nonlinear optical (NLO) properties, primarily due to its high molecular hyperpolarizability, which is a crucial factor for considering it as a potential NLO material [13]. The NLO characteristics, including dipole moment, polarizability, and hyperpolarizability, were calculated for the present molecule using the DFT method. The results show values of 7.128 D, 25.540 × 10^{-24} esu, and 3.982 × 10^{-30} esu, respectively. These values, along with their tensor components, are provided in **Table-3**, based on the Gaussian output data. The calculated β values for the compound is ten times larger than those of Urea (β = 0.31 × 10^{-30} esu), which serves as a standard reference material for comparison [14]. In addition to the high β value, the calculated dipole moment (μ) and polarizability (α) further indicate that the grown crystal could be a promising candidate for future nonlinear optical applications.

Analysis of Mulliken charges

Mulliken population analysis is a method used to determine the distribution of electronic charges on individual atoms within a molecule, based on its molecular orbitals. This charge distribution can be valuable in understanding the formation of donor-acceptor pairs and charge transfer interactions within the molecule. The charge distribution for the chalcone compound under investigation is illustrated in Fig. 10 and summarized in Table-4. Mulliken charge calculations are a key aspect of quantum chemical analyses, helping to elucidate the electronic characteristics of the molecular system [15]. In the chalcone molecule, most carbon atoms carry positive charges, indicating their role as electron acceptors, while oxygen atoms generally exhibit negative charges, making them electron donors. The carbon atom at position C5 shows a particularly high positive charge as, likely due to its bonding with the electronegative fluorine atom (F42). Similarly, C11 also carries a higher positive charge, which can be attributed to its connection with the electronegative oxygen atom (O25). Notably, O25 has the most negative charge of all the atoms in the molecule, which is influenced by the presence of the electron-donating benzyl group attached to it. The column chart model of Mulliken charges of each atoms is given in Figure-3.

Molecular electrostatic potential

The molecular electrostatic potential (MEP) is a crucial tool for identifying regions susceptible to electrophilic and nucleophilic attacks based on the distribution of electrostatic potential. Positive electrostatic regions are typically associated with nucleophilic attack sites, while negative regions are more likely to attract electrophilic attacks. The electrostatic potential is visually represented using color-coding: blue indicates positive regions, red signifies negative regions, and green marks areas with zero potential [16-18]. The positive electrostatic potential increases in the sequence from red to yellow, green, light blue, and finally blue. As shown in Figure-4, the hydrogen atoms on the molecule's surface exhibit the highest positive electrostatic potential, making them favorable sites for nucleophilic attack. Conversely, the most negative electrostatic regions are found around the carbonyl oxygen (O1), the benzyloxy oxygen (O2), and within the phenyl and phenol rings, suggesting that these areas are prone to electrophilic attack. The carbonyl oxygen, in particular, shows a high electron density (represented by a denser red color), indicating its significant role in biological activity, likely through hydrogen bonding interactions with the target.

NBO analysis

NBO analysis provides a clear description of the stabilizing interactions between filled and unoccupied orbitals and destabilizing interactions between filled orbitals [19, 20]. The energy values for the interaction between the filled i and vacant orbital j, calculated by the second order perturbation theory have been tabulated in Table-5. The intramolecular hyper conjugative interaction of σ(N1-C2) distribute to σ * (C6-H21) resulting to a stabilization of 1.64KJ/mole. This enhanced further conjugate with antibonding orbital of π * (C7-O8) in which stabilization of 2.99KJ/mole. In the case of σ (C11-H26) orbital, the σ * (C2H15), (C12-H29) show stabilization energy of 17.17KJ/mole and 2.23KJ/mole respectively. The magnitude of charges transferred from O8 LP(1) (N1-C7) and O8 LP (2) (C7-N9) shows that stabilization energies are 1.83 KJ/mole and 26.14KJ/mole respectively. Similarly electron donating from N1 LP (1) to the antibonding (C2-C3) (C2-H16) (C6-H22) resulting stabilization of (~5KJ/mole) the same N1LP (1) with (C7-O8) leads to a strong stabilization of 62.5KJ/mole. This is the highest energy from all interaction. NBO (Natural Bond Orbital) analysis is a powerful tool used to understand the bonding interactions between atoms in a

molecule. In the context of present compound, 2,4-dichloro-5-fluorophenyl-4-benzyloxy chalcones, NBO analysis can help in identifying the electron density interactions between donor (bonding) and acceptor (anti-bonding or lone pair) orbitals, along with their energy values. The interaction between C1-C2 (Bond) and Cl41 (anti-bonding), with an energy value of 20.67 kJ/mol, indicates a relatively weak interaction between the bonding orbital of C1-C2 and the anti-bonding orbital of Cl. Similarly, interactions such as C3-C4 (BD) and C19-O22 (BD*) with 55.65 kJ/mol show a stronger interaction, as expected from interactions involving a carbonyl oxygen. The values of E(2) (in kJ/mol) describe the energy associated with electron density delocalization between these orbitals. Higher values indicate more significant interactions that stabilize or destabilize the molecule. LP(2) on O22 (carbonyl oxygen) interacts with *BD(1)** (C3-C19) with an E(2) of 77.36 kJ/mol. This suggests significant electron delocalization, which is typical for conjugated systems with a carbonyl group. LP(2) on O25 (benzyloxy oxygen) interacts with *BD(2)** (C10-C11) with a much stronger E(2) value of 125.90 kJ/mol, indicating a very strong interaction that might enhance the conjugative stabilization of the molecule. The lone pairs on electronegative atoms like oxygen (from the carbonyl group or benzyloxy group) can engage in stabilizing interactions with electron-deficient centers, contributing to the molecule's overall stability. The carbonyl oxygen in chalcones often participates in strong electron-withdrawing effects and can interact with conjugated systems, enhancing the system's reactivity. Its interactions with bonding orbitals (C3-C19 and C19-O22) suggest a conjugative stabilization and influence on the electronic structure. The benzyloxy group also plays a role in stabilizing the structure via interactions with nearby bonds, particularly with C10-C11 (E(2) of 125.90 kJ/mol). This contributes to the conjugative delocalization that is often seen in chalcone derivatives, giving rise to enhanced stability and electronic properties. Chlorine and fluorine halogens participate in weaker interactions (compared to the oxygen atoms) but still affect the electron distribution in the molecule. Chlorine, with its larger atomic radius, shows weaker donor interactions, while fluorine contributes through electron-withdrawing effects due to its high electronegativity.

Drug-likeness and ADMET prediction

This chalcone's molecular weight suggests it is a moderately sized molecule, making it potentially suitable for drug development [21]. A LogP value of 6.6076 indicates the compound is highly lipophilic. While this may enhance membrane permeability, it could also lead to poor aqueous solubility, which is a challenge for bioavailability [22]. The presence of 6 rotatable bonds suggests some flexibility in the molecule, which is typical for many bioactive compounds [23]. Chalcone has 2 hydrogen bond acceptors and no donors, which is a favorable balance. Having hydrogen bond acceptors (but not donors) typically supports interactions with biological targets and improves solubility without causing excessive molecular rigidity [22].The chalcone shows promising bioavailability with good intestinal absorption [24] but poor skin permeability [25] and CNS penetration. The compound is metabolized by CYP3A4 and interacts with multiple cytochrome P450 enzymes [26], indicating potential for drug-drug interactions. Its cardiac safety could be a concern due to hERG II inhibition, and its relatively low water solubility and protein binding may influence its pharmacokinetics. Toxicity data suggest it is not mutagenic and has low acute toxicity in rodents [27], but further investigations are necessary for a comprehensive safety profile.

Target Prediction

The target prediction for 2',4'-dichloro-5'-fluorophenyl-4-benzyloxyphenylprop-2-en-1-one suggests several potential biological targets based on the probability values provided. Each target listed has a probability of 0.1133, indicating an approximately equal likelihood of interaction with the compound, based on the data provided. The present compound 2',4'-dichloro-5'-fluorophenyl-4-benzyloxyphenylprop-2-en-1-one shows potential interactions with a wide variety of targets, including, Oxidoreductases like MAOB and MAOA, which are involved in neurotransmitter regulation. It also hasinflammation-related targets such as COX-2 (PTGS2) and P2X7, which are involved in inflammatory pathways. GPCRs, including orexin receptors, cannabinoid receptors, and stress-related receptors like CRHR1. Another target of transporters like glycine transporter SLC6A9, influencing neurotransmission. It also targeted kinases and phosphodiesterases that regulate cellular signaling pathways. Each of these target classes may indicate that the compound could have therapeutic implications in areas like neurology, inflammation, pain management, and stress regulation. However, the relatively uniform probability (0.113) suggests that these

interactions are relatively equal and should be further explored with additional computational or experimental studies to confirm which targets the compound most strongly.

CONCLUSION

Present chalcone has been synthesised using microwave irradiation method to get higher yield with low time consumption. It has been characterized by IR and NMR spectra. Its DFT calculations have been calculated by B3LYP/6311++G(d,p) basis set with its optimized geometry. The obtained bond parameters are agreed with literature values. FMO study revealed that it has a low HOMO-LUMO gap as it is a soft molecule and can undergo chemical reactions easily and can expect better biological applications. Due to its higher electrophilicity index, strongly act as electrophile. NBO analysis proved its higher hyper conjugations within the molecule with higher stabilization energies cause its activeness. Due to its hyperpolarizability and dipole moments, can act as NLO material. MEP and Mulliken charges displayed its electron rich centre and individual charges. Computational drug likeness and target predictions say that the present molecule is suitable for several biological applications which interact some amino acid residues responded to antimicrobial, antidiabetic and anti-inflammatory tissues.

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Table-1 Selected Bond parameters of (*E*)-3-(4-(benzyloxy)phenyl)-1-(2,4-dichloro-5-fluorophenyl)prop-2-en-1-one by B3LYP/6311++(d,p) method

Bonding	Bond length	Bonding position	Bond angle	Position	Dihedral angle
22O-19C	1.256	4C-5C-6C	121	20C-21C-14C-9C	0.04
20C-21C	1.355	13C-12C-11C	120	4C-5C-6C-1C	0.71
4C-5C	1.381	31C-34C-36C	120	13C-12C-11C-10C	0.04
13C-12C	1.386	22O-19C-20C	123	1C-2C-3C-19C	180.21
1C-2C	1.393	20C-21C-14C	128	5C-6C-1C-2C	1.3
5C-6C	1.390	1C-2C-3C	122	6C-1C-2C-3C	0.24
6C-1C	1.389	5C-6C-1C	119	9C-10C-11C-25O	180.07
9C-10C	1.392	6C-1C-2C	119	31C-34C-36C-32C	0.09
20C-32C	1.396	9C-10C-11C	120	2C-3C-19C-20C	41.75
31C-34C	1.396	30C-32C-36C	120	34C-36C-32C-30C	0.08
2C-3C	1.401	2C-3C-19C	127	10C-11C-25O-26C	0.3
34C-36C	1.398	34C-36C-32C	120	29C-30C-32C-36C	0.12
36C-32C	1.398	10C-11C-25O	125	14C-9C-10C-11C	0.01
10C-11C	1.404	12C-11C-25O	116	21C-14C-9C-10C	179.97
12C-11C	1.403	29C-30C-30C	121	19C-20C-21C-14C	178.52
29C-30C	1.401	14C-9C-10C	122	11C-25O-26C-29C	179.69
14C-9C	1.409	21C-14C-9C	123	3C-19C-20C-21C	179.42
21C-14C	1.454	19C-20C-21C	121	25O-26C-29C-30C	89.31

19C-20C	1.460	11C-25O-26C	120	22O-3C-20C-19C	4.13
25O-11C	1.386	26C-29C-31C	120	42F-4C-6C-5C	0.02
26C-29C	1.501	3C-19C-20C	120	41Cl-5C-1C-6C	0.59
3C-19C	1.509	24F-5C-4C	120	40Cl-3C-1C-2C	3.48
42F-5C	1.388	25O-26C-29C	108	12C-10C-25O-11C	0.04
25O-26C	1.476	41Cl-6C-1C	120	26C-30C-31C-29C	1.5
41Cl-6C	1.804	40Cl-2C-1C	115	C19-C20-C21-C14	178.6
42Cl-2C	1.832			C4-C3-C19-C20	139.8
				C20-C21-C14-C13	180

Table-2 Electronic parameters calculated by DFT method

Parameters	**B3LYP/6311++G (d,p)**
E_{HOMO} (a u)	-6.294
E_{LUMO} (a.u)	-2.739
Energy gap (a.u)	3.555
Ionization energy (I)	6.294
Electron affinity(A)	2.739
Global hardness (η)	1.777
Chemical potential (μ)	-4.516
Electrophilicity index (ω)	5.738
Chemical softness (s)	0.563

Table-3 Dipolemoments, Polarizability and Hyperpolarizabilities of chalcone by DFT

Parameter	**Dipole moment (μ) Debye**	**Hyperpolarizability**	**β_ox10^{-30}esu**
μx	6.351	β_{xxx}	438.075
μy	-3.109	β_{xxy}	-75.982
μz	0.896	β_{xyy}	-11.836
μtot	7.128	β_{yyy}	-4.909
Parameter	**Polarizability**	β_{xxz}	-25.711
α_{xx}	-171.870	β_{xyz}	3.008
α_{xy}	3.475	β_{yyz}	-2.388
α_{yy}	-173.600	β_{xzz}	27.042
α_{xz}	4.239	β_{yzz}	-1.897
α_{yz}	1.653	β_{zzz}	13.129
α_{zz}	-171.544	βo	3.982
α_{tot} (esu) x 10^{-24}	25.540		

Table-4 Mulliken atomic charges calculated by DFT method

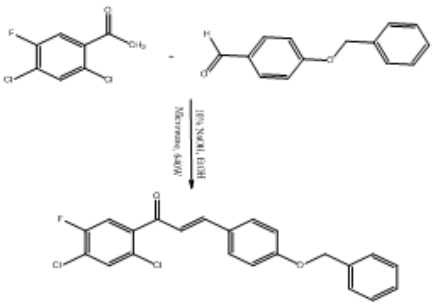
Atoms	**Mulliken charges (a.u)**	**Atoms**	**Mulliken charges (a.u)**
1 C	0.2545	21 C	0.0286
2 C	-0.2603	22 O	-0.3775
3 C	0.0147	25 O	-0.5045

4 C	0.0722	26 C	0.1271
5 C	0.4585	29 C	0.0195
6 C	-0.3695	30 C	0.0601
9 C	0.0979	31 C	0.0606
10 C	-0.0071	32 C	-0.007
11 C	0.2698	34 C	-0.0069
12 C	-0.0016	36 C	0.0297
13 C	0.0267	40 Cl	0.0262
14 C	-0.006	41 Cl	0.0568
19 C	0.21	42 F	-0.307
20 C	0.0345		

Table-5 NBO energies calculated by DFT method

Donor NBO (i)		Acceptor NBO (j)		E(2) KJ/mol
BD (1)	C 1 - C 2	BD*(1)	C 6 -Cl 41	20.67
BD (2)	C 1 - C 2	BD*(2)	C 3 - C 4	84.64
BD (2)	C 1 - C 2	BD*(2)	C 5 - C 6	78.66
BD (1)	C 3 - C 4	BD*(1)	C 2 -Cl 40	28.58
BD (2)	C 3 - C 4	BD*(2)	C 1 - C 2	94.85
BD (2)	C 3 - C 4	BD*(2)	C 5 - C 6	104.73
BD (2)	C 3 - C 4	BD*(2)	C 19 - O 22	55.65
BD (1)	C 4 - C 5	BD*(1)	C 5 - C 6	23.22
BD (1)	C 4 - C 5	BD*(1)	C 6 -Cl 41	21.67
BD (2)	C 5 - C 6	BD*(2)	C 1 - C 2	90.17
BD (2)	C 5 - C 6	BD*(2)	C 3 - C 4	80.88
BD (2)	C 9 - C 14	BD*(2)	C 10 - C 11	78.87
BD (2)	C 9 - C 14	BD*(2)	C 12 - C 13	85.48
BD (2)	C 9 - C 14	BD*(2)	C 20 - C 21	68.87
BD (2)	C 10 - C 11	BD*(2)	C 9 - C 14	99.79
BD (2)	C 10 - C 11	BD*(2)	C 12 - C 13	65.06
BD (2)	C 12 - C 13	BD*(2)	C 9 - C 14	70.58
BD (2)	C 12 - C 13	BD*(2)	C 10 - C 11	95.77
BD (2)	C 20 - C 21	BD*(2)	C 9 - C 14	46.15
BD (2)	C 20 - C 21	BD*(2)	C 19 - O 22	113.72
BD (1)	C 21 - H 24	BD*(1)	C 9 - C 14	21.25
BD (1)	C 21 - H 24	BD*(1)	C 20 - H 23	22.93
BD (2)	C 29 - C 30	BD*(2)	C 31 - C 34	87.11
BD (2)	C 29 - C 30	BD*(2)	C 32 - C 36	84.94
BD (2)	C 31 - C 34	BD*(2)	C 29 - C 30	88.53
BD (2)	C 31 - C 34	BD*(2)	C 32 - C 36	87.65
BD (2)	C 32 - C 36	BD*(2)	C 29 - C 30	88.83
BD (2)	C 32 - C 36	BD*(2)	C 31 - C 34	84.52
LP (2)	O 22	BD*(1)	C 3 - C 19	77.36
LP (2)	O 22	BD*(1)	C 19 - C 20	63.81
LP (1)	O 25	BD*(1)	C 10 - C 11	28.41
LP (2)	O 25	BD*(2)	C 10 - C 11	125.90
LP (3)	Cl 40	BD*(2)	C 1 - C 2	39.83

LP (3)	Cl 41	BD*(2)	C 5 - C 6	48.12
LP (2)	F 42	BD*(1)	C 4 - C 5	20.54
LP (2)	F 42	BD*(1)	C 5 - C 6	23.72
LP (3)	F 42	BD*(2)	C 5 - C 6	73.76



Scheme-1

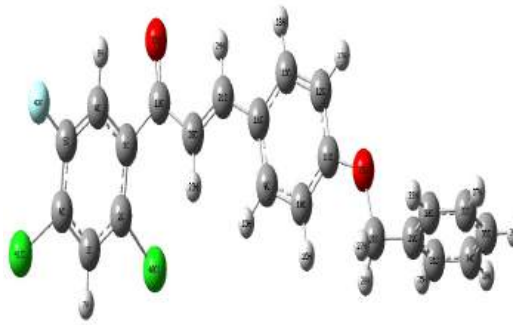


Figure-1. Optimized structure of (*E*)-3-(4-(benzyloxy)phenyl)-1-(2,4-dichloro-5-fluorophenyl)prop-2-en-1-one

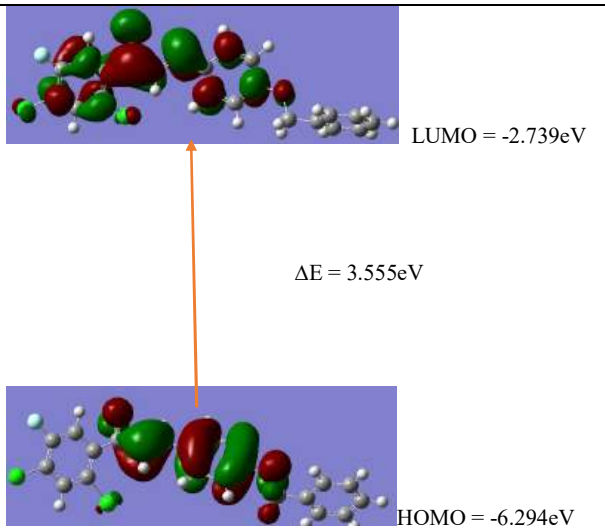


Figure-2. HOMO-LUMO pictorials of chalcone

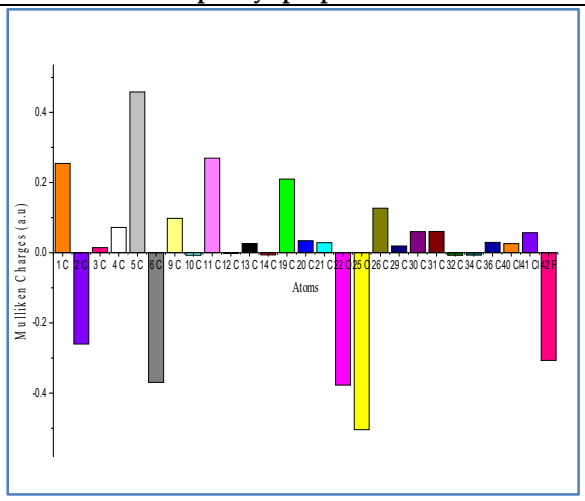


Figure-3. Column chart of Mulliken charges calculated by DFT method

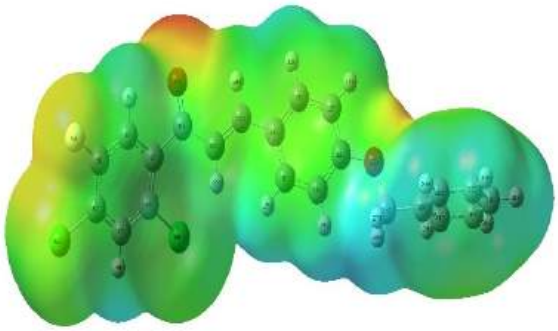


Figure-4 MEP surface of chalcone

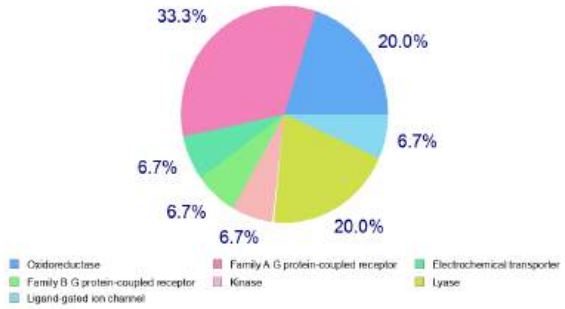


Figure-5

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RESEARCH ARTICLE

Bibliometric Analysis of Pose Estimation Techniques in Sports Performance Research

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ABSTRACT

This is a bibliometric analysis of pose estimation methods in sports performance that examines 154 sources and 345 documents from 2006 through 2025. The binned time-series analysis showcases the year-on-year rise in research activity, with the authors summarizing the progress level as presented in Table 1, demonstrating the development of the pose estimation technologies. Major contributors are identified, including key journals including SENSORS and IEEE ACCESS, universities such as the University of Toronto. These pose estimation tools can be used in different sports to improve the analysis of performance, training and prevention of injuries. The authors also proposed recommendations to improve partnerships, increase as well as develop real-time models, enlarge datasets, implement wearables, augment open access and fund superior hardware to strengthen progress in this area.

Keywords: Pose estimation, Sports Sciences, Bibliometric Analysis, R studio.

INTRODUCTION

Pose estimation is one of the most important areas under computer vision which has been advancing tremendously in the past 10 years (Sreedev & Ramakrishnan, 2024), especially in terms of sports performance analysis. This technique predicts the coordinates of pose points on the human body using images or videos (Barla, 2021) and can be used to analyze movement on a more detailed level. By providing precise motion data, pose estimation has become a pivotal tool in sports science, enabling advancements in training protocols, injury prevention, and

performance optimization (Rajesh & Janarthana, 2024). Typical works in this area have reported the ongoing, interdisciplinary research around pose estimation (Sreedev & Ramakrishnan, 2024), with applications in diverse domains, including, but not limited to human-computer interaction, animation and robotics. Across the field of science in sports, pose estimation technologies have played a pivotal role in delivering accurate assessments of joint angles alongside velocities and accelerations (Williams et al., 2021), which collectively contribute to improvement of athlete mechanics and development of customized training plans. For instance, Nakamura et al. (2022) showed the usage of pose estimation to analyze the dynamics of athletes in real time with feedback that could be used to improve performance. Deep learning has greatly contributed to the evolution of pose estimation approaches. CNNs, as summarized by Toshev and Szegedy (2014), have lead to significant improvements in accuracy and speed in solving pose estimation models. Real-time data analytics and feedback are critical for making adjustments on-the-go which is where these improvements make a difference. Additionally, pose estimation has further expanded into wearable and motion capture systems, which can offer detailed performance metrics (Pfister et al., 2015).

The world of sports in India is rife with a desire to use pose estimation for improving player performance. Research by Patel and Sharma (2022) and Reddy and Singh (2023) have outlined the niche opportunities and the potential in Indian sports space. Internationally, the rapid development of pose estimation can be closely tied to the construction of large annotated datasets, along with the emergence of advanced models, including the Cascaded Pyramid Network put forward by Chen et al. multi-person pose estimation, Generative Adversarial Nets (GANs) Framework (2018) The objective of this paper is to perform an extensive bibliometric analysis of pose estimation applied to sports performance research by using the Scopus database to explore the research scenery, leading contributors, and trends/patterns influencing the discipline over the years. This serves as an important reference point for researchers, practitioners, and policy makers interested in the potential developments and applications of pose estimation in sports science.

REVIEW OF LITERATURE

Pose Estimation

Pose estimation is one of the most basic task of computer vision which is to predict the locations of key points on human body from images or videos. And, because the scope of this technique, including human-computer interaction, sports performance measuring, animation, etc., it has become genuinely popular. Pose estimation aims to understand human body poses, movements, and behaviors that can express themselves in 2D or 3D (Samkari et al., 2023).

Traditional Methods

Traditional computer vision based methods were most commonly used in the early days of pose estimation, where we had hand crafted features and models that could detect/ localize joints in the body. Traditional methods like pictorial structure model used prior knowledge of human body and spatial relationships among parts (Gong et al., 2021). Geometric approaches are poorly centered in convenient geometric parameters related to pixels; hence, they cannot be optimally designed (Badiola-Bengoa & Mendez-Zorrilla, 2021), and traditional techniques faced difficulties in comprehending convolutional layers, blending comprehensive variants in pose, occlusions, and overlapping joints, and are not efficient for real-world applications.

Deep Learning Approaches

Deep learning revolutionized pose estimation and made it more dust and efficient. Convolutional Neural Networks (CNNs) provide the basis for most contemporary pose estimation models. One of the first to apply deep learning to human pose estimation was the DeepPose model (Toshev & Szegedy, 2014), which used CNNs to directly regress the locations of body joints from images (Toshev & Szegedy, 2014). Later models have expanded this initial framework, utilizing multi-stage architectures and taking advantage of large annotated datasets to improve performance (2018; Chen et al, 2018).

Applications in Sports Performance

Pose estimation has a wide range of applications in the analysis of sports performance. With accurate readings of the angles, velocities, and accelerations of relative joints, pose estimation systems allow for fine movement analysis in sports. It is important for optimizing practices, designing individualized training regimens, and avoiding injuries (Williams et al., 2021). For example, Nakamura et al. derived individual movement analysis in real-time by pose estimation to improve athletes' performance instantaneously (Nakamura et al., 2022).

Challenges and Future Directions

Despite continued improvements, pose estimation remains a challenging problem. However, occlusions, scale differences, and complex scene compositions can introduce challenges that hamper the accuracy of pose estimation models and variants. The computational complexity of deep learning models is also a barrier for real-time applications. Future work will probably address these issues with more robust models and advancing technology (Samkari et al, 2023). Pose estimation is an exciting application in the interface between sports science and technology. Deep learning based pose estimation models have shown great promise in this regard as they would continue to advance and become more accurate and efficient over time and may thus find even wider applications in various sports and other domains. This review summarizes the vast strides made in the field and the potential for future laboratory and clinical companies.

OBJECTIVES OF THE STUDY

1. To provide a comprehensive overview of the research landscape of pose estimation techniques in sports performance, identifying key trends, growth patterns, and the evolution of the field over time.
2. To recognize the most influential journals, and institutions, contributing to the advancement of pose estimation technologies in sports performance.
3. To explore the diverse applications of pose estimation tools across various sports, highlighting their impact on performance analysis, training, and injury prevention

METHODOLOGY

The study utilized the Scopus database for its comprehensive coverage of peer-reviewed literature. Initially, a keyword search using "Pose estimation" yielded 22,451 documents. To refine the search, the field was narrowed to sports, resulting in 1,245 documents. Further filtering based on document type included only articles (570 documents), excluding conference papers (617), reviews (27), book chapters (14), conference reviews (10), data papers (3), short surveys (2), retracted documents (1), and letters (1). Language criteria included only English documents (556), excluding Chinese (12), German (1), and Russian (1). Open access criteria included all open access documents (353), excluding gold (249), green (98), hybrid gold (41), and bronze (23). Finally, the publication stage was refined to include only final publications (345), excluding articles in press (8). The final dataset of 345 documents was exported in BibTeX format and analyzed using the Biblioshiny package in R Studio, a web interface for bibliometric analysis that allows for comprehensive analysis and visualization of bibliometric data. The analysis included descriptive analysis to provide an overview of publication trends, citation analysis to identify the most cited documents and influential authors, co-authorship analysis to explore collaboration patterns, keyword analysis to identify frequently used keywords and emerging research themes, and thematic mapping to visualize the evolution of research topics over time. This methodology outlines the systematic approach taken to filter and analyze the relevant literature on pose estimation techniques in sports performance research.

RESULTS

MAIN INFORMATION ABOUT THE DATA

To analyze pose estimation methods within sports performance research, we conducted a bibliometric analysis using Scopus from 2006 through 2025, with 154 sources including journals and books, and 345 documents. It is also

important to note here that the research output is growing at an annual rate of 3.72% where the mean of the documents featured in the dataset are 1.92 years meaning that the research is quite recent. The average number of citations per paper is 12.53, which indicates the quality of the research. A total of 2552 Keywords Plus and 1000 Author's Keywords were analyzed. 1327 authors contributed to these publications, and 15 of them have single-authored documents. There are 15 single-authored documents in total, and on average, each document has 4.55 co-authors, showcasing a high level of collaboration. Additionally, 26.67% of the documents involve international co-authorships, demonstrating significant global collaboration. Regarding document types, there are 342 articles and 3 documents labeled as 'article article', which might be a data entry error or a specific categorization. Overall, this analysis highlights the growth, collaboration, and impact of research on pose estimation techniques in sports performance, showing a steady increase in publications and a high level of international collaboration. The annual production data (Figure 1) for pose estimation techniques in sports performance research reveals a clear trend of increasing research activity over the years. From 2006 to around 2014, the number of articles published each year was relatively low and sporadic. However, starting from 2015 onwards, there is a noticeable increase in the number of articles published annually. The most significant growth can be observed from 2019 onwards, with 9 articles published in 2019, increasing to 26 in 2020, 39 in 2021, and surging to 69 in 2022. The peak was reached in 2023 with a total of 95 articles published. The data for 2024 and 2025 shows a slight decline with 86 and 2 articles respectively, which could be due to incomplete data collection for these years or other external factors. Overall, the trend indicates a growing interest and research activity in pose estimation techniques in sports performance over the past two decades. Bradford's Law (Table 1) states that journals in a field can be divided into a core set of journals that are most frequently cited and several other sets or zones with decreasing frequency of citations. In this analysis of the top 10 sources for pose estimation techniques in sports performance research, Zone 1 includes the top six sources: SENSORS (46 articles), IEEE ACCESS (23 articles), APPLIED SCIENCES (SWITZERLAND) (18 articles), SCIENTIFIC REPORTS (10 articles), COMPUTATIONAL INTELLIGENCE AND NEUROSCIENCE (9 articles), and SENSORS (SWITZERLAND) (9 articles). These sources collectively contribute to a cumulative frequency of 115 articles, indicating that these journals are the most influential and frequently cited in this research area.

Zone 2 includes the next four sources: JOURNAL OF BIOMECHANICS (8 articles), PLOS ONE (8 articles), COMPUTER VISION AND IMAGE UNDERSTANDING (6 articles), and ELECTRONICS (SWITZERLAND) (5 articles), contributing to a cumulative frequency of 27 articles. While still important, these journals are less frequently cited compared to those in Zone 1. Overall, the distribution of sources follows Bradford's Law, with a small number of journals in Zone 1 contributing to a large portion of the total articles published. This highlights the concentration of research output in a few key journals within the field of pose estimation techniques in sports performance research. The (Table 2) first 10 affiliations collaborating through pose estimation techniques in sports performance are led by University of Toronto with most produced articles (16). Next up is the University of Bath with 13 articles. However, seven articles have been published by Johns Hopkins University, and six articles have been contributed each by the Norwegian University of Science and Technology and the University of Antwerp. Such institutions include China University of Geosciences, Hanyang University, School of Health, Stanford University, University of British Columbia, — each with 5 articles published. The distribution indicates the contributions from a wide variety of institutions across various countries, demonstrating global interest and collaboration in advancing research on pose estimation techniques in sports performance. We expected this bibliometric analysis to give an overview regarding available pose estimation tools and their applications through various sports. These tools have proven versatile and efficient for improving performance, training, and avoiding injuries.

Basketball: Algorithms of human pose estimation for action prediction, overview of actions and localization of technical details.

- Race Walking: Fault detection using smartphone cameras.
- Volleyball: 3D pose refinement for spike analysis.
- Track and Field: Monocular 3D pose estimation from broadcasts.
- Rock Climbing: Move prediction systems.
- Resistance Training: Fatigue monitoring.
- Tennis: Sensor fusion and pose estimation for practice enhancement.

- Cycling: Pose estimation for fall modeling and surface area estimation.
- Baseball: 3D pitcher pose reconstruction.
- Running: Pose estimation for posture and tendon force prediction.
- Skiing: Keypoint detection and performance analysis.
- Golf: Swing analysis and performance prediction.
- Swimming: Underwater pose estimation.
- Badminton: Action analysis and trajectory simulation.
- Boxing: Pose estimation for upper extremity kinematics.
- Handball: Play classification and action tracking.
- Football (Soccer): Goalkeeper movement and penalty kick analysis.
- Martial Arts: Pose estimation for performance modeling.
- Dance: Pose estimation for movement tracking.
- Yoga: Pose estimation using deep learning.

The paper presents come cross-disciplinary work, as it discusses the versatility of pose estimation tools in different sports and activities on how they can give those involved headaches to gain an edge in whatever sport they participate in for performance, training, and injury prevention. This includes the increasing implementation of deep learning and computer vision in these tools, showcasing the current progressions in the field of sports science.

DISCUSSION

Insights with regards to pose estimation techniques: A bibliometric analysis in the context of sports performance research Notably, this work was greatly expanded upon from 2015 and saw a dramatic increase from 2019 to 2023 in the number of publications. Such an upward trend demonstrates the interest and investment that the sports science community is making into the area of pose estimation technologies. Towards a more unified approach to pose estimation from monocular images The analysis also illustrates the interdisciplinary nature of pose estimation, with potential applications spanning from sports to human-computer interaction, animation and robotics. The distribution of research output across a relatively small number of journals, as described by Bradford's Law, highlights the role of such journals as the capping points of influential work. The field is complemented by now important journals such as SENSORS, IEEE ACCESS, APPLIED SCIENCES (SWITZERLAND), among others. This global interest is also seen through the contributions of several, notable institutions such as the University of Toronto and the University of Bath. Pose estimation techniques have been broadly implemented in many common sports/activities, such as basketball, volleyball, tennis, swimming, etc. They have been useful to assist performance analysis, training and injury prevention. These tools illustrate the potential to revolutionise both performance analysis in sport.

CONCLUSION

The proposed research work gives a comprehensive overview of existing pose estimation methods and technologies used in human performance in sports and biofeedback. A large number of publications over time with a significant number of international collaborations reflect a thriving, expanding discipline. As the role of pose estimation technologies continues to grow, they are clearly becoming integral to helping athletes optimize performance, refine training programs and prevent injuries. The adoption of state-of-the-art technologies, including deep learning and computer vision, has made these tools even more accurate and applicable. In order to promote the field of pose estimation in sports performance, it is suggested to strengthen international and multi-disciplinary collaborations, as coalescing different specialties can help disseminate new innovative ideas. A challenge would be to suggest stronger and faster models to perform live pose estimation in the direct presence of problems as occlusions/changing size-body, or to reduce the time-response such to better respond to the demand of sports events. This will ensure that pose estimation models can perform across a range of sports and movements by expanding the diversity of annotated datasets. With the addition of pose estimation by integrating them with wearables it will pave way for detailed performance assessment for an athlete who will provide the coach with detailed insights on their

movements and techniques. More open-access papers will help to spread the message and to implicitly adopt pose estimation in sports science. Investing in sophisticated hardware including high-speed cameras and sensors will also improve data capture and analysis, facilitating the creation of more accurate, reliable pose estimation-facilitating tools. With these suggestions concerted to, the area can carry on to strong and making a significant donations to improve athletic effectiveness and the total improvement of sport science.

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Table 1: Top 10 Sources Based on Bradford's Law

Source	Rank	Freq	cumFreq	Zone
Sensors	1	46	46	Zone 1
IEEE Access	2	23	69	Zone 1
Applied Sciences (Switzerland)	3	18	87	Zone 1

Scientific Reports	4	10	97	Zone 1
Computational Intelligence and Neuroscience	5	9	106	Zone 1
Sensors (Switzerland)	6	9	115	Zone 1
Journal of Biomechanics	7	8	123	Zone 2
PLOS One	8	8	131	Zone 2
Computer Vision and Image Understanding	9	6	137	Zone 2
Electronics (Switzerland)	10	5	142	Zone 2

Table 2: Top 10 Affiliations in Pose Estimation Techniques in Sports Performance Research

Affiliation	Articles
University of Toronto	16
University of Bath	13
Johns Hopkins University	7
Norwegian University of Science and Technology	6
University of Antwerp	6
China University of Geosciences	5
Hanyang University	5
School of Health	5
Stanford University	5
University of British Columbia	5

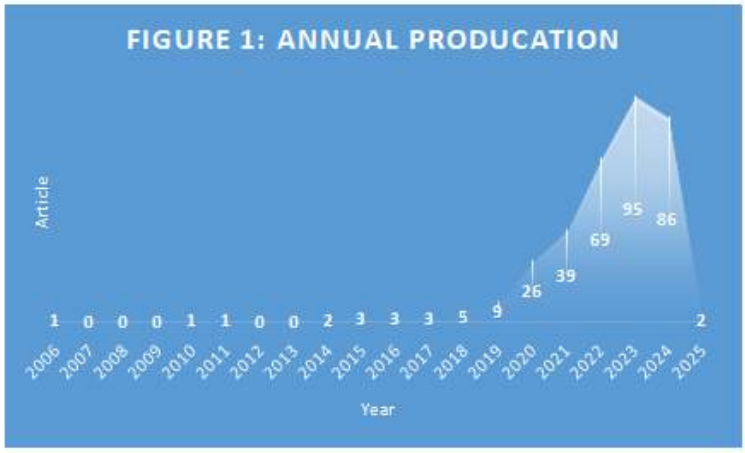


Figure: 1 Annual Production

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RESEARCH ARTICLE

Exploring the Anti-Diabetic Potential of Neeradimuthuvallathy Mezhugu: A Synergistic Approach through Gut Microbiota Modulation

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ABSTRACT

The frequency of diabetes mellitus, a chronic metabolic disease marked by persistent hyperglycemia, is rising alarmingly worldwide. Despite their effectiveness, conventional antidiabetic medicines frequently have drawbacks because of side effects, which highlights the need for alternative therapeutic techniques. With an emphasis on its function in regulating gut microbiota, this review investigates the anti-diabetic potential of Neeradimuthuvallathy Mezhugu (NM), a Siddha polyherbal and herbomineral combination. Recent studies have shown how important the gut microbiota is to the pathophysiology of diabetes, with microbial dysbiosis playing a role in insulin resistance, systemic inflammation, and altered glucose metabolism. With its varied phytochemical makeup, NM provides a comprehensive strategy for managing diabetes. Important components such as Withania somnifera, Hydnocarpus kurzii, and Semecarpus anacardium are abundant in bioactive substances such alkaloids, phenolic acids, and flavonoids, which have anti-inflammatory, hypoglycemic, and antioxidant qualities. These natural substances from the medicinal plants promote gut eubiosis by suppressing pathogenic species and promoting beneficial microbial populations, in addition to reducing hyperglycemia. This review summarizes the body of research to evaluate the potential of NM on insulin sensitivity and glucose metabolism and also to enhance the composition of the gut microbiota and its subsequent impacts. As a promising therapy for diabetic control, NM may also address microbial dysbiosis and promotes gut

health, providing insights into the complementary roles of modern microbiome science and traditional medicine.

Keywords: Diabetes, Siddha medicine, Neeradimuthuvallathy Mezhugu, Gut Microbiota, dysbiosis, eubiosis

INTRODUCTION

Diabetes is a chronic condition characterized by insufficient insulin production or ineffective insulin use, leading to elevated blood glucose levels (hyperglycemia). This disrupts glucose metabolism and causes long-term damage to organs and systems. A major non-communicable disease, diabetes is a leading cause of blindness, cardiovascular diseases, and strokes. Its prevalence has sharply increased, particularly in developing countries, with global cases rising from 108 million in 1980 to 422 million in 2014. In 2019, diabetes accounted for nearly 1.5 million deaths globally (WHO, 2021). (WHO, 2021) [1].

DIABETES - A GLOBAL SCENARIO

Diabetes prevalence has surged globally, affecting 463 million adults (9.3%) in 2019, with projections of 578 million (10.2%) by 2030 and 700 million (10.9%) by 2045. Over half (50.1%) of people with diabetes remain undiagnosed, highlighting the need for improved screening and awareness initiatives. [2]. Regional Variations shows that compared to lower rates in North America and the Caribbean (24.2%), the prevalence of undiagnosed diabetes is noticeably higher in regions like Southeast Asia (51.3%), the Western Pacific (52.8%), and Africa (53.6%) [3]. By 2045, diabetes cases are projected to rise by 46%, affecting 783 million people, or 1 in 8 individuals. Key drivers include urbanization, aging populations, reduced physical activity, and rising obesity rates, with type 2 diabetes accounting for over 90% of cases. [4]. Diabetes caused 1.6 million deaths in 2021, while other deaths were attributed to related illnesses such as kidney disease [5]. These figures emphasises the need for comprehensive public health initiatives to combat the global diabetes epidemic. The rising global prevalence of diabetes underscores the need to explore underlying factors beyond genetics and lifestyle, including the emerging role of gut microbiota in its pathophysiology. The primary aim of this review is to analyze the anti-diabetic efficacy of **Neeradimuthuvallathy Mezhugu (NM)** through the bioactive compounds present in its ingredients, thereby validating its effect in maintainging eubiosis among the gut microbiota. The formulation is a complex mixture of various medicinal plants, each known for their pharmacological effects, particularly in the treatment of diabetes. The review will explore the specific phytochemical compounds found in the key ingredients of NM and assess their potential role in combating hyperglycemia.

DIABETES AND GUT MICROBIOTA

The microorganisms present in the human gastrointestinal system are referred to as microbiota. Its makeup varies greatly during our lives and stabilizes somewhat as we get older. Diet, surroundings, medications and antibiotics taken, and the existence of illnesses all affect its structure [6], [7]. More than 100 trillion bacteria are thought to be present in a single person's gut microbiome, and the quantity varies depending on the part of the gastrointestinal tract, rising from the stomach to the colon [8]. Its estimated mass in an organism is between 1 and 3 kg, and its genetic material has 100 times more genes than the human genome [9], [10]. As previously stated, the makeup of microbiota is highly distinct, but in healthy people, the proportions are rather comparable, with *Firmicutes* accounting for 60% to 80% of the total, *Bacteroidetes* for 20% to 40%, and *Proteobacteria* and *Actinobacteria* for roughly 5% [8], [11]. Eubiosis is the condition in which helpful microorganisms coexist normally [12]. The existence of the microbiota–gut–brain axis, which refers to the two-way communication between the gut microbiota and the brain through the enteric nervous system (ENS), vagus nerve, immune system, neurotransmitters, short-chain fatty acids (SCFAs), and other mechanisms, makes it crucial for our functioning [13], [14]. A disturbance in the makeup and function of the intestinal microbiota is referred to as dysbiosis, and it impairs the body's ability to function [15]. Many recent

research indicates that certain compositional alterations in the gut microbiota may be linked to type 2 diabetes (T2DM). In one of the earliest investigations, Larsen et al. found that the microbiota of T2DM patients had much lower concentrations of the phylum *Firmicutes* and class *Clostridia* than the controls [16]. Microbial dysbiosis was confirmed in T2DM patients the metagenome-wide association study (MGWAS) by Qin et al., which involved 345 Chinese people with or without the disease [17]. Furthermore, studies propose that metformin, a commonly prescribed antidiabetic drug that is marked by a significant increase in the abundance of *Escherichia* species and a decrease in taxa linked to butyrate production, may have some role in changes in the gut microbiome composition in T2DM patients [18]. Studies have also shown that there are many molecular pathways by which dysbiosis contributes to the pathophysiology of type 2 diabetes. Through its effects on insulin sensitivity, inflammation, glucose and lipid metabolism, and gut permeability, the gut microbiota can influence the onset of diabetes. Branched-chain amino acids (BCAAs), bile acids, SCFAs, and LPSs are among the key regulators that can activate the aforementioned effects through a variety of signaling pathways. Recent research has shown the intricate connection between gut microbiota composition and metabolism, with changes in microbial communities linked to the onset and progression of diabetes. Gut microbiota-focused interventions are becoming more and more popular as a possible method of managing diabetes. A number of strategies are being researched to enhance metabolic health by favorably influencing the gut microbial ecology [19].

PHYTOCOMPOUNDS & GUT MICROBIOTA

Recent researches have proved that the phytochemicals present in medicinal plants medicinal systems, vegetables, fruits and natural food substances have a considerable role to play in the maintenance of eubiosis among the Gut Microbiota. The effects of particular flavones, such as chrysin, apigenin, baicalein, and luteolin on the intestinal microbiota were the subject of numerous human and animal investigations. The impact of pure apigenin on the concentrations of the single strain and community of human gut bacteria was investigated by Wang et al. (2017) [20]. In order to investigate the impact of apigenin on individual strains of intestinal bacteria, such as *Enterococcus caccae, Lactobacillus rhamnosus GG, Bifidobacterium catenulatum*, and *Bacteroides galacturonicus*, as well as a fecal inoculum, the growth profiles of the anaerobic bacteria were measured. The human large intestine was replicated in vitro. The results of that investigation demonstrated that, in contrast to other species studied, apigenin successfully inhibited the growth of *E. caccae* and the in vitro-cultured microbial community. Apigenin was found to reduce the ratio of *Bacteroidetes* to *Firmicutes.* The ability of citrus flavanones or citrus fruit-based food products to stimulate the production of short-chain fatty acids (SCFAs), reduce the number of harmful bacteria, and encourage the growth of beneficial microbes (like *Lactobacillus* and *Bifidobacterium* species) is the main focus of research looking at how these substances affect the modulation of gut microflora [21]. According to recent studies, quercetin administration altered the composition of the intestinal ecosystem by significantly increasing the abundance of beneficial *Lactobacillus, Bacteroides, Clostridium,* and *Bifidobacterium* while decreasing the proportion of Enterococcus and *Fusobacterium* [22, 23]. Anthocyanins have the ability to raise the frequency of beneficial bacteria, such as *Lactobacillus-Enterococcus spp. and Bifidobaterium spp.*, both in humans and in vitro [24, 25]. Curcumin treatment changes the composition and variety of intestinal microbiota and restores the function of the gut barrier in rats fed a high-fat diet, according to Feng et al. (2017) [26]. Animals treated with curcumin showed lower loads of pro-inflammatory enterococci and enterobacteria and higher proportions of anti-inflammatory *lactobacilli* and *bifidobacteria* [27]. It is reported in a study that Baicalin, one of the Flavanoids obtained from *Scutellaria baicalensis*, when administered orally in rats, is metabolized to baicalein and Oroxylin A in the intestine by the intestinal bacteria and thereby exhibiting its anti-inflammatory effects [28]. Building on the role of phytocompounds in modulating gut microbiota, these bioactive compounds serve as the foundation for traditional treatments like Siddha medicine in managing diabetes.

SIDDHA TREATMENT FOR DIABETES

Traditional and modern treatment approaches to manage diabetes primarily focuses on regulating blood glucose levels. Medications like metformin, sulfonylureas, and insulin therapy are commonly used. However, these treatments often come with side effects, including gastrointestinal disturbances, weight gain, and potential cardiovascular risks. Due to these challenges, there is a growing interest in exploring Traditional medicines and phytochemicals from natural sources for more effective and safer diabetes management. One such promising

Traditional treatment is the Siddha system of medicine, an ancient medicinal practise in South India, which emphasizes the use of natural herbs and compounds to treat various ailments, including diabetes. Siddha medicines are a blend of herbal ingredients that consists of a number of phytochemicals that safeguard the natural gut microbiota and promote the maintenance of gut eubiosis, supporting overall gut health. Siddha system of medicine consists of a number of medicines for various ailments including polyherbal and herbomineral formulations. 'Madhumegam' is the comparable condition for diabetes in Siddha. Many Siddha formulations such as Madhumega Chooranam, Aavarai Kudineer, Seenthil Chooranam, Abraga Chenduram, Naaval Kottai Chooranam have been the most in practise for diabetes management. Among them, Neeradimuthuvallathy Mezhugu (NM) has gained attention for its potential anti-diabetic properties. The drug Neeradimuthuvallathy Mezhugu (NM) is in practise for hundreds of years and one of its important indications is 'Madhumegam' (Diabetes). The reference for the study drug is taken from Siddha text 'Anubhoga Vaithiya Navaneetham' authored by Abdulla Saibu [29]. This formulation consists of a combination of plant and mineral ingredients, each contributing unique bioactive compounds with potential therapeutic effects.

INGREDIENTS OF NM

The chosen drug Neeradimuthuvallathy Mezhugu (NM) is a Herbomineral Siddha formulation constituting Herbal and Mineral drugs. NM's ingredients are listed in Table 1,and its herbal ingredients,which contain rich phytochemicals, are represented in Figure 1.

RESULTS

The Herbs included in the formulation NM, their phytochemical constituents, and their antidiabetic potential are listed in Table 2.

DISCUSSION

The symbiotic collective community of intestinal microorganisms, which includes bacteria, eukaryotes (primarily yeasts), viruses (primarily phages), archaea, and other microbial species, has developed over thousands of years of joint development and exhibits a complex and reciprocal relationship with humans and animals [93]. Approximately 1014 cells, mostly anaerobes such *Bacteroidetes, Firmicutes, Proteobacteria,* and *Actinobacteria*, are found in the human GI tract despite the existence of other microbial species [94], [95]. The phyla *Firmicutes* (Gram-positive) (such as *Lactobacillales, Clostridiales*, and *Ruminococcus* species) and Bacteroidetes (Gram-negative) (such as *Bacteroides* and *Prevotella* species) comprise over 90% of the microorganisms found in the Gastrointestinal tract of adults. A very small percentage is made up of facultative anaerobic bacteria and other phyla, such as *Actinobacteria* (Gram-positive, including *Bifidobacterium*), *Fusobacteria, Verrucomicrobia* (Gram-negative, including *Akkermansia muciniphila*), and *Proteobacteria* (Gram-negative) [96], [97], [98], [99], [100]. The phytochemical analysis of the ingredients in Neeradimuthuvallathy Mezhugu (NM) reveals a diverse range of compounds with proven anti-diabetic properties. These compounds, through their other pharmaceutical potential such as antioxidant, anti-inflammatory, and antimicrobial effects, contribute to the formulation's potential in managing diabetes. Neeradimuthuvallathy Mezhugu, a Siddha concoction made of medicinal herbs and minerals rich in phytochemicals, has promising anti-diabetic potential, according to the review. Its wide variety of bioactive substances, including flavonoids, alkaloids, and essential fatty acids, exhibit notable hypoglycemic, anti-inflammatory, and antioxidant properties. By addressing oxidative stress, insulin resistance, and hyperglycemia, these characteristics work together to improve its effectiveness in the comprehensive management of diabetes. Neeradimuthuvallathy Mezhugu (NM) represents a valuable alternative in diabetes management, offering insights into the potential of phytochemicals which may alter the composition of the gut microbiota and may become a crucial component of its effectiveness in addressing complex metabolic disorders. By restoring gut eubiosis through the aforementioned wide varieties of natural phytochemical rich ingredients, which is frequently disturbed in diabetes patients, the formulation may help lower inflammation and enhance metabolic processes. This link emphasizes how crucial the gut flora is to the control of

diabetes and how traditional remedies like NM may promote gut health while treating metabolic diseases. Further exploration and validation of such Siddha formulations could contribute to safer, effective, and holistic therapeutic options for diabetes and other chronic conditions.

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Table 1. Ingredients of Neeradimuthuvallathy Mezhugu (NM)

S.NO.	VERNACULAR NAME (TAMIL NAME)	BOTANICAL NAME
01	Serankottai	*Semicarpus anacardium*
02	Purified Neeradimuthu	*Hydnocarpus kurzii*
03	Parangipattai	*Smilax china*
04	Pirappan kizhangu	*Calamus rotang*
05	Karunseeragam	*Nigella sativa*
06	Seeragam	*Cuminum cyminum*
07	Vasambu	*Acorus calamus*
08	Sivanarvembu	*Indigofera aspalathoides*
09	Sanganver	*Azima tetracantha*
10	Karudan Kizhangu	*Corallocarpus epigaeus*

11	Amukkura Kizhangu	*Withania somnifera*
12	Vellarugu	*Enicostemma littorale*
13	Erukkanver	*Calotropis gigantean*
14	Athipattai	*Ficus racemosa*
15	Saranaiver	*Boerhaavia diffusa*
16	Milakaranai Ela	*Toddalia asiatica*
17	Veppam paruppu	*Azadiracta indica*
18	Vetpalai arishi	*Wrightia tinctoria*
19	Ellu	*Sesamum indicum*
20	Neeli samoolam	*Indigofera tinctoria*
21	Purified rasam	*Hydragyrum*
22	Purified Ganthagam	*Elemental Sulfur*
23	Purified thurusu	Copper Sulfate
24	Purified pal thuththam	Zinc Sulfate
25	Nei	*Bos indicus*

Table 2. Phytochemical constituents and Anti-diabetic potential of herbal ingredients of NM

S.No.	Plant Name	Phytochemical Composition	Medicinal Properties/Effects
01	*Semecarpus anacardium*	Bhilwanols, phenolic compounds, biflavonoids, sterols, glycosides. Anacardoside, semecarpetin, nallafl avanone, jeedifl avanone, semecarpufl avanone, gallufl avanone, anacardufl avone, mono-olefi n I, diolefi n II, bhilawanol-A, bhilawanol-B, amentoflavone tetrahydroamentoflavone semicarpol, anacardic acid, tetrahydrobustafl avone, O-trimethyl bifl avanone A1, O-trimethyl bifl avanone A2, O-tetramethyl bifl avanone A1, O-hexamethyl bichalcone A, O-dimethyl bifl avanone B, O-heptamethyl bichalcone B1, O-hexamethyl bichalcone B2, O-tetramethyl bifl avanone C., phenolics. [30]	Antidiabetic [31]
02	*Hydnocarpus kurzii*	Tannins, alkaloids, glycosides, terpenoidsFlavonoids (quercetin, kaempferol), a flavonolignan- Hydnocarpin, phenolic acids (gallic, ellagic), cyclopentenyl fatty acids, sterols[32], [33]	Antidiabetic [34]
03.	*Smilax china*	Steroids, flavonoids, alkaloids, terpenes, fatty esters and saponins [35]	Antidiabetic [36], [37]
04.	*Calamus rotang*	Gallic acid, alkaloids, and saponins carbohydrates, alkaloids, saponins, flavonoids, tannins, and phenolic compounds [38]	Antidiabetic [39]
05.	*Nigella sativa*	Thymoquinone (TQ), thymohydroquinone, thymol, carvacrol, Phellandrene, α-pinene, and β-pineneThymoquinone. thymoquinone, α-phellandrene, thymol, proteins, oleic acid, and carbohydrates, including palmitic acid, oleic acid, linoleic acid, and trans-anethole, Quinones, Phenolics[40], [41]	Antidiabetic [42]
06	*Cuminum cyminum*	Alkaloid, coumarin, anthraquinone, flavonoid, glycoside, protein, resin, saponin, tannin and steroid. alkaloids, coumarins, anthraquinones, flavonoids, glycoside, proteins, resins, saponins, tannins, steroids, dietary fibers, minerals, fats, vitamins, Organic acids, isoflavonoids, luteolin, and apigenin, Cuminaldehyde, cymene, cuminic alcohol (cuminol), γ-terpinene,	Antidiabetic [45]

		safranal, limonene, eugenol, β-myrcene, α-Phellandrene, β-Phellandrene, α- and β-pinene [43], [44]	
07	*Acorus calamus*	Glycosides, phenylpropanoids, sterols, triterpene glycosides, triterpenoid saponins, sesquiterpenoids, monoterpenes, and alkaloids [46], [47]	Antidiabetic [48]
08	*Indigofera aspalathoides*	Flavonoids, tannin, phenol, saponin and sterol, n-butyl ester of nanodecanoic acid, 1-octadecanol, 4- heneicosanone, α-amyrin, n-octacosanol, salicylic acid, β-sitosterol, erythroxydiol X and Y alkaloids, anthraquinones, flavonoids, glycosides, polyphenol, tannins, triterpenes and terpenoids [49], [50]	Antidiabetic [51]
09	*Azima tetracantha*	Indole glucosinolate, flavonoids, acyl-glycosides, piperidine alkaloids (azimine, azcarpine). Steroids, phenolic compounds, tannins, glycosides, saponins, anthraquinones, quinones, proteins [52], [53], [54]	Antidiabetic [55]
10	*Corallocarpus epigaeus*	Alkaloids, flavonoids, triterpenoids, steroids, carbohydrates, proteins and amino acids, saponins, tannins & phenolic compounds, phytosterol, glycosides [56]	Antidiabetic [57]
11	*Withania somnifera*	Alkaloids (somniferine, somnine, etc.), terpenoids, withaniol, somnirol, somnitol. Steroidal flavonoid glycosides, glycowithanolides, steroidal lactones, phenolics, amino acids, chlorogenic acid, glycosides, glucose, tannins, flavanoids[58] [59], [60]	Antidiabetic [61]
12	*Enicostemma littorale*	Flavonoids (quercetin, kaempferol), alkaloids (swertiamarin), glycosides (saponins, flavonoid glycosides) [62], [63], [64]	Antidiabetic [65]
13	*Calotropis gigantean*	Cardiac glycosides, madrine, β-sitosterol, saponins, tannins, alkaloids, flavonoids, Cardenolides, Benzoylinesolone and calotropons. alkaloids, cyanogenic, glycosides, phenolics, tannins 19, cardenolides 20, 21, flavonoids 22, terpenes 23, 24, sterols 25, Proteinases 26 and nonprotein amino acid [66], [67]	Antidiabetic [68]
14	*Ficus racemose [47], [49]*	Flavonoids (quercetin, kaempferol, rutin), phenolic acids (gallic acid, ellagic acid, ferulic acid), triterpenoids. Flavonoids-Bergenin, alkaloids, tannins, glycosides, sterols (β-sitosterol, lupenol, and stigmasterol), Gluanol acetate [69], [70]	Anti-diabetic [71]
15	*Boerhaavia diffusa*	Flavonoids, saponins, proteins, carbohydrates, phenols, alkaloids, glycosides, isoflavonoids. Hydroxybenzoic, Hydroxycinnamic, Acylquinic Acids, and Derivatives, boeravinone B, eupalitin, Isovitexin, kaempferol 3-O-glucoside, Isoquercitrin, Rutin, Fatty Acids, heptanol pentosyl-hexoside, ursolic acid hexuronyl-hexoside. [72], [73], [74]	Antidiabetic [75]
16	*Toddalia asiatica*	Flavonoids (quercetin, kaempferol), polyphenols (gallic acid, ellagic acid, ferulic acid) [76], [77]	Antidiabetic [78]
17	*Azadirachta indica*	Flavonoids, saponins, tannins, reducing sugar, glycosides, terpenoids. azadirachtin, gedunin, and nimbolide), limonoids, nimbolinin, nimbin, nimbidin, nimbidol, sodium nimbinate, Quercetin and ß-sitosterol, polyphenolic flavonoids [79], [80]	Antidiabetic [81]
18	*Wrightia tinctoria*	Flavonoids, alkaloids, saponins, sugars, tannins, steroids, anthraquinones. cycloartenone, cycloartanes, cycloeucalenol besides alpha and beta amyrin, terpene wrightial, oleanolic acid, ursolic acid and the	Antidiabetic [85]

		betasitosterol. Beta amyrin Indigotin, indirubin, tryptanthrin, isatin, anthranillate, and rutin [82], [83], [84]	
19	*Sesamum indicum*	Sesamin, sesamolin, sesamol, sesaminol, anthraquinones, phytosterols [86], [87]	Antidiabetic [88]
20	*Indigofera tinctoria*	bietone, Indirubin, Indican, Flavonoids, Tannins, Phenolics, Saponins, Terpenoids, Anthraquinone, Steroids, Indigo, Alkaloids [89], [90], [91]	Antidiabetic [92]



Fig 1. Herbal Ingredients of Neeradimuthuvallathy Mezhugu (NM)

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RESEARCH ARTICLE

Mapping Research Trends in Technology and Higher Education: A Bibliometric and Meta-Analysis Approach

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ABSTRACT

This study presents a systematic review and meta-analysis of the most influential authors and publishers in academic literature, directed on technology and higher education. Using bibliometric analysis tools such as VOS viewer and SPSS, the study recognizes the top 10 authors and publishers with the utmost citation trends. A total of 712 terms were extracted from article titles, with a minimum occurrence threshold of 5 and a set threshold of 16. After filtering, 15 key terms were analysed to understand dominant research themes. The study also explores year-wise publication trends, revealing a consistent increase in scholarly output. Additionally, Principal Component Analysis (PCA) was employed to identify clusters of research themes, categorizing them into seven primary groups, including higher education institutions, artificial intelligence, technology adoption, student performance, and the impact of COVID-19 on education. The analysis provides valuable insights into emerging trends, dominant research contributors, and potential research gaps, offering a foundation for future studies. These findings are expected to guide researchers, policymakers, and educators in understanding scholarly impact and shaping future research directions in technology and higher education.

Keywords: Bibliometric Analysis, Meta-Analysis, VOS viewer, SPSS, Citation Analysis, Top Authors, Top Publishers, Technology, Higher Education, Research Trends

INTRODUCTION

Academic research impact is frequently measured through citation trends, reflecting the influence and reach of authors and publishers. This study aims to systematically analyze the most influential contributors in scholarly literature in the fields of technology and higher education using bibliometric tools such as VOS viewer and SPSS. By leveraging these analytical techniques, this study identifies key authors and publishers with the highest citation impact, offering a comprehensive overview of the leading research contributions. Additionally, this study examines year-wise publication trends to track the evolution of research activity in technology and higher education. A dataset of 200 research articles sourced from Scopus was analysed to determine patterns in scholarly output. Principal Component Analysis (PCA) was employed to categorize research themes into distinct clusters, revealing emerging trends and thematic interconnections. To deepen the investigation, meta-analysis and text mining techniques were applied to identify research gaps and potential areas for future exploration. By systematically mapping existing literature, this study highlights underexplored topics, methodological advancements, and opportunities for interdisciplinary research. The dataset shows an increasing trend in publications over recent years, indicating a growing interest in technology and higher education research. Meta-analysis is a statistical approach used to systematically collect and assess the findings of previous studies. In the context of this study, it helps identify key advancements and areas that require further research in higher education and technology. It involves the quantitative synthesis of results from multiple studies to assess their overall impact. Evaluating the diversity of research contributions across various studies. Enhancing the reliability of findings by integrating different academic insights. SPSS Tools for Meta-Analysis Effect Size Calculation Measures the impact of individual studies. Assesses variability among different studies. Publication Bias Assessment uses funnel plots to identify over- or underrepresented studies. SPSS for Bibliometric Analysis SPSS (Statistical Package for the Social Sciences) is a powerful tool for conducting statistical analysis in bibliometric research. It is useful for Analysing co-authorship networks and citation patterns. Identifying research clusters using Principal Component Analysis (PCA)**.**Applying factor analysis to categorize related research topics. Examining the relationship between citation impact and publication frequency through correlation analysis**.** VOS viewer for Bibliometric Visualization is a specialized software used to visualize bibliometric relationships. In this study, it is applied in the following ways mapping co-authorship networks to analyse collaboration patterns. Building citation networks to identify influential research articles. Detecting keyword co-occurrences to highlight major research topics. Examining institutional and regional collaborations in academic publishing. Bibliometric Analysis provides a quantitative assessment of research impact, focusing on Citation Analysis identifies the most influential authors, publications, and publishers. Co-Word Analysis Examines keyword relationships to detect research trends. Co-Authorship Analysis collaboration patterns among researchers

Year-Wise Publication Trend

This chart shows the year wise data of the author from 1995 to 2024, in this observation the number of publication remain low until 2015 and then its start increasing in 2016 with the number 09 authors from 2021 to 2023it remained stable around 21 author. In the year of 2024 drop to 4 authors, this trend shows growing interest after 2016with high

Top 10 Authors with Highest Citation Trends

C. Gouedard leads with the highest impact with 446 citation followed by S. Liu and V. Kuleto. All top 10 authors have over 130 citation, where its shows the strong influence and recognition in research area.

Top 10 Publishers with Highest Citation Trends

Sustainability (Switzerland) ranked first with 710 citation, where it's showing the highest impact among the publishers. Followed by the international journal of greenhouse gas control with 468 citation.

There are 712 terms available from the title. The threshold is 16, with a minimum occurrence of 5.

LITERATURE REVIEW

Nguyen, T., & Pham, H. (2025): This study analyses the role of mobile learning in promoting collaborative learning environments, highlighting its effectiveness in facilitating peer interaction and knowledge sharing. **Lee, K., & Park, S. (2025):** This research examines the challenges and opportunities of implementing mobile learning in higher education, providing a comprehensive analysis of technological, pedagogical, and institutional factors. **Garcia, P., & Martinez, R. (2025):** Exploring faculty perceptions of mobile learning, this study identifies key barriers and facilitators to the adoption of mobile technologies in university teaching. **Alyahya, M.A**."E-Learning Experience in Higher Education amid COVID-19 **Pedraja-Rejas L *et al.*(2024):** This systematic review explores the relationships between mobile learning, learning outcomes, and the development of critical thinking in university students, analysing empirical articles published between 2015 and May 2024. **Romero-Rodríguez, *et al.*(2024):** This study presents a systematic literature review of mobile learning, discussing its potential to digitally transform teaching and learning processes in higher education. **Alrasheedi, M *et al*.(2024):** An empirical study exploring management's perspective on critical success factors for mobile learning in higher education institutions, highlighting the significance of university commitment and change management practices.

Ali *et al*. (2024): This paper discusses the development of an intelligent mobile Outcome-Based Education (OBE) system in higher learning institutions, aiming to enhance teaching and learning performance monitoring. **Denoyelles *et al*. (2023):** This research analyzes the evolving landscape of students' mobile learning practices in higher education, highlighting the impact of the pandemic on mobile device usage for learning. **Wu, L., & Parker, B. (2021):** The Effectiveness of Flipped Classrooms: A Meta-Analysis of Higher Education Research. **Johnson P & Lee M (2023):** This study provides an in-depth analysis of artificial intelligence applications in higher education, emphasizing the impact of AI-driven tutoring systems on student learning outcomes and engagement levels. The findings reveal the potential of AI to personalize education and address learning gaps effectively. **Williams R & Chen L (2022):** Their research focuses on the role of gamification in digital learning environments within universities. The study found that incorporating game-based elements significantly enhances student motivation and knowledge retention. **Romero-Rodríguez *et al.* (2021):** This study presents a systematic literature review of mobile learning, discussing its potential to digitally transform teaching and learning processes in higher education. **Patel, R., & Anderson, C. (2022):** The Role of Big Data in Higher Education: A Bibliometric Analysis. **Martinez C & Roberts (2020):** This study explores the impact of virtual reality in STEM education, demonstrating how immersive technologies can improve conceptual understanding and practical skills in science and engineering disciplines.

Harris B & Stewart E (2019): Investigating the role of mobile learning in higher education, their research highlights the increasing adoption of smartphones and tablets as primary learning tools, promoting accessibility and flexibility in education. **Alrasheedi, M *et al*.(2018):** An empirical study exploring management's perspective on critical success factors for mobile learning in higher education institutions, highlighting the significance of university commitment and change management practices. **Kim Y & Patel R (2018):** This paper analyzes the role of big data analytics in enhancing decision-making processes within universities, illustrating how institutions leverage data-driven insights to improve student success and institutional efficiency **Alrasheedi, M., &Capretz, L. F. (2018):** This meta-analysis identifies critical success factors affecting mobile learning adoption in higher education, emphasizing the importance of user-friendly application design and ubiquitous learning opportunities. **Sharma, M.** "Factors influencing cloud computing adoption for higher educational institutes in India: A fuzzy AHP approach **Mitchell, G., & Carter, S. (2018):** Personalized Learning in Higher Education: Research Trends and Future Directions. **Dawson, E., & Miller, N. (2019):** Internet of Things (IoT) in Universities: Research Mapping and Trends.

OBJECTIVES

1. To analyse year-wise publication trends in technology and higher education.

2. To identify the top 10 most influential authors based on citation counts.
3. To determine the top 10 publishers with the highest citation trends.
4. To explore research gaps using meta-analysis and text mining.

METHODOLOGY

This study employs a quantitative research design with a bibliometric and statistical approach to analyse trends in higher education selection influenced by technology and social media. The research integrates bibliometric analysis, statistical modeling, and meta-analysis to identify key patterns, relationships, and research gaps in the field. The study utilizes secondary data collected from the Scopus database, which is a widely recognized source for high-quality academic publications. The data collection process follows these steps: A total of 200 records were retrieved based on relevance to higher education selection, social media influence, and technological impact.

Filtering Criteria
Records were refined based on citation trends, publication details, and availability of author and publisher information.

Keyword and Author Thresholds
A minimum occurrence threshold was set at 2 for authors and 5 for terms in titles, ensuring that frequently occurring concepts and influential authors were prioritized in the analysis. The study applies a combination of bibliometric visualization, statistical analysis, and text mining techniques:

VOS viewer
Used to construct and visualize bibliometric networks, such as co-authorship, keyword co-occurrence, and citation relationships.

SPSS
Applied for descriptive statistical analysis and Principal Component Analysis (PCA) to identify key factors influencing higher education choices/

Meta-Analysis & Text Mining
Conducted to synthesize previous research findings and extract emerging themes, helping to identify future research gaps in the domain.

Data Collection
- The study retrieved 200 records from the Scopus database.
- Records were filtered based on citation trends, publication details, and availability of author and publisher information.
- A threshold of a minimum occurrence of 2 was set for authors and 5 for terms in titles.

Data Analysis Tools
- ✓ **VOS viewer**: Used for visualizing bibliometric networks.
- ✓ **SPSS**: Applied for statistical analysis and principal component analysis (PCA).
- ✓ **Meta-Analysis & Text Mining**: Employed to identify future research gaps.

RESULTS AND DISCUSSION

Principal Component Analysis (PCA) and Cluster Analysis
The PCA analysis identified the following key research clusters:

Cluster 1: Higher education institutions, performance.
Cluster 2: Challenges, COVID-19, and higher education.
Cluster 3: Case studies, higher education institutions.
Cluster 4: Adoption, factors, university research.
Cluster 5: Artificial intelligence, factors, and universities.
Cluster 6: Effects, students, technology.
Cluster 7: Research impact.

SUGGESTION

Clustering outcomes are highly sensitive to the threshold parameters set during the analysis. For instance, in hierarchical clustering, adjusting the similarity or distance threshold can significantly alter the number and composition of clusters. A lower threshold might produce more clusters by distinguishing smaller variations between data points, while a higher threshold could merge groups that may otherwise be distinct. In density-based clustering methods, such as DBSCAN, modifying parameters like the minimum number of points or the radius can lead to the identification of different cluster structures. Different statistical and machine learning software packages use distinct algorithms, optimization techniques, and default settings, which can impact clustering results. For example, SPSS, Python (Scikit-learn), and R might implement k-means clustering with slight variations in centroid initialization, convergence criteria, or distance calculations. Even when using the same clustering algorithm, the underlying mathematical computations or default parameters in one software might not align precisely with another, leading to variations in the number and structure of clusters. The choice of algorithm plays a crucial role in determining clustering patterns. K-means clustering, for example, assumes spherical clusters and requires pre-specification of the number of clusters, which can influence the results based on the chosen value. In contrast, hierarchical clustering does not require a pre-defined number of clusters but is sensitive to linkage methods (e.g., single-linkage vs. complete-linkage). Similarly, density-based clustering (DBSCAN) identifies clusters of varying densities but may struggle with detecting clusters of different shapes in high-dimensional data. Thus, selecting an appropriate clustering method based on the dataset's characteristics is essential to achieving meaningful results. The number of publications analysed in the study directly impacts the clustering outcomes. A larger dataset may reveal more distinct patterns, leading to a greater number of clusters, whereas a smaller dataset may result in fewer clusters due to limited variations. Additionally, the inclusion or exclusion of certain publications could shift the focus of the analysis, thereby changing how clusters are formed. Expanding the dataset over time or across different sources might introduce new themes or perspectives, further influencing clustering outcomes.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

This study provides an insightful analysis of the most influential authors and publishers in research literature related to technology and higher education, based on citation trends and bibliometric analysis. By examining citation patterns, co-authorship networks, and publishing trends, the study identifies key contributors, leading institutions, and emerging areas of research within this domain. The findings highlight dominant scholars and institutions shaping the field, as well as notable shifts in research focus over time. The results from Principal Component Analysis (PCA) reveal distinct thematic clusters that define the current research landscape, indicating how different subfields within technology and higher education are evolving. These insights contribute to a better understanding of knowledge dissemination and scholarly impact in the field. Future research could delve deeper into unexplored areas by employing advanced text mining techniques such as natural language processing (NLP) and machine learning algorithms. Investigating research gaps and identifying underrepresented topics could help shape future scholarly discourse. Additionally, incorporating more advanced bibliometric indicators—such as co-citation analysis, keyword co-occurrence, and author collaboration networks—could provide a more comprehensive perspective on

global academic trends. Further exploration of interdisciplinary collaborations and cross-institutional research patterns may also enhance the understanding of how knowledge flows across different academic domains.

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Table:1 Top 10 Authors with Highest Citation Trends

Rank	Author Name	Citations
1	C. Gouedard	446
2	S. Liu	338
3	V. Kuleto	274
4	M. Valenti	178
5	P. Borm	161
6	R. Hasan	155
7	N. Fukugawa	140
8	A. Gunasinghe	136
9	P. Westhead	130
10	R. Bucea-Manea-Țoniș	130

Table: 2 Top 10 Publishers with Highest Citation Trends

Rank	Publisher	Citations
1	Sustainability (Switzerland)	710
2	International Journal of Greenhouse Gas Control	468
3	Vadose Zone Journal	338
4	Interactive Technology and Smart Education	197
5	Education and Information Technologies	192
6	Journal of Materials Chemistry A	178

7	British Journal of Educational Technology	168
8	Inhalation Toxicology	161
9	International Journal of Sustainability in Higher Education	154
10	Technological Forecasting and Social Change	145

Table: 4 Extraction Method: Principal Component Analysis.

Total Variance Explained									
Component	Initial Eigen values			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.244	14.961	14.961	2.244	14.961	14.961	2.069	13.796	13.796
2	2.149	14.325	29.285	2.149	14.325	29.285	1.754	11.696	25.492
3	1.807	12.044	41.329	1.807	12.044	41.329	1.663	11.086	36.578
4	1.543	10.284	51.613	1.543	10.284	51.613	1.582	10.550	47.128
5	1.254	8.360	59.973	1.254	8.360	59.973	1.455	9.700	56.827
6	1.112	7.416	67.389	1.112	7.416	67.389	1.303	8.686	65.513
7	1.013	6.752	74.141	1.013	6.752	74.141	1.294	8.628	74.141
8	.884	5.892	80.034						
9	.649	4.329	84.362						
10	.605	4.036	88.398						
11	.544	3.625	92.024						
12	.479	3.191	95.215						
13	.415	2.765	97.980						
14	.303	2.020	100.000						
15	-2.292E-16	-1.528E-15	100.000						

Table: 5 Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 14 iterations.

Rotated Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
adoption	-.125	-.017	-.273	.708	-.036	-.195	-.246
artificial intelligence	.250	-.011	-.290	-.324	.730	-.020	-.179
case	.167	.242	.769	-.057	.012	-.226	-.119
challenge	.283	.590	-.146	.217	.291	.227	-.318
covid	-.129	.753	.128	-.177	-.169	-.138	-.096
effect	-.064	-.034	-.247	-.230	-.593	.175	-.178
factor	.123	-.088	.141	.797	.067	-.006	.168
hei	.037	-.193	.807	.012	.027	.158	-.049
higher education	-.216	.671	-.115	-.028	.378	-.066	.320
higher education institution	.811	-.320	.086	-.124	.112	-.021	-.146
impact	-.017	-.028	-.128	.017	-.009	.072	.899
performance	.511	-.210	-.269	-.277	-.516	-.058	.230
student	-.263	-.199	-.025	-.062	-.138	.829	.007
technology	-.760	-.097	-.178	-.237	-.092	.123	-.020
university	-.482	-.293	-.045	.233	-.006	-.610	-.172

Table:6

Rotated Component Matrix[a]							
Component							
	1	2	3	4	5	6	7
adoption				0.708			
artificial intelligence					0.730		
case			0.769				
challenge		0.590					
covid		0.753					
effect						0.175	
factor				0.797			
hei			0.807				
higher education		0.671					
higher education institution	0.811						
impact							0.899
performance	0.511						
student						0.829	
technology						0.123	
university				0.233			
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.							
a. Rotation converged in 14 iterations.							

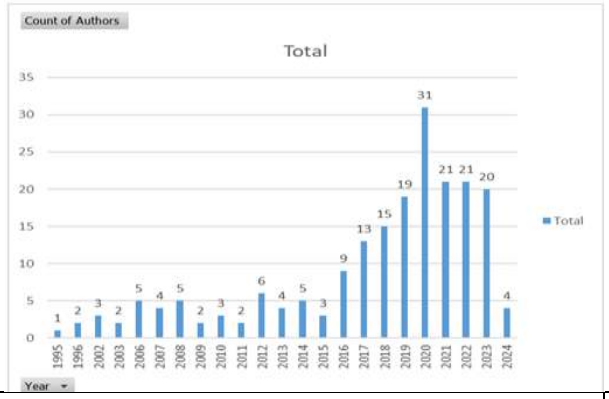


Fig :1 Year-Wise Publication Trend

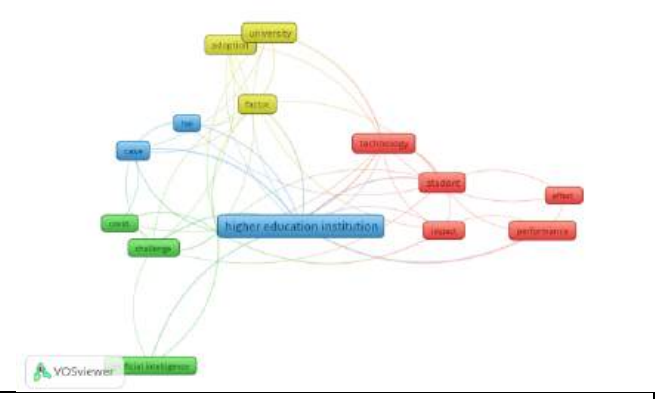


Fig: 2 Top 10 Publishers with Highest Citation Trends

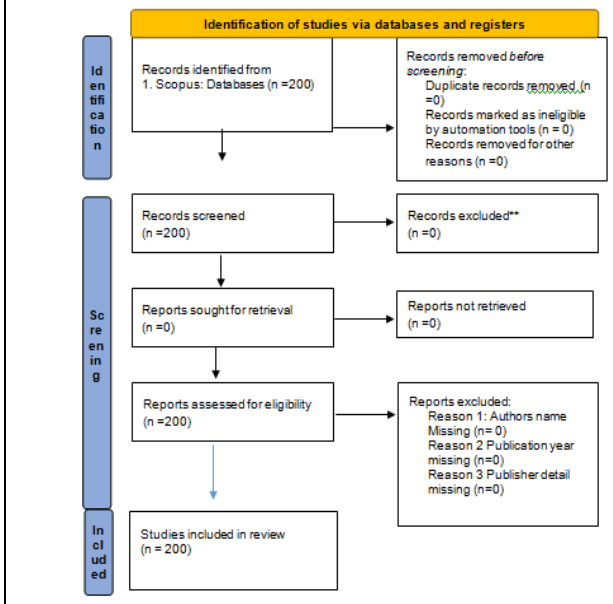

Identification of studies via databases and registers
Identification
Records identified from
1. Scopus: Databases (n =200)
Records removed *before screening*:
Duplicate records removed (n =0)
Records marked as ineligible by automation tools (n = 0)
Records removed for other reasons (n =0)
Screening
Records screened
(n =200)
Records excluded**
(n =0)
Reports sought for retrieval
(n =0)
Reports not retrieved
(n =0)
Reports assessed for eligibility
(n =200)
Reports excluded:
Reason 1: Authors name Missing (n= 0)
Reason 2 Publication year missing (n=0)
Reason 3 Publisher detail missing (n=0)
Included
Studies included in review
(n = 200)

Fig: 3

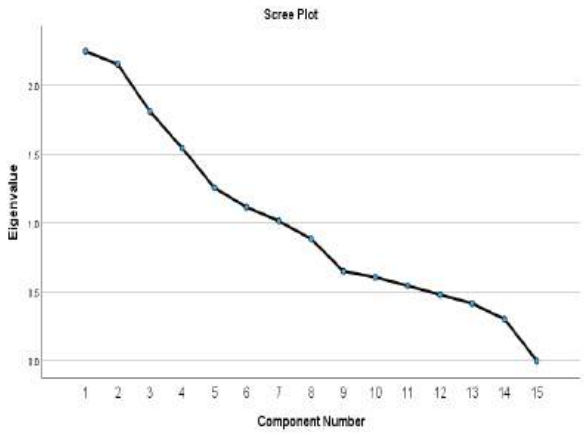

Scree Plot
Eigenvalue
2.0
1.5
1.0
.5
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
Component Number

Fig: 4

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RESEARCH ARTICLE

Predicting the Cause of Vitamin D Deficiency on Thyroid and Autoimmune Disorders using Machine Learning Classifiers

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ABSTRACT

In recent days, the role played by Machine Learning (ML) algorithms is inevitable in the diagnosis and classification of various human diseases. It has shown encouraging results in early detection of any disease. Thyroid illness and Vitamin D Deficiency (VDD) are major global health issues and there is a great need to forecast their severity. Keeping this in mind, this work aimed to apply ML techniques/algorithms to predict the cause or impact of vitamin D on thyroid disorders [1]. The data for this study has been sourced from the UCI (UC Irvine Machine Learning Repository) data Repository. Two datasets, namely (i) 25OHD & TSH and (ii) Hypothyroid, were used in this investigation. The research attempts to detect vitamin D insufficiency and demonstrate its involvement in causing thyroid disease with the aid of more classifiers of ML and their comparative assessment. The analysis includes present classifiers such as Random Forest (RF), Support Vector Machine (SVM), and the Synergized Hybrid Random Vector Classifier (SHRVC) – the proposed hybrid classifier. A number of criteria, including F1-score, accuracy, sensitivity, specificity, and precision, are used to evaluate the effectiveness of these algorithms. The results show that with 98% accuracy for both datasets and by performing strongly for the trained and tested data, the proposed SHRVC classifier outperformed the SVM and RF classifiers.

Keywords: Vitamin D Deficiency (VDD), Hypothyroid, SVM, RF, SHRVC, Classification.

INTRODUCTION

One of the most threatening health issues of today is the deficiency of Vitamin D in which millions of individuals worldwide suffer. Researchers worldwide made some works and suggested a potential association among vitamin D deficiency and thyroid conditions, raising the probability that low vitamin D level may significantly affect thyroid health. This study thus focuses on applying the algorithms of ML to forecast the risk of vitamin D insufficiency and its impact on thyroid health using data, as there are currently no such predictive tools available for this purpose as far as the authors are concerned [2]. Vitamin D, a steroid hormone, has historically been associated with the metabolism of phosphorus and calcium. The discovery of its receptor's pleiotropic expression and the enzymes that play a role in its metabolism has prompted investigations into its additional functions. Numerous studies have explored vitamin D's impact on autoimmune diseases, particularly autoimmune disorder affecting the thyroid. Current findings predominantly highlight a connection between vitamin D deficiency and an increased risk of developing, or having higher antibody levels associated with, Hashimoto's thyroiditis, Graves' disease, and postpartum thyroiditis. However, some reports contradict these associations, making it challenging to reach a consensus [3]. It remains uncertain whether the above said connection represents a underlying mechanism, a causal link, or an outcome in the process of autoimmunity. Numerous studies examining the correlation among genetic variations in vitamin D and autoimmune thyroid illnesses have frequently yielded conflicting findings. However, recent research has revealed a significant inverse relationship involving thyroid-stimulating hormone (TSH) concentrations and 25-hydroxyvitamin D (25OHD) levels, intending to provide a possible for them. This finding recommends to state that the insufficient vitamin D levels might play a role in, or exacerbate thyroid-related conditions, emphasizing the importance of assessing the level of D vitamin status for the appropriate management and prevention of thyroiditis disorders [4]. The present study seeks to expand on these findings by using a machine learning model to forecast vitamin D insufficiency and investigate its influence on thyroid classification. Machine learning is an emerging trend that is promptly gaining momentum in the medical sector, particularly for disease prediction and classification. This study uses ML techniques for predicting vitamin D insufficiency and its impact on thyroid disorder classification. By analyzing a large dataset that includes TSH levels and 25OHD, the study aims to develop a model which will accurately predict the autoimmune disorder thyroiditis and highlight potential warning signs for medical professionals. The focus is on developing a classification model using these techniques to predict thyroid disease based on vitamin D deficiency and other relevant factors. Ultimately, the study aims to elucidate the complicated relationships among vitamin D deficiency and thyroid health, informing improved diagnostic and therapeutic strategies through advanced computational tools and comprehensive data analysis [5]. The current need of the medical industry to diagnose any disease at an earlier stage necessitate in developing self-regulating smart systems for it [6] and henceforth the present problem is not an exception for it. The prediction and classification with ML tools can be implemented by integrating the vast patient data available in the healthcare industry. The prevalence of certain diseases could be reduced and avoided in some cases by handling and effectively processing the extensive data available in the medical databases. This will enable healthcare professionals to more efficiently and rapidly predict illnesses and suggest diagnoses.

LITERATURE REVIEW

This paper highlights some literature reviews on thyroid disease prediction using various approaches and some literature reviews on various models forecasting numerous illnesses by efficiently applying ML techniques and the application of ML methods in health care sector, because as far as the knowledge of the authors are concerned, the presently taken problem of identifying the association of 25-OHD serum Vitamin D and the Thyroid Simulating Hormone (TSH) is a novel problem under Machine Learning Domain and hence there is no existing literature review specifically available for addressing this problem. This section reports a list of literatures on the problem of identifying the impact of vitamin D on thyroid and autoimmune diseases and the use of ML domains in healthcare sectors. A systematic review was carried out by Maciejewski et al [7] to elucidate the possible connection between thyroid cancer risk and gene variations related to Vitamin D. A comprehensive analysis of studies on the Calcitriol

receptor polymorphisms was included in the review; however, the results were equivocal and did not provide compelling evidence that these genetic variants were linked to an elevated risk of thyroid cancer. On the other hand, correlations between particular SNPs(Single Nucleotide Polymorphism) in the VDR gene and a higher risk of medullary thyroid carcinoma (MTC) have been discovered. To confirm these results and get a deeper understanding of the involvement of Vitamin D-associated genes in the development and progression of thyroid malignancy the scientists have decided to look for additional research in this arena. Thyroid autoimmunity shown by Liu et al [8] to identify it's significant impact on embryo quality during in vitro fertilisation (IVF). Regardless of thyroid autoimmune illness, they also found a relationship between follicular concentrations of D_Vitamin & Nuclear receptor regulation of Vitamin_D3 in granulosa cells. Fluctuating vitamin D concentrations and thyroid activity throughout pregnancy were investigated by Wang et al [9]. The significance of sufficient D_Vitamin levels for thyroid health was demonstrated in accordance with their discovery of a positive link between optimal vitamin D levels and fT3 (Free Triiodothyronine), fT4 (Free Thyroxine) and TSH in the first and third trimesters, respectively. But, they concluded that further research is required, as the study's limitations were made clear.Chen et al [10] utilized machine learning techniques to predict cardiac conditions. After comparing several models such as DecisionTree, RandomForest, LightGBM, and LogisticRegression—they discovered LightGBM was the most successful, obtaining an accuracy of 76.9%. According to the study, ML possesses the capability to serve as an effective aid in healthcare for the early identification and therapy of cardiac disorders. LightGBM appears to have the greatest promise for enhanced prediction. Balaji *et al.* [11] explored MLT to predict liver disease, aiming to improve the accuracy of detection and the standard of healthcare. They utilized a collection of techniques including Classification Trees, ANNs, KNNs and support vector classifiers. The analysis discovered that different methods varied in several known factors namely, sensitivity, accuracy, and precision. But drawbacks such as poor performance on big datasets and difficulties gathering data in real time have also been pointed out. The results demonstrated the usefulness of the suggested algorithms to detect liver disease at an earlier stage. The effectiveness of ML approaches and autonomous pipelines in identifying Alzheimer's Disease (AD) was investigated by Shukla *et al* [12]. They discovered that these techniques classified classes into single and binary categories with above 95% accuracy. Preprocessing, multi-class categorization, registration, and other difficulties were also mentioned.

The study highlighted the promise of cutting-edge machine learning techniques by evaluating several biomarkers and classification strategies in addition to identifying efficient AD detection methods. Kadhim *et al* [13] investigated machine learning models with the goal of increasing diagnostic accuracy for early-stage COVID-19 prediction. They discovered that algorithms with high precision—98.0% to 99.5% accuracy rates—such as Random Forest and K-Nearest Neighbour can forecast COVID-19. Model performance was enhanced by strategies like the Synthetic_Minority_Over_Sampling_Technique (SMOTE) and Filter Based FSTs Kishore *et al* [14] carried out a work to evaluate various ML algortihms for predicting diabetes, using a range of these algorithms which are generally performed in ML arena. Among them, the RF algorithm achieved the maximum predictive precision for assessing diabetes risk levels, primarily due to its robust handling of complex data structures. The study also pointed out the limitations of other approaches, such as genetic programming and noted that alternative models like Artificial Neural Networks and Fuzzy-Based Systems were less effective compared to machine learning techniques in predicting diabetes. Raj *et al* [15] investigated machine learning algorithms that use medical history, age, gender, smoking behaviours and other characteristics and predicted lung cancer with 95% accuracy. Although they acknowledged the need for more validation in clinical settings, they emphasised their potential for early diagnosis. This study's purpose was to fine-tune ML models for clinical use and to discover important predictive features. Chen *et al* [16] predicted new-onset post-stroke depression (PSD) using XGBoost machine learning methods. Finding clinical characteristics for early diagnosis in high-risk individuals was the study's main goal. The models exhibited drawbacks, including different sensitivities and specificities, even if they were useful in identifying patients who were at risk. In order to build and validate machine learning models that potentially enhance clinical outcomes for stroke patients at risk of acquiring PSD, the authors emphasised the significance of real-world data. Peng *et al*. [17] devised an XGBH (eXtreme Gradient Boosting with Hybrid features) computational intelligence framework to improve the estimation of heart-related condition risks by concentrating on essential factors like age, arterial pressure, and lipid levels. The model demonstrated superior accuracy compared to traditional methods, allowing for earlier identification and

intervention for individuals at high risk. Future prospective studies across diverse populations are required to assess the framework's practicality and dependability in real-world medical environments. On viewing the various studies in the health care sector, it is clearly seen that the ML models could be effectively used for the identification or prediction problems in health care arena. With this insight, the authors have used the existing ML models and also developed new hybrid models for determining the impact of Vitamin D on Thyroid and autoimmune disorders.

PROPOSED APPROACH

This section describes the research approaches used to look at how thyroid illnesses are affected by vitamin D deficiency. The experimental strategy focuses on key risk variables and methods for predicting vitamin D deficiency and determining how it relates to thyroid conditions. Data is gathered at the start of the process using datasets from the UCI Machine Learning Repository.

Collection of Data

In this research, two open source datasets were used to examine the impact of several factors on thyroid health. There are 433 samples from both male and female respondents in the first dataset, which is referenced in [18]. There are nine components to it, including laboratory tests (such as 25-hydroxyvitamin D (25OHD) levels and thyroid-stimulating hormone (TSH) levels) and patient demographics (weight, height, sex, age, and season of data collection). Another one is taken from the UCI Machine Learning Repository available on Kaggle database [19]. This dataset includes 3,772 cases with 28 variables, including age and sex, medical history, and treatment status indicators such as taking thyroxine, querying thyroxine, and querying hypothyroid. It offers an extensive synopsis of thyroid-related variables, facilitating an in-depth examination and modeling of hypothyroidism.

Dataset and Attributes

Table – I provides an overview of key features in a medical dataset related to vitamin D (25OHD) and thyroid health (TSH). It includes patient demographics, such as a unique Patient identifier, Weight, Height, and BMI - which is calculated from height and weight. The dataset also includes sex (in which the value of 1 indicates male and 2 indicates female) and Age in years. Season represents the time of year during which data was collected. Important health indicators include 25OHD, measuring vitamin D levels, and TSH, indicating Thyroid-Stimulating Hormone levels, both of which are crucial for understanding thyroid function. Finally, the Classification feature is a binary target variable, with 0 indicating no disease and 1 indicating the presence of a disease, which is useful for disease prediction and classification The above dataset described in Table - II lists numerous characteristics from a medical dataset pertaining to thyroid conditions and therapies. It contains information on the patient's age (0 to 92 years) and sex (0 = female, 1 = male). The patient's condition and course of therapy with regard to their thyroid include whether they are taking antithyroid or thyroxine medication, whether they have had thyroid surgery, and whether they have had I131 treatment (radioactive iodine). It also contains markers of the patient's health, such as whether they are ill, pregnant, or suffering from psychological disorders, goitre, tumours, or hypopituitarism. The table includes detailed medical questions on thyroid conditions, including hyperthyroidism and hypothyroidism, as well as whether or not certain indicators or hormones, such TSH, T3, TT4, T4U, and the Free Thyroxine Index (FTI) were assessed. The use of lithium is also mentioned.

Data Pre-Processing

For the pre-processing of data, both 25OHD & TSH and hypothyroid datasets are loaded using pandas, and missing values indicated by '?' are replaced with NaN in order to standardize the handle the missing value of any data carefully. In 25OHD & TSH dataset, missing values in numerical columns such as 'Patient', 'Weight', 'Height', 'BMI', 'Age', '25OHD', and 'TSH' are replaced with the mean, while categorical columns like 'sex', 'season', and 'class' are filled with the most frequent value to maintain consistency. Similarly, in the hypothyroid dataset, missing values in numerical columns such as 'age', 'TSH', 'T3', 'TT4', 'T4U', and 'FTI' are replaced with the mean, and categorical columns such as 'sex', 'on thyroxine', and 'referral source' are filled with the mode. For both datasets, the features (X) – 'Patient', 'Weight', 'Height', 'BMI', 'Age', '25OHD', and 'TSH' for the 25OHD & TSH dataset, and those features which are represented in Table-II for the hypothyroid dataset – are separated from the target variable (y). The

25OHD & TSH dataset uses 'class' as the target, while the hypothyroid dataset uses 'binary Class'. Categorical features in both X datasets are converted to numerical format using Label Encoder to ensure compatibility with machine learning algorithms. Finally, both datasets are divided into training and testing sets using an 80-20 split to prepare for model assessment.

Balancing the Dataset

Balancing the data addresses the challenge posed by imbalanced datasets, in which the performance of the model may be biased due to unequal distribution of classes. This study employed SMOTE approach to create mock examples of the minority class in the training set, resulting in a more balanced dataset. The SVM and Random Forest classifier were configured to adjust weights according to class frequencies, ensuring that the model adequately considered the minority class during training. Training on these balanced data enhances the model's capability to correctly forecast both categories, leading to fairer and more balanced outcomes. This method is applied to both the 25OHD, TSH and Hypothyroid datasets [20]. The figures illustrate the distribution of the target variables after applying re-sampling techniques to address the imbalanced datasets. The first figure, Fig. 1 shows the allocation of the "CLASSIFICATION" variable in the 25OHD & TSH dataset, and the second figure, Fig.2 shows the allocation of the "binary Class" variable in hypothyroid dataset. Both figures depict the frequencies of the target classes (0 and 1) after re-sampling, where SMOTE approach was employed to make stability over the dataset by generating synthetic examples of the underrepresented class. The even bars for both classes 0 and 1 in both figures indicate that after re-sampling, the datasets have equal numbers of samples for both classes, which resolves the issue of class imbalance. This balanced dataset ensures that ML models, like SVM, and Random Forest do not prefer the majority class and could effectively discover to predict both classes accurately, leading to improved and fairer model performance.

Histogram graph of the Dataset

A distribution chart of the dataset's features is employed to evaluate the data spread. This visualization helps to see if the values are evenly spread. As illustrated in the Figures, Fig. 3 and Fig. 4, the histogram shows that the data spread is uniformly Scattered [20]. The histograms display how features are spread out in the dataset, providing a brief summary of how the data is distributed. In Fig. 3, for the first dataset, the 'patient' which represents the ID of patients, showed a uniform distribution, 'weight' and 'BMI' followed a bell-shaped, normal pattern. 'Sex' and 'Height' exhibited clustered distributions and age was slightly skewed. '25OHD' and 'TSH' levels had skewed distributions and were concentrated around lower values. And in Fig. 4, for the 2nd dataset, binary features such as thyroxine, sick, and others show that most patients fall into the "no" category. Hormone levels such as TSH, T3, and FTI vary, with some concentrated and others spread. In both datasets, the target variables, 'Classification' and 'Binary Class' are binary, showing whether a condition is present or absent. This visualization helps in understanding the distribution, skewness, and balance of preprocessing.

MACHINE LEARNING

The capability to create systems that can learn from existing data is achieved with this subfield of AI. This could also make predictions about future events based on past experiences. The objective of ML is to build models by training them on a dataset to recognize patterns and make predictions. In this context, the present aim is to create and deploy a ML model that can predict thyroid illness based on levels of Vitamin D deficiency. The process involves using ML algorithms to uncover underlying trends within the data. The dataset has been preprocessed to address any missing values and ensure its cleanliness. The accuracy of the models is then evaluated by testing them on the dataset to assess their effectiveness in predicting thyroid disease [21].

SUPERVISED LEARNING

This is a category of ML in which algorithms are developed on extensive datasets containing input variables and their associated labeled outcomes. The system to infer patterns from the data and generate predictions or projections based on new unseen inputs. Supervised learning encompasses two main types: classification and regression. Classification entails forecasting categorical outputs, whereas regression emphasizes estimating continuous numerical values [21].

CLASSIFICATION

Classification is the method of splitting information among categories according to the relationships between different data values. In this case, categorization was used to predict thyroid issues based on the degree of vitamin D insufficiency. Although there are enormous techniques of ML available, the approach presented can utilize any of the following models or methodologies. This study employed widely-used classification algorithms listed earlier and also developed a novel synchronized hybrid random vector classifier (SHRVC) to forecast the objective [22].

Implemented Models

In implementation, three classification algorithms are used. They are as followed.

Support Vector Machine – SVM

It is a supervised learning method widely exploited for categorization processes. This generally operates with the process of identifying the finest decision boundary, or hyperplane plane, which distinguishes various classes in an n-dimensional space. The nearest points to this boundary are called support vectors, which give the algorithm their name. SVMs are extensively utilized in tasks like facial recognition, image identification, and text classification. In this study, SVM has been applied for its efficacy in handling high-dimensional data and preventing overfitting. The RBF kernel had been used to capture nonlinear patterns with hyperparameters optimized via grid search and cross-validation [23].

Random Forest Classifier

This classifier is considered as a combined learning strategy derived from decision tree structures, was employed for its capability to manage extensive datasets and high-dimensional feature spaces. It provides good accuracy and robustness against overfitting, owing to its inherent bagging approach. The model was optimized by tuning the quantity of trees and the utmost power for each tree through a randomized cross-validation search. For understanding the contributions of each feature to predict the model, feature importance had been analyzed [24].

Synergized Hybrid Random Vector Classifier (SHRVC)

The Synergized Hybrid Random Vector Classifier (SHRVC) integrates the strengths of SVM and RF to enhance classification accuracy as well as robustness. The process begins with feature transformation, where the dataset is mapped into a feature space learned by the SVM to improve class separability. This transformed feature space was then used to train a Random Forest model, capturing both linear and nonlinear relationships through its ensemble learning approach. Predictions from both the SVM and Random Forest were combined using a weighted voting scheme, where weights were assigned based on cross-validated performance scores to ensure that the final predictions leveraged the strengths of both models. To implement SHRVC, we initialized an SVM with probability estimates enabled and a Random Forest with 100 estimators, both set with a random state of 42 for reproducibility. These models were integrated into a hybrid setup by using a voting classifier with 'soft' voting. The SHRVC model was developed using the training dataset and estimated on the test dataset, with performance metrics including accuracy and a confusion matrix to evaluate the classification outcomes, including true positives, true negatives, false positives, and false negatives.

RESULTS AND DISCUSSION

In this comparative analysis, Python was chosen as the programming language for constructing the analytical model using the Jupyter Notebook within the Anaconda environment. This setup offers several advantages, including the ease of dataset exploration and effective pattern identification. This study involved evaluating a variety of classification algorithms in order to find the most effectual algorithm which can best suit to a given dataset. The UCI dataset containing health records was separated into two subsets: a training set and a test set. After isolating the dataset, data pre-processing had been done for the choice of preparing the data for data_analysis process. Prior to classification, feature-selection techniques were applied. Two hybrid feature selection methods, Corr Recursive

Feature Selection (CRFS) and RanChi Ensemble Selection (RCES), were used to identify important features from the serum 25OHD and TSH datasets and the hypothyroid dataset, respectively. Following feature selection, classification algorithms were applied to both the datasets. Existing algorithms used for this research work as mentioned earlier as well as the proposed hybrid classification model, Synergized Hybrid Random Vector Classifier (SHRVC) were used for carrying out the study. The outcomes of these evaluations are presented below:

Comparative Analysis of Existing and Proposed Hybrid Classifiers for both 25OHD & TSH and Hypothyroid Dataset

The following table, Table III and the figure Fig. 6 compare the performance metrics of three classifiers used on the 25OHD & TSH dataset. By obtaining the highest accuracy outcomes (0.98), sensitivity (0.97), specificity (1.00), precision (1.00), and F1-Score (0.99), SHRVC, when compared with all other algorithms out-performed well in terms of classification accuracy for both true positive and true negative instances. Though the Random Forest classifier falls somewhat behind the proposed SHRVC, the performance of it cannot be underestimated as it possesses the highest accuracy (0.97) and F1Score (0.98). Compared to the other two models, the SVM's performance is lower with an accuracy of 0.88 and an F1-Score of 0.88, indicating that it may be less effective. SHRVC achieves nearly perfect classification results overall, outperforming the existing classifiers. This comparison shows that SHRVC is the most successful classifier in this investigation, followed by Random Forest and SVM. Table IV displays a comparison of performance indicators for three classifiers discussed earlier on the Hypothyroid dataset. SVM scores were lower at 0.93, whereas Random Forest and SHRVC both obtained the greatest accuracy at 0.98. SVM scores poorly at 0.27 in terms of sensitivity; however, SHRVC performs well with a score of 0.84, demonstrating that it successfully identifies true-positive cases. In addition, SHRVC outperformed SVM (0.93) and Random Forest (0.95) in attaining perfect specificity (1.00). Moreover, SHRVC produces at 0.89, and Random Forest at 0.87, the F1-Score supports these results; SVM severely trails with a score of 0.41. In general, SHRVC is the best classifier for the hypothyroid dataset; it performs very well in terms of sensitivity and specificity, while SVM shows some significant drawbacks. The Figure, Fig. 7 compares the performance metrics of the three classifiers on the Hypothyroid dataset, focusing on the well-known four key metrics of any classifier. SVM, represented by the blue line, show signs of the poor performance in all metrics, particularly in sensitivity, where it scored significantly lower than the others. Random Forest, shown by the red line, performs consistently well, achieving strong scores in accuracy, specificity, and F1-Score, but does not excel in sensitivity compared to SHRVC. The SHRVC, represented by the green line, had the highest scores on the key metrics, indicating its better ability to classify instances effectively. Overall, the analysis Shows that SHRVC is the most effective classifier for the hypothyroid dataset, outperforming both SVM and Random Forest across most metrics.

CONLCUSION

The study concludes by highlighting the exceptional performance of the Synergized Hybrid Random Vector Classifier (SHRVC) across two important medical datasets, 25OHD & TSH and Hypothyroid, in comparison to conventional classifiers like SVM and Random Forest. On the 25OHD and TSH datasets, SHRVC consistently outperformed the other models, demonstrating its superior capacity for effectively distinguish between positive and negative cases. While SVM exhibited lower performance, particularly in identifying true positive instances, Random Forest performed well but did not match the comprehensive capabilities of SHRVC. The comprehensive analysis of SVM, Random Forest, and the Hybrid Classifier (SHRVC) clearly demonstrates that SHRVC consistently delivers more balanced and accurate results across both datasets. Its higher performance metrics on the 25OHD and TSH dataset emphasize its efficacy to find true positives and true negatives, while on the Hypothyroid dataset, it achieves the highest sensitivity and specificity, showcasing its robustness in detecting hypothyroid conditions. The results strongly suggest that Vitamin D levels are crucial in diagnosing and managing thyroid disorders, supporting the hypothesis that Vitamin D deficiency significantly contributes to thyroid disorder and other autoimmune diseases.

This study reinforces the importance of incorporating Vitamin D assessments into routine thyroid disease screening and management practices, as doing so could enhance diagnostic precision and improve patient outcomes.

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Table – 1: Dataset for 25OHD &TSH

Feature	Description
Patient	Represents the patient identifier
Weight	The patient's weight
Height	The patient's height
BMI	Derived measurement based on an individual's height and weight.
Sex	Categorical variable representing gender, where 1 likely represents male and 2 represents female.
Age	The patient's age
Season	Likely a categorical variable representing different seasons
25OHD	Concentrations of 25-hydroxyvitamin D (25OHD), a marker of vitamin D status.
TSH	Thyroid-Stimulating Hormone (TSH) levels
Classification	A binary classification indicating the target variable, where 0 likely represents one class (non-disease) and 1 represents another (disease)

Table –2: Dataset for Hypothyroid

Feature	Description
Age	The patient's age in years (0 to 92).
Sex	The gender of the patient (0 = female, 1 = male).
On thyroxine	Whether the patient is on thyroxine treatment (0 = no, 1 = yes).
Query on thyroxine	A query or question regarding the patient being on thyroxine (0 = no, 1 = yes).
On antithyroid medication	Whether the patient is using antithyroid medication (0 = no, 1 = yes).
Sick	Indicates if the patient is currently sick (0 = no, 1 = yes).
Pregnant	Whether the patient is pregnant (0 = no, 1 = yes).

Thyroid surgery	Indicating if the patient has had thyroid surgery (0 = no, 1 = yes)
I131 treatment	Showing if the patient has undergone it (0 = no, 1 = yes).
Query hypothyroid	A query about whether the patient may have hypothyroidism (0 = no, 1 = yes).
Query hyperthyroid	A query about whether the patient may have hyperthyroidism (0 = no, 1 = yes).
Lithium	Whether the patient has been on lithium treatment (0 = no, 1 = yes).
Goitre	Whether the patient has goiter (0 = no, 1 = yes).
Tumor	Indicates if the patient has a tumor (0 = no, 1 = yes).
Hypopituitary	Whether the patient has hypopituitarism (0 = no, 1 = yes).
Psych	Whether the patient has any psychological disorders (0 = no, 1 = yes).
TSH measured	Indicates if Thyroid-Stimulating Hormone (TSH) was measured (0 = no, 1 = yes).
TSH	Thyroid-Stimulating Hormone level.
T3 measured	Indicates if Triiodothyronine (T3) was measured (0 = no, 1 = yes).
T3	Triiodothyronine hormone level.
TT4 measured	Indicates if Total Thyroxine (TT4) was measured (0 = no, 1 = yes).
TT4	Total Thyroxine hormone level.
T4U measured	Indicates if Thyroxine Utilization (T4U) was measured (0 = no, 1 = yes).
T4U	Thyroxine Utilization level.
FTI measured	Indicates if the Free Thyroxine Index (FTI) was measured (0 = no, 1 = yes).
FTI	Free Thyroxine Index, calculated from T4 and T3 uptake.
TBG measured	Indicates if Thyroxine-Binding Globulin (TBG) was measured (0 = no, 1 = yes).
Referral source	The source from which the patient was referred (categorical, coded from 0 to 4).
BinaryClass	The target variable indicating disease status (0 = no disease, 1 = disease).

Table -3: Comparison of performance metrics of Existing and Proposed Synergized Hybrid Random Vector Classifier (SHRVC) 25OHD &TSH

CLASSIFIER/PERFORMANCE METRICS	SVM	RAMDOM FOREST	SHRVC CLASSIFIER
Best Accuracy	0.88	0.97	0.98
Best Sensitivity	0.93	0.95	0.97
Best Specificity	0.93	0.98	1.00
Best Precision	0.92	0.97	1.00
Best F1-Score	0.88	0.98	0.99

Table-4: Comparison of Performance Metrics of Existing and Proposed Synergized Hybrid Random Vector Classifier (SHRVC) –Hypothyroid Dataset

CLASSIFIER/PERFORMANCE METRICS	SVM	RAMDOM FOREST	SHRVC CLASSIFIER
Best Accuracy	0.93	0.98	0.98
Best Sensitivity	0.27	0.80	0.84
Best Specificity	0.93	0.95	1.00
Best Precision	0.80	0.91	0.94
Best F1-Score	0.41	0.87	0.89

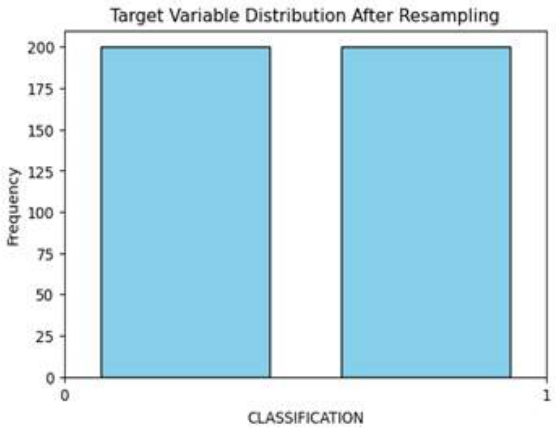


Fig. 1: Balancing the 25OHD & TSH Dataset

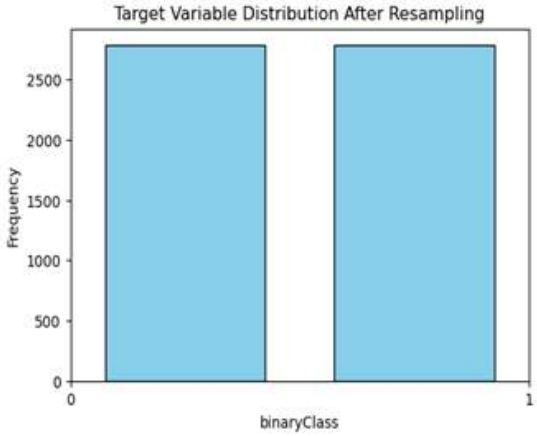


Fig. 2: Balancing for Hypothyroid Dataset

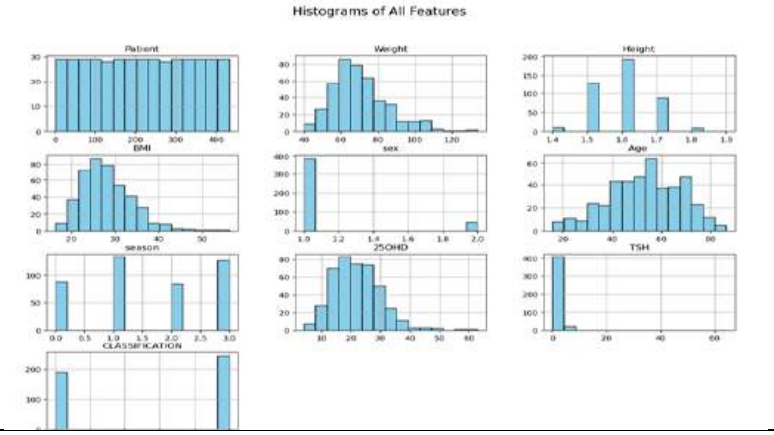


Fig.3 : A histogram of 9 attributes present in the dataset

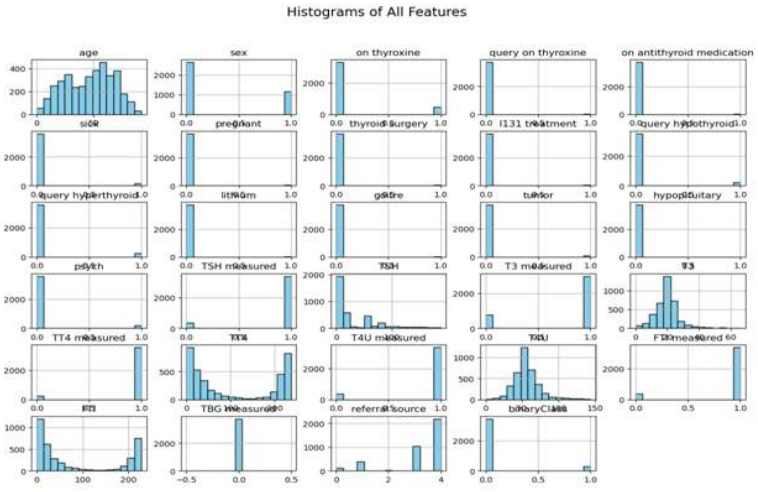


Fig.4: A histogram of the 28 attributes in the dataset

Algorithm: Pseudo Code of Proposed Hybrid Classification Algorithm(SHRVC)

Input: Dataset (df)
Process:
Step 1: Load the dataset into a DataFrame df.
Step 2: Handle missing values:
- Replace ? with NaN and impute missing values.

Step 3: Encode categorical features numerically.
Step 4: Divide the data into training and testing sets (e.g., 80%/20%).
Step 5: Perform feature selection:
- **5.1:** Conduct a Chi-Squared test and select top k features.
- **5.2:** Train RandomForestClassifier to get feature importances and select top k features.
- **5.3:** Identify common features selected by both methods.

Step 6: Train models using common features:
- **6.1:** Train a RandomForestClassifier.
- **6.2:** Train an SVC (Support Vector Classifier).

Step 7: Combine models using a VotingClassifier (soft voting).
Step 8: Generate predictions for the test set with the hybrid model.
Step 9: Assess the model's performance.
- Calculate accuracy, precision, recall, specificity, and F1-score.
- Generate a confusion matrix.

Output:
- Selected features.
- Model performance metrics.
- Confusion matrix.

Fig.5: Proposed Hybrid Classification Algorithm (SHRVC)

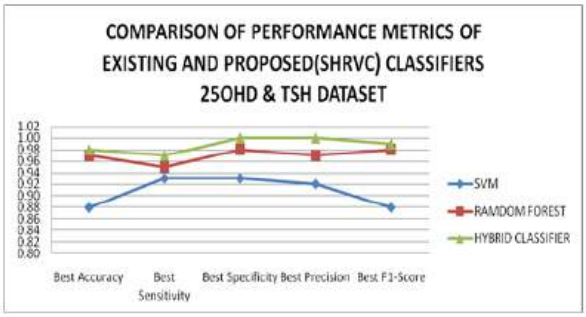


Fig. 6: Comparative Analysis of Performance Metrics for Existing and Proposed Classifiers on the 25OHD & TSH Dataset dataset

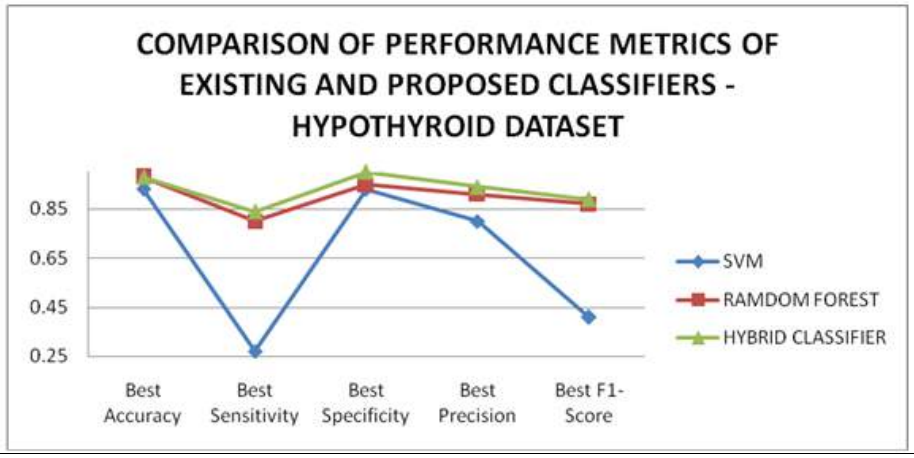


Fig. 7: Comparative Analysis of Performance Metrics for Existing and Proposed Classifiers on the Hypothyroid Dataset

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RESEARCH ARTICLE

Plant Mediated Synthesis of Silver Nanoparticles from *Barleria longiflora* Leaves with Evolution of their Antidiabetic Properties

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ABSTRACT

Green nanotechnology provides eco-friendly strategies for nanoparticle synthesis. *Barleria longiflora* L.f., rich in phytochemicals, holds promise for antimicrobial and antidiabetic applications. To synthesize silver nanoparticles (AgNPs) using *B. longiflora* extract and assess their physicochemical characteristics and enzyme inhibitory potential. Shade-dried and acetone-defatted leaves were extracted with ethanol and water. AgNPs were synthesized using 1 mM silver nitrate under sunlight. Characterization was done via UV–Vis, FTIR, and SEM. Enzyme inhibition assays targeted α-amylase and β-glucosidase, with Acarbose as standard. UV–Vis and FTIR confirmed nanoparticle formation and capping. SEM showed crystalline morphology. The extract inhibited α-amylase (75.0%) and β-glucosidase (58.2%) in a dose-dependent manner, with IC_{50} values of 53.3 and 85 mg/mL, respectively. *B. longiflora*-based AgNPs represent a green and cost-effective synthesis route with moderate antidiabetic potential, supporting their use in biomedical applications.

Keywords: *Barleria longiflora*, silver nanoparticles, green synthesis, enzyme inhibition, antidiabetic, phytochemicals, nanobiotechnology

INTRODUCTION

Nanotechnology has emerged as a transformative field in recent years, largely due to the extraordinary physicochemical properties exhibited by nanoparticles ranging from 1 to 100 nm in size. These distinct attributes are influenced by pivotal factors such as particle dimension, morphology, and structural configuration, which have driven intensive scientific efforts to fine-tune these parameters for a wide array of applications [18]. Currently, there is a pronounced shift toward eco-conscious, non-toxic, reliable, and sustainable methodologies for engineering nanoparticles with precise size and shape, especially for biomedical purposes [11]. A broad spectrum of nonmaterial's originating from substances such as alginate, gold, magnesium, titanium, copper, zinc, and silver has been synthesized and systematically investigated for their functional potential [4]. Among various nanomaterials, silver nanoparticles (AgNPs) are particularly distinguished for their remarkable and adaptable surface plasmon resonance (SPR) characteristics, which contribute significantly to their versatility in biomedical and technological applications [19]. In comparison to other noble metal nanoparticles, silver nanoparticles (AgNPs) have been the focus of extensive research due to their diverse functional attributes, including potent antimicrobial, anticancer, antioxidant, and larvicidal effects, coupled with their economic viability. Additionally, AgNPs exhibit broad applicability across multiple domains such as biosensing, catalysis, and photovoltaic systems [2]. Traditionally, nanoparticles have been synthesized via chemical and physical methods, which are often associated with high production costs and the utilization of toxic reagents that can pose serious environmental and biological hazards [1]. This challenge has catalyzed the development of green synthesis strategies that employ biological systems including bacteria, fungi, yeast, actinomycetes, and particularly plant extracts to mediate the reduction of silver ions into silver nanoparticles (AgNPs). Although microbial routes enable both extracellular and intracellular nanoparticle formation, they often demand rigorous aseptic protocols, intensive labor, and substantial operational costs. In contrast, plant-mediated synthesis has gained traction as a viable and eco-friendly alternative, utilizing phytochemicals as natural reducing and stabilizing agents, while circumventing the need for elaborate microbial culture techniques [24]. Medicinal plants, especially those long utilized in traditional and alternative healing systems, are increasingly recognized as ideal bioresources for the eco-friendly synthesis of biocompatible metal nanoparticles [9]. Among these, the use of plant leaves presents a particularly simple, sustainable, and effective approach for nanoparticle fabrication. This underscores the necessity of advancing alternative green technologies that not only reduce dependency on hazardous chemicals but also capitalize on the inherent phytochemical richness of natural materials for the environmentally benign production of silver nanoparticles [15].

MATERIALS AND METHOD

Collection of Plant Material and Preparation of Extracts

Barleria longiflora L.f., belonging to the family Acanthaceae [31], was selected for this study due to its potential in the green synthesis of nanoparticles. Plant specimens were collected from Erattaimalai in the Tiruchirappalli District of Tamil Nadu, India. The species was taxonomically identified and authenticated by the Botanical Survey of India, Southern Regional Centre, Coimbatore, Tamil Nadu. The collected leaves were shade-dried to retain phytochemical constituents and subsequently ground into a coarse powder. The powdered material was initially defatted using acetone to eliminate non-polar components. This was followed by ethanol extraction, with the resulting solution concentrated via evaporation to yield a dry alcoholic extract. For aqueous extraction, the powdered leaves underwent cold maceration in distilled water for 24 hours, following the procedure described [23].

Preparation of Silver Nitrate Solution

Commercially obtained silver nitrate (molecular weight: 169.87 g/mol) was used to prepare a 1 mM solution. A precise amount of silver nitrate was accurately weighed and dissolved in distilled water to achieve the desired concentration.

Synthesis of Silver Nanoparticles

To 750 mL of the prepared 1 mM silver nitrate solution, 7.5 mL of *Barleria longiflora* plant extract was added in a clean conical flask. The mixture was exposed to direct sunlight with continuous shaking to initiate nanoparticle synthesis. A visible color change from light yellow to brown indicated the formation of silver nanoparticles. As the reaction progressed, the solution gradually became colorless, and nanoparticles were observed settling at the bottom of the flask.

Optimization of Nanoparticle Synthesis Parameters

UV–Visible Spectroscopy

The bioreduction of Ag^+ ions was monitored using UV–Vis spectral analysis. The absorption spectrum of the reaction mixture was recorded at room temperature using a U-3200 Hitachi spectrophotometer with a 1 nm resolution over the wavelength range of 200–800 nm.

Fourier-Transform Infrared Spectroscopy (FTIR)

For FTIR analysis, the silver nanoparticle solution was centrifuged at 10,000 rpm for 30 minutes. The pellet obtained was washed three times with 20 mL of deionized water to remove unbound proteins and other impurities. The purified sample was then dried, finely ground with KBr, and analyzed using a Shimadzu IR Affinity-1 spectrometer in diffuse reflectance mode at a resolution of 4 cm^{-1}.

Scanning Electron Microscopy (SEM)

At the peak of nanoparticle production, the reaction supernatant was air-dried, and the resulting nanoparticles were deposited onto glass substrates. Surface morphology and particle size were observed using a VEGA 3 TESCAN Scanning Electron Microscope, with micrographs captured focusing on aggregated nanoparticle clusters.

Inhibition of α-Amylase Enzyme

A 0.1% (w/v) starch solution was prepared by dissolving 0.1 g of potato starch in 100 mL of 16 mM sodium acetate buffer. The α-amylase enzyme solution was made by dissolving 27.5 mg of the enzyme in 100 mL of distilled water. The colorimetric reagent was prepared using sodium potassium tartrate combined with 96 mM 3,5-dinitrosalicylic acid (DNS) solution. Starch solution was added to control and test tubes containing the plant extract (leaf and rhizome formulations), followed by the addition of α-amylase under alkaline conditions at 25°C. The reaction was allowed to proceed for 3 minutes. Maltose formation was measured by the reduction of DNS to 3-amino-5-nitrosalicylic acid, and absorbance was recorded at 540 nm.

Inhibition of β-glucosidase Enzyme

β-Glucosidase inhibition was assessed by incubating 1 mL of a 2% (w/v) starch-based substrate (glucose, maltose, or sucrose) with 0.2 M phosphate buffer (pH 8.0) and varying concentrations of plant extract for 5 minutes at 37°C. The reaction was initiated by adding 1 mL of β-glucosidase enzyme (1 U/mL), followed by a 40-minute incubation at 35°C. The reaction was terminated by adding 2 mL of 6N HCl. The resulting color intensity was measured spectrophotometrically at 540 nm, following the method described [30].

$$\text{Inhibition \%} = \frac{\text{Control- Test}}{\text{Control}} \times 100$$

RESULTS

Synthesis of Silver Nano Particle (SNPs)

During the biosynthesis of silver nanoparticles (SNPs) employing the leaf extract of *Barleria longiflora* and silver nitrate ($AgNO_3$), a distinct visual shift in color from pale yellow to deep brown was observed, signifying successful nanoparticle formation. The pH value exhibited a modest rise from 4.0 to 4.60, accompanied by a pronounced color intensity (+++), indicating robust synthesis activity. This rapid conversion, occurring within 20 minutes, affirmed the

effective generation of silver nanoparticles. The underlying mechanism driving this color transition is linked to surface plasmon resonance (SPR), an inherent optical behavior exhibited by silver nanoparticles in aqueous media [32].

UV-Visible Spectroscopy

The UV-VIS analysis of *Barleria longiflora* extract revealed two significant absorption peaks at wavelengths of 398.75 nm and 458.35 nm. The first peak at 398.75 nm exhibited an absorbance of 0.9427, indicating the presence of compounds that absorb in the near-visible region, likely flavonoids or phenolic compounds as well as to the stabilization of the resultant nanoparticles [27]. The second, more intense peak at 458.35 nm showed a higher absorbance of 1.1062, suggesting a stronger presence of chromophoric compounds, which may contribute to the plant's coloration and potential antioxidant activity [10]. These results indicate the presence of bioactive compounds in the extract, which may also play a role in the synthesis and stabilization of silver nanoparticles.

FT-IR Spectroscopy

The IR spectrum exhibits several characteristic absorption bands indicating the presence of multiple functional groups. A strong and broad band at 3445 cm^{-1}, along with a peak at 2927 cm^{-1}, corresponds to O–H stretching vibrations, which are indicative of alcohol groups, specifically pointing toward the presence of both primary and secondary alcohol functionalities likely from hydroxyl groups in plant metabolites [26]. A distinct absorption at 2094 cm^{-1} is attributed to N=C stretching, suggesting the presence of an isothiocyanate group [8]. Additionally, a peak at 1639 cm^{-1} represents C=C stretching, which is commonly associated with alkenes [29]. The band at 1412 cm^{-1} is due to S=O stretching, indicating the presence of a sulfate group [5]. A notable absorption at 1120 cm^{-1} corresponds to C–O stretching, supporting the identification of a secondary alcohol [25]. Finally, the absorption observed at 657 cm^{-1} is assigned to C–Br stretching, pointing toward the presence of a halo compound, as interpreted from FT-IR data [7].

Scanning Electron Microscopy (SEM)

The SEM revealed a high density of silver nanoparticles synthesized using *Barleria longiflora* extract, further confirming the successful formation of silver nanostructures. This analysis provided valuable information regarding the morphology and size of the nanoparticles. SEM results indicated that the particles exhibited a crystalline structure with an approximate size of 10 μm. Silver nanoparticles synthesized through this green approach have demonstrated significant toxicity against multidrug-resistant bacteria, highlighting their strong potential for biomedical applications. The current study presents a straightforward, rapid, and cost-effective method for producing silver nanoparticles. The use of such environmentally friendly nanomaterials in antimicrobial treatments, wound healing, and various medical and electronic fields underscores the promise of this green synthesis route for large-scale production of other inorganic nanomaterials.

α-Amylase Activity

The α-amylase inhibitory activity of *Barleria longiflora* extract was assessed at various concentrations (25, 50, 75, and 100 mg/mL) and compared with Acarbose, a standard pharmacological inhibitor. At 25 mg/mL, the extract showed an inhibition rate of 37.2%, marginally lower than Acarbose's 40.2%. With escalating concentrations, the extract exhibited a progressive and concentration-dependent increase in enzyme inhibition 46.8% at 50 mg/mL, 59.6% at 75 mg/mL, and 75.0% at 100 mg/mL. In contrast, Acarbose displayed a slightly higher inhibition across the same concentrations, registering 52.5%, 64.8%, and 76.9%, respectively. The IC_{50} value, denoting the concentration required to inhibit 50% of enzymatic activity, was calculated as 53.3 mg/mL for the extract and 44.9 mg/mL for Acarbose, reaffirming the latter's greater potency. Nonetheless, *Barleria longiflora* exhibited a notable and consistent inhibitory pattern, underscoring its potential as a natural alpha-amylase inhibitor capable of delaying carbohydrate metabolism and mitigating postprandial hyperglycemia an essential mechanism in diabetes management.

β-Glucosidase Activity

The inhibitory efficacy of *Barleria longiflora* extract on β-glucosidase enzyme activity was assessed at incremental concentrations (25, 50, 75, and 100 mg) and benchmarked against Acarbose, a well-established antidiabetic reference

compound. At the lowest concentration of 25 mg, the extract achieved a 26.3% suppression of enzyme activity, slightly trailing Acarbose, which recorded a 30% inhibition. As the dosage increased, the plant extract demonstrated a clear dose-responsive enhancement in inhibitory capacity 35.9% at 50 mg, 42.7% at 75 mg, and peaking at 58.2% at 100 mg. Acarbose maintained superior inhibitory efficiency at each corresponding concentration (40%, 50%, and 60%, respectively). The half-maximal inhibitory concentration (IC_{50}) was calculated as 85 mg for the extract, compared to 75 mg for Acarbose, indicating the extract's comparatively lower potency. Nonetheless, the extract's consistent and progressive inhibition of β-glucosidase underscores its pharmacological promise as a plant-based adjunct for glycemic regulation and diabetes management.

DISCUSSION

The observed color change from yellowish to dark brown, correlated with the increase in absorbance at 458.35 nm, further supports the synthesis of silver nanoparticles in the extract. This color transition is attributed to the excitation of surface plasmon vibrations in the silver nanoparticles, a characteristic feature that occurs due to the collective oscillation of free electrons in the metal when exposed to light [23]. This shift in color, accompanied by the distinctive absorbance peaks, serves as a confirmation of the nanoparticle formation process and provides insight into the synthesis mechanism. The UV-VIS spectroscopic analysis, therefore, not only reveals the presence of bioactive compounds in the *Barleria longiflora* extract but also offers a simple yet effective means to monitor the synthesis and stability of metal nanoparticles in aqueous solutions. The combination of flavonoids, phenolic compounds, and silver nanoparticles in the plant extract further suggests that this approach may hold significant promise for various applications, including drug delivery, antimicrobial treatments, and antioxidant therapies. The FT-IR results provide substantial evidence of the role of various plant metabolites in the synthesis of silver nanoparticles. The presence of hydroxyl, isothiocyanate, alkene, sulfate, and alcohol groups suggests a complex interaction between the plant extract and silver ions, where bioactive compounds such as polyphenols, flavonoids, and alkaloids likely contribute to both the reduction of silver ions and the stabilization of nanoparticles. These compounds may form a protective layer around the nanoparticles, preventing aggregation and ensuring colloidal stability [6]. Moreover, the functional groups identified in the FT-IR spectrum indicate that the plant extract possesses significant chemical diversity, which may be leveraged in the synthesis of nanoparticles with enhanced bioactivity. Overall, the FT-IR analysis supports the conclusion that the *Barleria longiflora* leaf extract contains a variety of functional groups that not only participate in the reduction of silver ions but also play a crucial role in stabilizing the silver nanoparticles, making them suitable for a wide range of applications, including antimicrobial, anticancer, and drug delivery systems [20].

SEM analysis confirmed the successful green synthesis of silver nanoparticles (AgNPs) using *Barleria longiflora* extract, revealing a high density of crystalline nanostructures with an approximate size of 10 μm, likely due to aggregation. The morphology and size support the role of plant-derived phytochemicals as effective reducing and stabilizing agents [1, 16]. The synthesized AgNPs exhibited strong antibacterial activity against multidrug-resistant bacteria, indicating their potential for biomedical applications such as antimicrobial coatings and wound healing. These findings are consistent with previous studies highlighting the bactericidal mechanisms of AgNPs, including membrane disruption and ROS generation [22, 14]. This study demonstrates a simple, eco-friendly, and scalable method for AgNP production, promoting sustainable nanomaterial development for medical and environmental use. The *Barleria longiflora* extract demonstrated a clear, concentration-dependent inhibition of alpha-amylase activity, achieving 75.0% inhibition at 100 mg/mL. Although slightly less potent than the standard drug Acarbose (76.9% at 100 mg/mL), the extract's IC_{50} value (53.3 mg/mL) suggests moderate efficacy as a natural enzyme inhibitor, compared to Acarbose's 44.9 mg/mL. These findings indicate that the phytochemicals in *B. longiflora* likely flavonoids, tannins, and phenolic acids—interact with the active site of alpha-amylase, thereby delaying starch breakdown and glucose absorption [12]. This mechanism is vital for controlling postprandial blood glucose spikes, a key factor in managing type 2-diabetes. The extract's performance aligns with earlier studies on plant-based alpha-amylase inhibitors, such as those from *Salacia reticulata* and *Syzygium cumini*, which also showed dose-dependent

inhibition comparable to Acarbose [3, 28]. Importantly, natural inhibitors tend to have fewer gastrointestinal side effects than synthetic drugs, making *B. longiflora* a promising candidate for nutraceutical development or adjunct therapy. The *Barleria longiflora* extract demonstrated a dose-dependent inhibition of β-glucosidase activity, peaking at 58.2% inhibition at 100 mg/mL. Though slightly less potent than Acarbose (60% at the same concentration), the extract's consistent efficacy (IC_{50}: 85 mg/mL vs. Acarbose's 75 mg/mL) highlights its potential as a natural glycosidase inhibitor. This enzyme plays a key role in the hydrolysis of glycosidic bonds in disaccharides, facilitating glucose release. By inhibiting β-glucosidase, *B. longiflora* extract may help slow glucose absorption and attenuate postprandial hyperglycemia is a critical strategy in managing type 2 diabetes [17]. The inhibitory effects likely stem from phytoconstituents such as flavonoids and polyphenols, which are known to interact with glycosidase active sites [21]. Similar dose-responsive inhibition has been reported in other medicinal plants, including *Momordica charantia* and *Punica granatum*, supporting the role of natural inhibitors as safer alternatives or adjuncts to synthetic drugs [13].

CONCLUSION

This investigation successfully established a green, sustainable method for synthesizing silver nanoparticles utilizing *Barleria longiflora* leaf extract. The biosynthesis process proved to be efficient, economical, and environmentally benign. Structural and functional characterization through UV–Vis spectroscopy, FTIR, and SEM affirmed the formation, stability, and morphological traits of the nanoparticles. The plant-derived extract exhibited significant and concentration-dependent inhibition of α-amylase and β-glucosidase, indicating its potential as a natural antidiabetic agent. Although marginally less effective than Acarbose, the standard inhibitor, the consistent enzyme-suppressing activity of *B. longiflora* underscores its pharmacological relevance. Overall, the study supports the application of *B. longiflora*-mediated silver nanoparticles in therapeutic domains, particularly for glycemic control and microbial intervention. Future research involving in vivo analysis and clinical validation is warranted to further substantiate its biomedical utility.

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"The authors declare no conflict of interest."

The authors declare no conflicts of interest. The funders had no role in the design of the ; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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Table 1. Indication of Color Change in Synthesis of Silver Nano Particle (SNPs)

S.No	Plant Leaf Extract+Agno3	Color Change		Ph Change		Color Intensity	Time	Result
	Scientific Name	Before	After	Before	After			
1	*Barleria longiflora*	Light yellow	Brown	4.0	4.60	+++	20 min	Positive

Note: +++ Dark brown

Table 2: UV-VIS Analysis of *Barleria longiflora*

S.No	Wave Length	Absorbance
1	398.75	0.9427
2	458.35	1.1062

Table 3: FTIR Analysis of *Barleria longiflora*

S.No	Frequency (cm^{-1})	Type of Bond	Functional Group
1	3445	O–H stretching	Alcohol
2	2927	O–H stretching	Alcohol
3	2094	N=C stretching	Isothiocyanate
4	1639	C=C stretching	Alkene
5	1412	S=O stretching	Sulfate
6	1120	C–O stretching	Secondary Alcohol
7	657	C–Br stretching	Halo compound

Table 4. Anti-Diabetic Activity of *Barleria longiflora* by Using α-Amylase Enzyme

Type	Concentration of Plant Extract (mg/mL)	% of Inhibition	Acarbose
α-Amylase Enzyme	25	37.2	40.2
	50	46.8	52.5
	75	59.6	64.8
	100	75.0	76.9
IC_{50} Value		53.3	44.9

Table 5. Anti-Diabetic Activity Of *Barleria longiflora* by Using β-glucosidase enzyme

TYPE	CONCENTRATION OF PLANT EXTRACT (mg)	% OF INHIBITION	ACARBOSE
β-glucosidase Enzyme	25	26.3	30
	50	35.9	40
	75	42.7	50
	100	58.2	60
IC $_{50}$ Value		85	75



Fig. 1. Synthesised Silver Nanoparticles

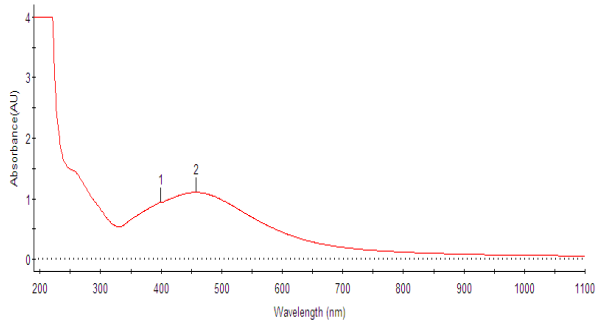


Fig. 2. UV-VIS Analysis of *Barleria longiflora*

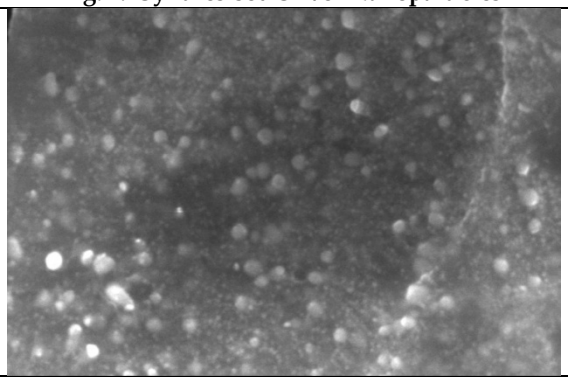


Fig. 3. SEM Analysis of SNPS

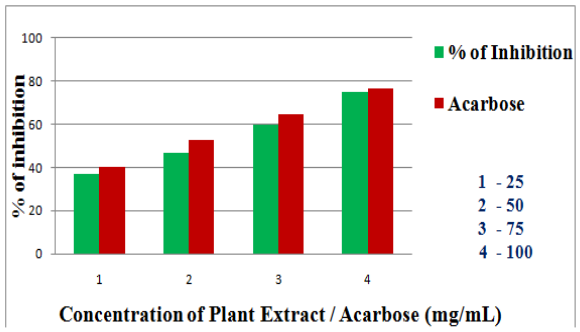


Fig. 4. The graph illustrates the concentration-dependent α -amylase inhibition by *Barleria longiflora* extract and Acarbose (mg/mL)

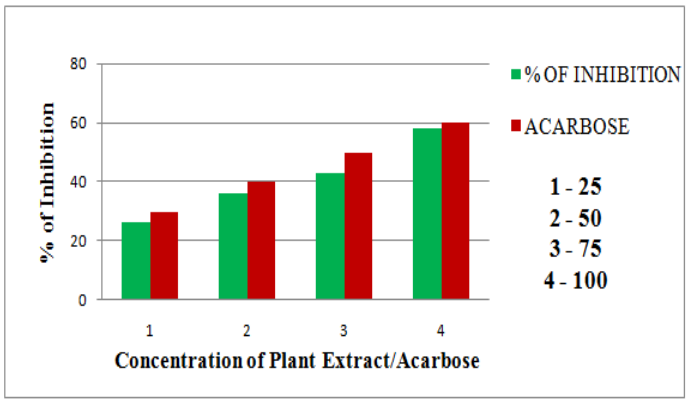


Fig. 5. The graph illustrates the concentration-dependent Beta Glucosidase inhibition by *Barleria longiflora* extract and Acarbose. (mg/mL)

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RESEARCH ARTICLE

A Study on work Place Well-Being and Work Life Balance At Chemical Manufacturing Company

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ABSTRACT

Work-life balance and employee well-being are critical for the success of both the individual and the organization in today's competitive, fast-paced workplace. Workplace well-being relates to the mental, physical and emotional health of employees at their workplace. Taking care of these two areas leads to higher productivity, more motivated employees, and a higher job satisfaction. As such, this study aims to evaluate the state of workforce well-being/ work-life balance among chemical industry employees today. The research is based on a mix of survey responses and employee feedback. The qualitative and quantitative methods explore the influence of workplace policy, job pressure, mental health care and working time on employee well-being. It also outlines some of the major difficulties that employees encounter in achieving a balance between their occupational and personal life. The study's findings reveal that despite the perception of strong support for mental health and job security in workplaces, the overwhelming majority of workforces are suffering from work overload and a lack of flexibility. The majority of employees feel great about current wellness programs, but they want more options on how to use their time, including flexible hours and the ability to work remotely. Companies need to focus more on flexible work arrangements, mental health initiatives and career growth opportunities, the study said. But those steps can help professionals lower employee stress and job satisfaction while also building a healthier, happier workforce. Encouraging employee well-being and supporting work-life balance is good for workers and also reflects on the long-term well-being of organizations.

Keywords: The qualitative and quantitative methods explore the influence of workplace policy, job pressure, mental health care and working time on employee well-being.

COMPANY PROFILE

The study is based on chemical manufacturing and distribution company headquartered at Chennai, Tamil Nadu, India. Established in the early 1980s, the company has grown from a small distributor into a globally recognized

player in the chemical industry. It serves a wide range of sectors including pharmaceuticals, agriculture, textiles and industrial solutions, delivering reliable and innovative chemical products to its customers. With a strong domestic and international presence, the company operates through multiple branches across India and key global locations. It supports thousands of clients with dedicated teams in logistics, technical services, and customer support, aiming to maintain high standards in product quality, safety, and environmental responsibility. Apart from industrial chemicals, the company has also launched a hygiene product line under its own brand, focusing on eco-friendly, non-toxic, and biodegradable cleaning solutions for personal and community use. These products certified for sustainability and are designed to meet modern hygiene needs while minimizing environmental impact. The organization's commitment to innovation, customer satisfaction, and employee well-being makes it a valuable case for studying workplace practices in the chemical sector.

REVIEW OF LITERATURE

Maslow's Hierarchy of Needs (1943): Abraham Maslow explained that for individuals to perform well, their basic needs such as safety, belongingness, and self-esteem must be fulfilled. In the workplace, this means organizations should ensure a healthy environment, recognition, and personal growth opportunities to improve employee well-being. **Greenhaus and Beutell (1985):** This study introduced the concept of work-family conflict, which occurs when responsibilities from work and home interfere with each other. It emphasized that poor work-life balance can lead to stress, low job satisfaction, and even health issues. **Guest's Model of Work-Life Balance (2002):** According to Guest, achieving balance depends on supportive organizational policies, employee attitudes, and job design. The model suggests that companies should focus on flexibility, career development, and stress-free environments to maintain employee satisfaction. **Demerouti et al. – Job Demands-Resources Model (2001):** This model explains how job demands (like workload) and job resources (like support and flexibility) influence employee stress and motivation. A good balance between the two helps improve both performance and well-being. **Seligman's PERMA Model (2011):** Applying this model in the workplace helps create a more supportive and engaging work culture that boosts employee happiness and productivity.

RESEARCH DESIGN

One strategy for methodically resolving research issues is research methodology. It directs the researcher to conduct the study in a scientific manner. It includes several phases that are often chosen by a researcher to examine his research issue and the reasoning behind it. The research approach comprises the reasoning behind the techniques.

DESIGN SAMPLE

Judgmental sampling is the sample design that is employed. With this approach, the researcher's judgment is used to choose the population's components, guaranteeing that only individuals who possess pertinent information and skills are incorporated into the research. Another name for this technique is as purposive sampling since the investigator carefully selects the most qualified respondent's ability to offer insightful information. The Work place well-being and work life balance research of this company, the participants are chosen according to their background, position, and participation in the use and execution of chemical manufacturing company.

THE SIZE OF THE SAMPLE

The sample size that satisfies the requirements of effectiveness, representativeness, dependability, and adaptability is referred to as an optimal sample. The sample size chosen for the research is 110 employees from different streams.

DATA COLLECTION TOOLS

Data Sources

- Primary data through surveys
- Secondary data from case studies and articles

CONDUCTED STUDY

Original Information

Original information gathered by researchers directly from their sources is referred to as primary data, origin of interest. This information is acquired using techniques like surveys, questionnaires, observations, tests, or interviews conducted especially for the ongoing investigation. Given that original data is gathered straight from the participants or phenomenon under investigation. Primary data was gathered via a well-designed questionnaire.

Survey

For this, a questionnaire with 25 multiple-choice questions was created . The staff members of the company, were given the questionnaire. Finding out more about "A study on Workplace well-being & Work life balance" was the goal. In response to each question, the respondents expressed their opinions.

STATISTICAL TOOLS

Statistical techniques are used to analyze the data. The data gathered is analyzed using simple percentage analysis.

- Correlation-coefficient Analysis
- T-Test
- U-Test
- Regression
- F-Test

Hypotheses: 1 Age Group & Feeling Stressed at Work

(1&8) (H_0): There is no relationship between the age group and stress level at work.

(H_1): younger employees feel stressed more than the older employees at work.

Hypotheses: 2 Age Group & Awareness of wellness programs

(1&10) (H_0): There is no relation between the age group and wellness programs.

(H_1): Younger employees are more like to know about and use wellness programs.

Hypotheses: 3 Gender & Supervisor Support

(2&11) (H_0): There is no relationship between the gender and the supervisor support.

(H_1): Employees feel less supported by the supervisor for well-being.

Hypotheses: 4 Years in Organization & Feeling Valued

(4&14) (H_0): There is no relation between years in organization and feeling valued.

(H_1): Employees with more experienced in the organization feel more valued.

Hypotheses: 5 Age Group & Weekly Working Hours

(1&17) (H_0): There is no relationship between the age group and weekly working hours.

(H_1): Younger employees are work more hours each week than older employees.

CORRELATION CO-EFFICIENT

(1 & 8) Age Group & Feeling Stressed at Work

Hypothesis: There is a significant relationship between an employee's age group and their frequency of feeling stressed or overwhelmed at work.

Null Hypothesis(H0): There is no relationship between the age group and their feeling of stressed.

Alternative Hypothesis(H1): There is relationship between the age group and feeling overwhelmed at work.

Age group (x)	10	30	50	20
Feeling overwhelmed at work (y)	0	0	14	96

x	y	x^2	y^2	xy
10	0	100	0	0
30	0	900	0	0
50	14	2500	196	700
20	96	400	9216	1920
ΣX=110	ΣY=110	Σx^2=3900	Σy^2= 9412	Σxy=2620

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$
$$= \frac{4 \times 2620 - 110 \times 110}{\sqrt{[4 \times 3900 - 110^2][4 \times 9412 - 110^2]}}$$
$$= \frac{10480 - 12100}{\sqrt{[15600 - 12100][37648 - 12100]}}$$
$$= \frac{-1620}{\sqrt{[3500 - 25548]}}$$
$$= \frac{-1620}{\sqrt{89418000}}$$
= -0.1713

Since the correlation coefficient r=−0.1713, it indicates a weak negative correlation between the age group and feeling overwhelmed at work. This means that as age increases, the level of feeling overwhelmed at work slightly decreases, but the relationship is very weak.

U- TEST

(2 & 11) Gender & Supervisor Support for Well-Being

Hypothesis: There is a gender-based difference in the perception of supervisor support for mental health and well-being.

H0: There is no significant gender difference in the perception of supervisor support for mental health.

H1: Female employees perceive less support from their supervisors regarding mental health and well-being compared to male employees.

Gender	80	30
Mental health support	110	0

Dates: 80, 110, 30, 0

Ascending order: 0, 30, 80, 110

Rank: 1, 2, 3, 4

R_1 = 2+3 = 5

R_2 = 1+4= 5

Find u_1& u_2

$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$

$= 5 - \frac{2(2+1)}{2}$

$= 5 - \frac{2(3)}{2}$

$= 5 - \frac{6}{2}$

$= 5 - 3$

$U_1 = 2$

$U_2 = R_2 - \frac{n_2(n_2+1)}{2}$

$5 - \frac{2(2+1)}{2}$

5 - $\frac{2(2+1)}{2}$

5- $\frac{6}{2}$

5 - 3

$U_2 = 2$

Conclusion:

$N_1 = 2$

$N_2 = 2$

Level of significance = 5% = 0.05

Two – tailed test: this implies we're testing if the means are different ($u_1 \neq u_2$).

u> table value.

2>0

H0 is rejected in favor of H1.

Regression

(4 & 14) Years in Organization & Feeling Valued at Work

Hypothesis: *Employees who have worked longer in an organization feel more valued and recognized for their contributions.*

H0: There is no significant relationship between years of service and feeling valued at work.

H1: Employees with more years in an organization report higher recognition and appreciation at work.

Years of working	12	14	48	10
contribution	110	0	0	0

$$bxy = \frac{n\sum xy - \Sigma \times \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

x	y	X^2	Y^2	xy
12	110	144	12100	1320
40	0	1600	0	0
48	0	2304	0	0
10	0	100	0	0
$\sum x$= 110	$\sum y$=110	$\sum x^2$= 4148	$\sum y^2$=12100	$\sum xy$=1320

X on y n = 4

$$bxy = \frac{N\Sigma xy - \Sigma x \Sigma y}{N\sum y^2 - (\sum y)^2}$$

$$= \frac{4(1320) - (110)(110)}{4(12100) - 110)^2}$$

$$= \frac{5280 - 12100}{48400 - 12100}$$

$$= \frac{-6820}{36300}$$

= -0.1879

Y on x

$$bxy = \frac{n\sum xy - \Sigma \times \Sigma y}{n\Sigma x^2 - (\Sigma x)^2}$$

$$= \frac{2(1320) - (110)(110)}{2(4148) - (110)^2}$$

$= \frac{2640 - 12100}{8296 - 12100}$

$= \frac{-9460}{-3804}$

= 2.4869

bxy = -0.1879

byx = 2.4869

$\bar{x} = \frac{\Sigma x}{n}$ $\bar{y} = \frac{\Sigma y}{n}$

$= \frac{110}{4}$ $= \frac{110}{2}$

$\bar{x}$= 27.5 $\bar{y}$= 55

Regression equation of x on y

$x - \bar{x} = bxy(y - \bar{y})$

$x - 27.5 = 0.1879(y - 55)$

$x - 27.5 = -0.1879y + 10.3345$

$x = -0.1879y + 10.3345 + 27.5$

x=-0.1879y + 37.8345

Regression equation of y on x

$y - \bar{y} = byx(x - \bar{x})$

$y - 55 = 2.4869(x - 27.5)$

$y = 2.4869x - 68.3898 + 55$

y=2.4869x − 13.3898

F-TEST

(1 & 17) Age Group & Average Weekly Work Hours

Hypothesis: *The number of hours an employee works per week varies significantly with age group.*

H0: There is no significant relationship between age group and average weekly work hours.

H1: Younger employees tend to work longer hours compared to older employees.

Age of respondents	10	30	50	20
Working hours per week	22	51	37	0

x	y	X^2	Y^2
10	22	100	484
30	51	900	2601
50	37	2500	1369
20	0	400	0

$\overline{x_1} = \frac{\Sigma x}{n_1}$

$= \frac{110}{4} = 27.5$

$\overline{x_2} = \frac{\Sigma y}{n_2}$

$= \frac{110}{3} = 36.6$

$$S_1^2 = \frac{\Sigma x^2}{n_2} - (\overline{x_1})^2$$

$$= \frac{3900}{4} - 110^2$$

= 975 – 12100

= -11,125

$$S_2^2 = \frac{\Sigma y^2}{n_2} - (\overline{x_2})^2$$

$$= \frac{4454}{3} - 110^2$$

=1484.6 – 12100

=-10615.4

$$s_1^2 = \frac{n_1 s_1^2}{n-1}$$

$$= \frac{4 \times -11,125}{4-1}$$

$$= \frac{-44500}{3}$$

= -14833.3

$$s_2^2 = \frac{n_2 s_2^2}{n-1}$$

$$= \frac{3 \times -10615.4}{3-1}$$

$$= \frac{-31,846.2}{2}$$

= -15,923.1

$$F = \frac{S_1^2}{S_2^2}$$

$= \frac{-14833.3}{-15923.1}$ = 0.9315

Degree of freedom

Degree of freedom for the numerator (df_1) = N2 – 1 = 3 – 1 = 2
Degree of freedom for the numerator (df_2) = N1 – 1 = 4 – 1 = 3
The critical F-value
Significance level of α = 0.05
The critical value for two tailed test with df_1 = 2 and df_2 = 3
Using a F distribution table the critical F- value is approximately 9.55
Compare the calculator f statistic (0.9315) to the critical F- value (9.55).
In this case, 0.9315 < 9.55

Conclusion

Since the calculator F statistic (0.9315) is less than the critical F- value (9.55), we failed to reject the null- hypothesis.

Findings

Analysis of the survey responses.

- Majority of the respondents were male 69%, showing that workforce in the sample is mainly male.
- 30-40 years age group employees are 38%, which is the largest age group in the survey.
- 40% of the employees are working in the middle level job roles.
- 44% of the employees have been working for 4 to 7 years in the organization.
- 87% of the respondents says they rarely feel stressed or overwhelmed at work.
- 49% of the employees work from the office and others in hybrid or remote basis.
- 78% of the employees rated their well-being at work as excellent.
- 100% of the employees said their company ha well-being policies.
- 71% of the employees says they don't have time for their personal activities.
- 69% of the employees feel valued and supported in the organization.
- 37% of the respondents says they feel motivated while others gave different opinions.
- 63% of the employees are satisfied with their leaves they receive and others are not.
- 46% of the respondents work for 40 to 50 hours per week, which is shows a high workload.
- 44% of the employees often work on weekends.
- 69% of the employees said they can disconnect from their work during their personal time.
- 100% of the respondents would recommend their company as a workplace that supports well-being and work-life balance.

Suggestions

Based on the survey findings, the following suggestions are recommended to enhance employee well-being and promote better work-life balance at the organization:

1. **Introduce Flexible Work Policies**
   - Flexible Work Hours: As 100% of employees reported that flexible work hours are not available, it is advisable to implement flexible timing options. This can include staggered shifts or adjusted start and end times.
   - Hybrid Work Model: Where feasible, adopt a hybrid model that allows employees to work partly from home. This approach can help reduce stress, save commuting time, and improve overall balance.
2. **Improve Employee Well-Being Initiatives**
   - Mental Health Support: Continue providing access to counseling and mental health programs, as already appreciated by employees. These initiatives should be promoted actively to ensure maximum utilization.
   - Decrease Work Overload: Take into account transferring duties to make more time for personal interests, as 71% of workers feel they don't have enough time for them.

3. Encourage a Culture of Positive Work

- Encourage Downtime and pauses: To lower stress and boost productivity, encourage brief pauses while work.
- Recognition Programs: To keep employees motivated and satisfied with their jobs, periodically recognize and reward them.

1. **Improve Leave Policies**
   - Reevaluate Leave Structure 37% of respondents are dissatisfied with leave policies, compared to 63% who are. Determine whether more leave for mental health or personal reasons can be implemented.

5. Expand Opportunities for Career Advancement

- Training & Development: Provide educational opportunities to maintain staff engagement and lessen stress at work.
- Internal Mobility: To make work interesting and rewarding, let employees try out various positions within the company.

CONCLUSION

The study on work-life balance and workplace well-being emphasizes how crucial it is to provide a flexible and encouraging work environment. According to the findings, there are important areas that require development, especially in work-life balance, flexibility, and personal time management, even though many employees have positive feelings about certain aspects, such as job security and workplace well-being policies. By implementing flexible work arrangements, professional advancement possibilities, mental health support, and a balanced workload, companies such as chemical manufacturing company's can improve employee happiness. In addition to enhancing worker well-being, addressing these issues will result in increased engagement, decreased stress, and increased productivity. A balanced workplace promotes job happiness, lowers burnout, and eventually helps the business succeed.

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RESEARCH ARTICLE

Evaluation of Antioxidant Efficacy of 2,4,6-Octatrienoic Acid using *In vitro* Assays

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ABSTRACT

Medicinal plants are abundant in natural antioxidants capable of neutralizing reactive oxygen species (ROS). This research aims to investigate the ROS scavenging ability of 2,4,6-Octatrienoic acid through detailed *in vitro* analyses. The antioxidant properties of 2,4,6-Octatrienoic acid were thoroughly assessed using a diverse range of free radical scavenging methods, including DPPH (2,2-diphenyl-1-picrylhydrazyl), ABTS (2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)), hydrogen peroxide (H2O2), superoxide, and hydroxyl radical assays, as well as the ferric reducing antioxidant power (FRAP) assay. The compound revealed strong antioxidant activity, exhibiting results similar to that of reference standard, ascorbic acid. These findings reveal the potential of 2,4,6-Octatrienoic acid as a promising candidate for further investigation into its anti-carcinogenic properties, with future validation recommended through experimental studies on suitable cell lines.

Keywords: 2,4,6-Octatrienoic acid, Antioxidant, Reactive oxygen species.

INTRODUCTION

Oxidative stress arises from a disturbance in the intricate equilibrium between the body's oxidative and antioxidative mechanisms, typically causing from anexcessive generation of ROS, whichin turn accumulates oxidative damage by-products, thereby initiating the progression of numerous diseases. The major contributors to this phenomenon are

superoxide, hydrogen peroxide, and hydroxyl radicals, which actsas a central part in initiating oxidative stress [1]. The concentrations of ROS are precisely controlled, sustained at minimal levels, and balanced in a dynamic equilibrium under normal biological phenomenon. At these regulated levels, ROS serve an essential function as crucial signaling molecules, modulating cellular processes and governing various physiological activities. However, an overproduction of ROS that surpasses the cell's antioxidant defensesresults indisruptions of structure and function of cells, affecting critical biomolecules such as membranes, lipids, proteins, lipoproteins, and DNA [2]. Oxidative stress is thus serves as akey contributorin the development of numerous diseases, including cancer, cardiovascular and neurodegenerative disorders[3,4]. To counteract such deleterious effects, the body relies on an enzymatic and non-enzymatic mechanisms. Enzymes such as superoxide dismutase, glutathione peroxidase, and catalase are central to this defense, facilitating the breakdown of ROS into less reactive compounds [5,6]. Superoxide dismutase catalyzes the conversion of superoxide radicals into oxygen and hydrogen peroxide, while glutathione peroxidase reduces hydrogen peroxide to water and lipid peroxides to their respective alcohols, using reduced glutathione as a substrate. Catalase enhances this defense system by breaking down H_2O_2 into water and oxygen, especially when hydrogen peroxide is present at elevated concentrations. Non-enzymatic antioxidants, such as reduced glutathione itself, directly neutralize ROS, including hydroxyl radicals and singlet oxygen, thereby preventing cellular damage [7]. 2,4,6-Octatrienoic acid (Figure 1)is a notable bioactive compound of*Deschampsiaantarctica* (Antarctic hair grass), a resilient flowering plant native to the harsh Antarctic Peninsula [8]. *Deschampsiaantarctica* belongs to the Poaceae family and has evolved remarkable adaptations to endure extreme conditions, including freezing temperatures, high UV radiation, and severe winds. Among the bioactive compounds it synthesizes are polyunsaturated fatty acids, flavonoids, phenolic acids, and secondary metabolites like 2,4,6-octatrienoic acid. These compounds are pivotal for combating oxidative stress induced by UV radiation, which generates ROS in plant tissues [9,10]. The antioxidant activity of 2,4,6-Octatrienoic acid was comprehensively evaluated through a diverse range of free radical scavenging assays, including DPPH, ABTS, H_2O_2, superoxide, hydroxyl radicaland the FRAP assay.

MATERIALS AND METHODS

Chemicals

2,4,6-Octatrienoic acid was purchased from Sigma-Aldrich Private Limited in India, and the remaining chemicals were procured from Himedia Laboratories in Mumbai.

DPPH assay

The scavenging ability of 2,4,6-Octatrienoic acid for DPPH radicals was assessed by measuring the reduction in absorbance at 517 nm [11]. A 0.1 mM DPPH solution (333 µL) in methanol was combined with 1 mL of 2,4,6-Octatrienoic acid in Dimethyl sulfoxide (DMSO) at different concentrations. The mixture was shaken thoroughly and incubated at room temperature for 30 minutes. After incubation, the absorbance was recorded at 517 nm using a UV-visible spectrophotometer (Multiskan GO; Thermo Fisher Scientific). A decrease in absorbance of the reaction mixture correlated with a higher free radical scavenging activity.

DPPH radical scavenging activity was calculated as below

$$\text{Scavenging effect (\%)} = \frac{\text{Absorbance of control} - \text{Absorbance of test}}{\text{Absorbanceofcontrol}} \times 100$$

ABTS assay

The antioxidant efficacy of 2,4,6-Octatrienoic acid was evaluated using the ABTS radical scavenging method [12]. The ABTS solution was allowed to reach room temperature, and Trolox standards were prepared by diluting the stock solution with Assay Buffer. A dilution series was created, with assay buffer serving as the zero standard. Samples or Trolox standards, along with the 2,4,6-Octatrienoic acid working solution, were added to the assay plate. Following this, 100 µL of the ABTS solution was introduced, and the mixture was incubated for 5 minutes. The reaction was terminated by adding 50 µL of Stop Solution, and the absorbance was measured at 745 nm to evaluate the antioxidant activity.

$O_2^{\bullet-}$scavenging activity

The assay established by Nishikimi et al., was revised to evaluate the superoxide radical scavenging potential of 2,4,6-Octatrienoic acid [13]. This assay utilizes a coupling reaction between phenazinemethosulfate and nicotinamide adenine dinucleotide to generate superoxide radicals, which then reduce nitroblue tetrazolium, resulting in the formation of a purple formazan. The formazan formed was measured spectrophotometrically at 560 nm to assess the scavenging activity.

$OH^{\bullet}$ scavenging assay

The potential of 2,4,6-Octatrienoic acid to scavenge hydroxyl radicals was assessed using the technique outlined by Halliwell et al., [14]. This method relies on the hydroxyl radical's capacity to degrade deoxyribose, resulting in the production of substances that react with thiobarbituric acid (TBA), resulting in a pink color. The absorbance of the formed complex was recorded at 532 nm to assess its radical scavenging potential.

H_2O_2 Assay

The hydrogen peroxide scavenging potential of 2,4,6-Octatrienoic acid and ascorbic acid was analyzed following the approach outlined by Jayaprakasha et al [15]. This method relies on monitoring the decline in H_2O_2 concentration by measuring absorbance at 230 nm. In this procedure, a 20 mM hydrogen peroxide solution was combined with different concentrations of 2,4,6-Octatrienoic acid or ascorbic acid and allowed to react for 10 minutes. The absorbance at 230 nm was then recorded to assess the extent of hydrogen peroxide degradation.

FRAP Assay

Reducing power of 2,4,6-Octatrienoic acid was assessed using FRAP Method [16]. The FRAP assay was performed by adding 0.2 mL of methanolic extract (at concentrations of 0.1, 0.5, 1, and 2 mg/mL) to 3.8 mL of FRAP reagent, which was prepared by mixing sodium acetate buffer, TPZT, and FeCl3. After incubation at 37°C for 30 minutes, absorbance was measured at 593 nm. Results were expressed as milligram equivalents of FeSO4 per milligram of dry weight, with a calibration line established using FeSO4 concentrations of 0.0025, 0.005, 0.01, and 0.02 mg/mL.

STATISTICAL ANALYSIS

The data were presented as mean ± SD. The Student's t-test was performed to assess the statistical variances among the groups at each concentration. A p-value below 0.05 was considered as statistically significant. The graphical method was utilized to find out the IC_{50} concentration.

RESULTS AND DISCUSSION

This study investigated the antioxidant efficacy of 2,4,6-Octatrienoic acid using a series of specific colorimetric assays. The scavenging efficacy of 2,4,6-Octatrienoic acid was evaluated and compared to the standard reference compounds, ascorbic acid and trolox, specifically for the ABTS assay. Figures 2–7 illustrate the comparative free radical scavenging effects of 2,4,6-Octatrienoic acid against ascorbic acid across multiple assays. For the DPPH radical assay, the IC_{50} value of 2,4,6-Octatrienoic acid was 24 μg/ml, in comparison to 23 μg/ml for ascorbic acid. In the ABTS assay, 2,4,6-Octatrienoic acid showed an IC_{50} of 60 μg/ml, while trolox demonstrated a stronger activity with an IC_{50} of 52 μg/ml. For superoxide radicals (O2-·), the IC_{50} of 2,4,6-Octatrienoic acid was 34 μg/ml, slightly weaker than the 28 μg/ml observed for ascorbic acid. Similarly, the hydroxyl radical scavenging activity yielded an IC_{50} of 38 μg/ml for 2,4,6-Octatrienoic acid and 35 μg/ml for ascorbic acid. Hydrogen peroxide scavenging revealed an IC_{50} of 44 μg/ml for 2,4,6-Octatrienoic acid, whereas ascorbic acid exhibited a more potent activity with an IC_{50} of 36 μg/ml. The reducing power assay indicated an IC_{50} of 74 μg/ml for 2,4,6-Octatrienoic acid compared to 60 μg/ml for ascorbic acid, with the activity increasing proportionally to the concentration. Overall, 2,4,6-Octatrienoic acid exhibited significant scavenging activity against free radicals and hydrogen peroxide, with its effectiveness increasing as the concentration was increased, although its effectiveness was consistently lower than that of the reference compound, ascorbic acid and trolox. *In vitro* free radical scavenging assays are indispensable tools for assessing the antioxidant potential of

medicinal plants and their bioactive constituents. These assays offer significant and precise insights into the ability of natural compounds to neutralize ROS and other free radicals, which play a significant role in oxidative stress-related diseases such as cancer, cardiovascular disorders, and neurodegenerative conditions [17]. Over the last decade, researchers globally have increasingly relied on these assay systems to systematically evaluate and compare the ability of natural products to act as antioxidants, thereby advancing the discovery of novel therapeutic agents. The antioxidant efficacy of 2,4,6-Octatrienoic acid was comprehensively evaluated using a diverse array of *in vitro* assays. This systematic approach allowed for the assessment of its ability to mitigate oxidative damage through neutralization of key radicals, including DPPH, ABTS, superoxide anions, hydroxyl radicals, and hydrogen peroxide. The findings of this study underscore the potential of 2,4,6-Octatrienoic acid as a bioactive compound with promising antioxidant properties, paving the way for further exploration of its therapeutic applications and mechanisms of action. In recent years, the DPPH assay has become a reliable method for evaluating the antioxidant potential of natural compounds under in vitro conditions [18]. This assay works by measuring the reduction of the stable DPPH radical, which has a deep violet color due to its broad absorption spectrum. When a hydrogen atom donor is introduced, the DPPH radical is reduced to its hydrazine form, causing a color change from violet to pale yellow, which is quantitatively assessed using UV-Vis spectroscopy. As a result, the DPPH assay serves as a tool for evaluating the antioxidant capacity of plant extracts and active constituents. In this study, 2,4,6-octatrienoic acid demonstrated strong DPPH radical scavenging activity, highlighting its potential as a promising antioxidant agent. The ABTS assay is widely recognized method for assessing antioxidant activity and to evaluate the antioxidant efficacy of both hydrophilic and lipophilic compounds. ABTS radicals were generated by reacting ABTS with potassium persulfate under dark conditions. The resulting stable radical solution was then diluted and used to determine the antioxidant efficacy of test compounds by measuring the reduction in absorbance at 734 nm [19]. The present results reveals the strong ABTS scavenging potential of 2,4,6-octatrienoic acid.

Superoxide radicals ($O_2^{\bullet-}$) are highly reactive and can convert into hydroxyl radicals ($OH^{\bullet}$), which cause extensive damage to DNA and other cellular components. This oxidative stress contributes to the progress of various diseases such as cancer and neurodegenerative disorders [17]. Antioxidants that scavenge superoxide radicals prevents cell damage and disease progression. The test compound's ability to scavenge superoxide radicals is evaluated by its capacity to facilitate the conversion of NBT into purple-colored NBT diformazan through the action of superoxide radicals [20]. The current study observed that 2,4,6-Octatrienoic acid exhibits a notable capacity to effectively scavenge superoxide radicals. This remarkable ability underscores its potential as a potent antioxidant capable of neutralizing superoxide radicals, thereby mitigating oxidative stress and its associated cellular damage. Hydroxyl radicals ($OH^{\bullet}$) are highly reactive ROS that damage proteins by breaking disulfide bonds, disrupting their structure and function. They also initiate lipid peroxidation in cell membranes, damaging unsaturated fatty acids and producing lipid peroxides [21]. This leads to changes in membrane fluidity and permeability, impairing cellular functions such as transport and signaling, which can contribute to diseases like cancer and neurodegenerative disorders. The present study found that 2,4,6-Octatrienoic acid demonstrated significant efficacy in scavenging hydroxyl radicals under *in vitro* conditions. This ability highlights its potential as a protective agent for cellular membranes, offering a defense against oxidative stress-induced damage. By neutralizing these highly reactive species, 2,4,6-Octatrienoic acid maintains the membrane integrity and cellular stability under oxidative conditions. Hydrogen peroxide (H_2O_2), a byproduct of normal cellular metabolism, becomes harmful when overproduced, leading to oxidative stress. It can be converted into highly reactive hydroxyl radicals ($OH^{\bullet}$) through Fenton's reaction, which causes significant damage to proteins and cell membranes. These hydroxyl radicals can alter protein structure, initiate lipid peroxidation, and disrupt membrane integrity, impairing cellular functions [22]. This oxidative damage is linked to the development of diseases such as cancer, neurodegenerative disorders, and cardiovascular conditions. Thus, controlling H_2O_2 levels is essential to prevent such diseases [23].The present study observed that 2,4,6-Octatrienoic acid demonstrated the capacity to effectively scavenge H_2O_2 under *in vitro* conditions, thereby protects ROS mediated cell damage. FRAP assay is widely utilized analytical procedure for quantifying the antioxidant ability of bioactive compounds andrelies on the reduction of Fe^{3+} to Fe^{2}, resulting in formation of a colored ferrous-tripyridyltriazine complex. The intensity of the resulting color, which directly correlates with the compound's reducing potential, is precisely quantified via spectrophotometric analysis at an optimal wavelength, ensuring high sensitivity and reproducibility[24].In the present investigation, 2,4,6-Octatrienoic

acid exhibited exceptional ferric-reducing capacity, underscoring its efficacy as a potent free radical scavenger. This remarkable activity highlights the compound's electron-donating ability, which is critical for neutralizing ROS and mitigating oxidative damage. The present study thus explores the promising *in vitro* free radical scavenging ability of 2,4,6-Octatrienoic acid. The antioxidant efficacy of 2,4,6-Octatrienoic acid was much comparable to that of ascorbic acid which suggests its capacity to mitigate oxidative stress.

CONCLUSION

The present findings explores2,4,6-Octatrienoic acid as a promising natural antioxidant. This antioxidant potential needs to be further evaluated in *in vitro* and *in vivo* experimental model to validate its effect on oxidative stress related disorders.

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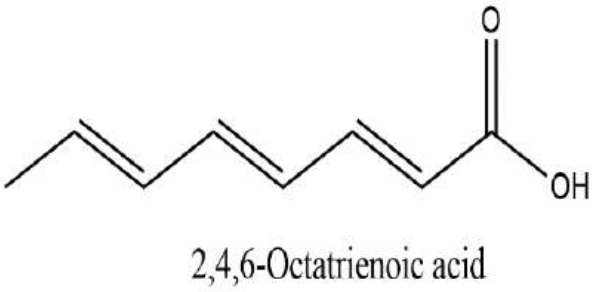


Figure 1:Structure of 2,4,6-Octatrienoic acid

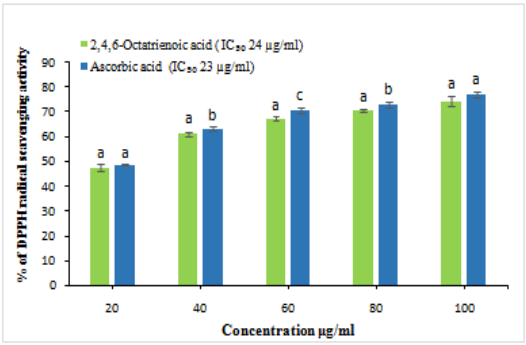


Figure 2: Scavenging activity of 2,4,6-Octatrienoic acid against DPPH radicals was compared to ascorbic acid (standard). Two distinct superscript letters at each concentration differ at $p < 0.05$.

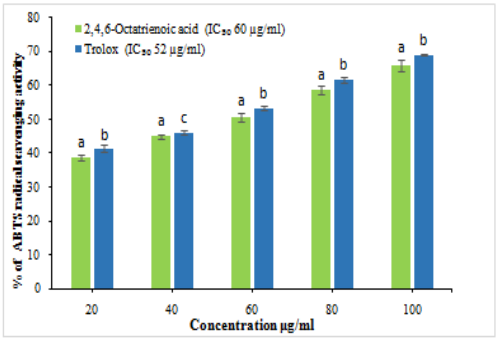


Figure 3:Scavenging activity of 2,4,6-Octatrienoic acid against ABTS radicals was compared to ascorbic acid (standard). Two distinct superscript letters at each concentration differ at $p < 0.05$.

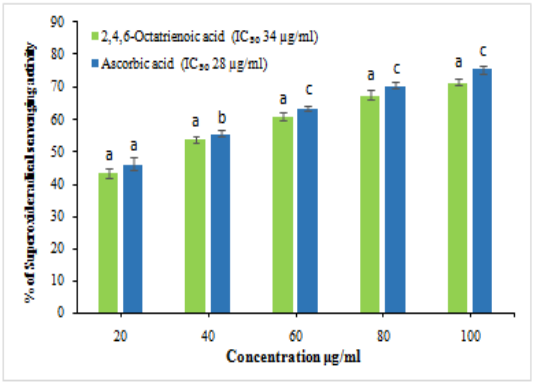


Figure 4: O_2•- scavenging potential of 2,4,6-Octatrienoic acid was compared to ascorbic acid (standard). Two distinct superscript letters at each concentration differ at $p < 0.05$.

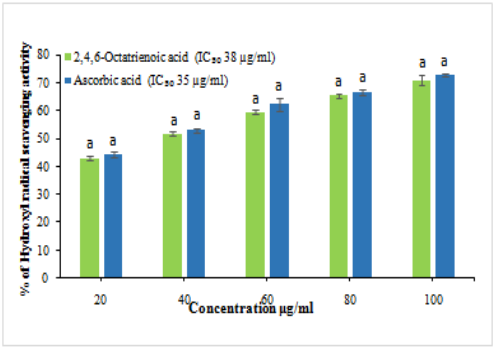


Figure 5: OH˙ scavenging potential of 2,4,6-Octatrienoic acid was compared to ascorbic acid (standard).Two distinct superscript letters at each concentration differ at $p < 0.05$.

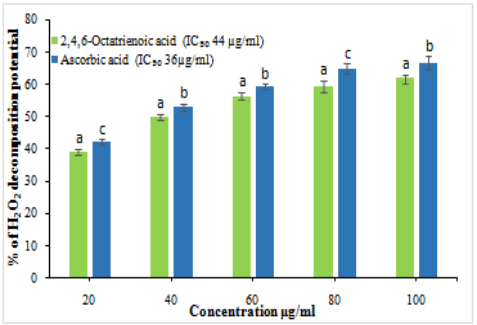


Figure 6: H_2O_2 scavenging potential of 2,4,6-Octatrienoic acid was compared to ascorbic acid (standard).Two distinct superscript letters at each concentration differ at $p < 0.05$.

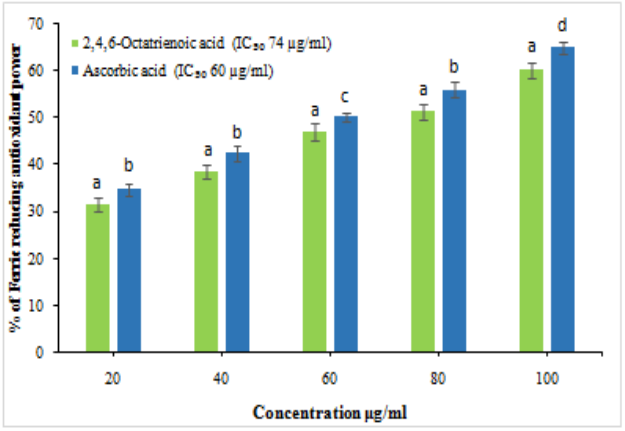


Figure 7: Reducing power efficacy of 2,4,6-Octatrienoic acid was compared to ascorbic acid (standard).Two distinct superscript letters at each concentration differ at $p < 0.05$.

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RESEARCH ARTICLE

Unlocking the Power of Oregano: Antimicrobial, Antioxidant, and Therapeutic Properties

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ABSTRACT

Oregano (*Origanum vulgare*) has been increasingly recognized for its significant antibiotic properties, offering promising alternatives to conventional antimicrobial agents. This review article examines the spectrum of antibiotic activity associated with oregano, focusing on its active constituents, particularly carvacrol and thymol, and their mechanisms of action, also several other benefits such as antifungal, anticancer, anti-oxidant, anti-parasitic therapeutic effects using oregano in the form of an essential oil, extract and powder. We analyse recent studies evaluating oregano's effectiveness against a range of pathogens, including both Gram-positive and Gram-negative bacteria, as well as its potential in combating antibiotic-resistant strains. The review also explores the safety profile, and potential synergistic effects of oregano oil with other antibiotics. By synthesizing current research, this article aims to provide a comprehensive overview of oregano's therapeutic potential, highlight areas for further investigation, and discuss its role in the broader context of antimicrobial resistance and natural product-based therapies.

Keywords: Oregano, anti-microbial, oregano essential oil, anti-oxidant actrivity, anti-biotic resistance

INTRODUCTION

The increasing incidence of antibiotic-resistant bacteria has heightened the quest for alternative antimicrobial drugs that may successfully treat infections while halting the growth of resistance. In this context, natural materials have garnered a lot of attention as potential sources for novel antibiotics. Antibiotic resistance is one of the problems that have made it more challenging to effectively manage dangerous bacteria in recent years. The World Health Organization has recognized antimicrobial resistance (AMR) as a significant global public health concern. The overuse and/or abuse of antibiotics in veterinary medicine, animal agriculture, and human health is the cause of the sharp rise in AMR. As a result, studies on substitute agents have started, with one method including natural raw materials. Since germs are becoming more and more resistant to previously recommended medications, the creation of new medications seems to be the most important prerequisite for managing them at the time. [1, 2] Of them, oregano (*Origanum vulgare*) has emerged as a particularly intriguing candidate due to its well-established antibacterial properties. [3] Belonging to the Lamiaceae family, oregano has long been prized for its culinary and therapeutic uses. The main components that give the plant its antibacterial properties are thymol and carvacrol, two of its many bioactive chemicals. The effectiveness of these phenolic chemicals against viruses, bacteria, fungi, and other harmful microbes has been shown to be broad-spectrum. The natural essential oil derived from oregano plants contains terpinene, thymol, cymene, and carvacrol. [4] The compositional profile of essential oils from throughout the world has been determined by several investigations. Region, climate, growth type, extraction/analytical techniques, and vegetation time all affect the composition. [5, 6, 7]Artificial antioxidants such as butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) have been linked to some negative effects on food preservation. Natural extracts have been used more frequently in recent years because of their ability to enhance personal health and combat diseases, cancer, and atherosclerosis. Numerous research has examined the essential oil makeup of several aromatic and therapeutic crops. In [8], recent studies on the application of essential oils in animal nutrition have concentrated on how they may enhance growth performance, rumen fermentation, and nutrient absorption.

Oils, which are frequently obtained from plants, contain substances including phenols, terpenes, and aldehydes that may have bioactive qualities that affect metabolism, digestion, and the microbial balance of the rumen. [9, 10, 11, 12, 13] Recent research has provided insight into how oregano essential oil produces its antibiotic properties, with particular attention to how it may damage microbial cell membranes, disrupt enzyme activity, and impede bacterial quorum sensing. Since its components may provide an alternative or distinct approach to conventional antibiotics, oregano's potential to address the problem of antibiotic resistance has attracted more study attention. This article aims to provide a comprehensive evaluation of oregano's antibiotic properties along with several other characteristics, including a list of its active constituents, the degree of its antimicrobial activity, and its medicinal applications. Because of its well-established antibacterial and antifungal qualities, oregano essential oil is highly valued for use in food, agriculture, and animals. [14, 15] The fragrant perennial herb oregano (*Origanum vulgare*), which is a member of the Lamiaceae family of mints, is valued for both its flowering tops and its tasty dry leaves. Native to the hills of western Asia and the Mediterranean, oregano has migrated to parts of the US and Mexico. The herb is essential to Mediterranean cooking and has long been used to season a wide range of meals. For instance, Greek or Italian oregano is a culinary variety with a strong aroma and a warm, strong flavor. Oregano is a perennial plant that looks like a herb and has spherical, green leaves. Although it can occasionally be grown as a perennial for three to four years, oregano is usually planted as an annual in the colder northern regions. [16]

The Background of Oregano

Typical name: Oregano

Known in Latin as *Origanum vulgare*

Other names include European oregano, wild marjoram, and Spanish thyme.

Since oregano was first grown in Greece, the Greeks were the first to use it. They believed that this plant was created by the Goddess Aphrodite. She wanted it to symbolize happiness as it blossomed in her yard. The English term oregano comes from the Greek words oros, which means "mountain," and ganos, which means "joy," or "joy of the

mountains." Later, the Romans adopted oregano due to its flavor and ease of production. Their love for the plant helped make it popular throughout Europe and Northern Africa. In medicine throughout the Middle Ages, oregano was frequently used. To treat a range of ailments, such as rheumatism, toothaches, indigestion, and coughing fits, they would chew the oregano leaves. During this time, Oregano also visited China. It was also used for medicinal purposes in this area. The Chinese believed it helped with fever, vomiting, and stomach issues. Throughout the Elizabethan era, oregano was used for practically everything. It was used to encourage luck and good health. Spells for protection, peace, happiness, health, luck, and letting go of a loved one all included it. It was also worn while sleeping to give one telepathic dream. In the United States, oregano did not gain popularity until the conclusion of World War II. The herb was discovered by soldiers during the Italian Campaign and returned to the United States.
Culinary Uses: Italian cookery is where oregano is most frequently used. It is a necessary ingredient in pizza sauces, tomato sauces, vegetable meals, and the seasoning of grilled meat. Oregano is a great substitute for marjoram or thyme if you don't have either in your spice cabinet.

Medicinal Uses

According to the ancient Greeks, oregano may also be used as a poison counter. Convulsions, dropsy, infections, and skin irritations were all treated with it. They also used it to counteract the effects of narcotic poisons. Oregano has been used to cure a variety of ailments, such as diarrhea, upset stomach, and nausea. Oregano is also used to treat arthritis and joint and muscle aches and discomfort because to its antibacterial and anti-inflammatory properties. [17] Oregano is one of the most valuable spices in the world in terms of trade. Oregano's name comes from the ancient Greek terms "Oros" and "Ganos," which mean "the beauty of the mountains," respectively. Oregano is the popular term for a wide-ranging taste and scent that characterizes a plant that is cultivated on its own all over the world. The primary source of oregano, a spice used all over the world, is more than 60 plant species. The Lamiaceae family comprises the majority of them. European oregano is used to season meat and meat-based products like sausages, as well as to season salads, stews, sauces, and soups. The leaves and essential oil (EO) are also used in culinary products, cosmetics, and alcoholic liqueurs. In addition to being considered therapeutic plants, oreganos from Mexico and India are mostly used as food flavourings. 39 species of the European genus *Origanum* are widely distributed in the Mediterranean area, according to Vokou and Kokkini (1993). Although O. *dictamnus* is native to the island of Crete in southern Greece, the species most frequently found there is *Origanum vulgare*. In calcareous soils, oregano plants, which are perennial herbs, grow well on their own. While *origanum* plants have numerous glands covering their aerial vegetative organs (stems, leaves, and bracts), their reproductive organs (calyces and corollas) contain fewer glands. The main components of oil, the monoterpenes carvacrol and thymol, are what give the essential oil released by these glands its unique scent. The *gynoecium* and stamens of the flowers have not been reported to contain glandular hairs (Padulosi, 1997). Several stems, erect or ascending, petiolate or subsessile leaves, and flowers arranged in loose or dense spikes that form a paniculate or corymbiform inflorescence are characteristics of Origanum species, which are subshrubs or perennial plants. Understanding the immense morphological and chemical variation of the genus *Origanum*, as well as the natural distribution of all its taxa, would enable full exploitation of this most promising crop.Aromatic plants, commonly known as herbs and spices, such as oregano, have a variety of bioactive compounds with strong antibacterial, antiparasitic, cytotoxic, and antioxidant qualities (Christaki et al., 2012; Giannenas et al., 2013; Sivropoulou *et al*., 1996). Not only do they serve as a spice, but they are also commercially significant for human and animal nutrition. [18] Investigating and gathering *Origanum vulgare* accessions and populations is a crucial first step in preserving the species' genetic diversity. Leto and Salamone (1997) collected 214 biotypes from 24 places around the Mediterranean and conserved them for ex-situ conditions. The diverse morphologies of the biotypes demonstrated notable variance.

Pharmacognosy of *Oreganum vulgare*

Botanical characteristics

- Kingdom: Plantae
- Family: Lamiaceae
- Genus: Origanum
- Species: O. vulgare

Phytochemistry

- Essential oil (3.5%): carvacrol, thymol, p-cymene, y-terpinene
- Phenolic acids: rosmarinic, caffeic, quinic
- Flavonoids: luteolin, apigenin
- Terpenes: ursolic, oleanolic acid

Pharmacological activities

- Antimicrobial: antibacterial, antifungal, antiviral
- Anti-inflammatory
- Antiparasitic
- Wound healing
- Digestive aid
- Immune system support
- Anti-cancer properties

Parts used-

- Leaves
- Aerial parts
- Essential oil

Antioxidant activity

Oregano is a good source of natural antioxidants that might be used in the food and pharmaceutical sectors as a safer alternative to manufactured antioxidants. [19, 20] The DPPH method indicates that the oregano herb's essential oil has an antioxidant activity of about 60–70%. [21, 22] The stable DPPH radical is commonly used to evaluate the antioxidant activity of specific chemicals and extracts derived from plant material. We were able to observe a high degree of antioxidant activity at the reduction of free radicals (>71%) by using this approach. An OE fraction of carvacrol, terpinen-4-ol, and γ-terpinene was discovered by Olmedo et al. to have a similar high ability to scavenge free radicals (77.2%). The significant antioxidant activity of the essential oil isolated from O. vulgare L. ssp. Hirtum was confirmed using three different methods, including the DPPH method. [23, 24] High concentrations of thymol, carvacrol, or both are associated with the action of oregano essential oil. Because of the way the compounds are structured, carvacrol and thymol may both trap free radicals and produce stable forms that don't show radical activity. The active molecules in oregano have a lower reduction potential than free radicals because of their aromatic ring. Additionally, they have the ability to transfer hydrogen to the free radical from the aromatic ring's hydroxyl group, rendering it inactive. [25, 26] Oxidative stress, which happens when the body has too many free radicals and not enough antioxidants, can lead to aging-related disorders. The medicinal herb *Origanum vulgare*, sometimes referred to as oregano, is well-known for its antioxidant qualities and other health advantages. The study discovered that oregano retains more of its antioxidant activity when consumed in an encapsulated form as opposed to when taken as a split powder, indicating that the encapsulated form is more beneficial to health. [27]

The technique employed, the oil's content, and the particular characteristics of the antioxidants under investigation all affect how potent oregano essential oil is as an antioxidant. According to the research, oregano oil has potent antioxidant properties in various fractions, especially those that include thymol and carvacrol. This might make oregano oil a useful natural food additive that helps maintain food quality. This emphasizes how crucial it is to measure antioxidant activity at different doses in order to make precise judgments on their efficacy. [28] Foods and plants rich in polyphenols have received particular interest due to their many biological effects, particularly their antioxidant activity. Strong antioxidant activity has been demonstrated by the phenolic compounds found in *Oreganum vulgare*, most of which include phenolic moieties such 3,4-dihydroxyphenyl, 4-(b-D-glucopyranosyloxy) benzyl alcohol (gastrodin), and 3-(3,4-dihydroxyphenyl) lactic acid (danshensu). [29, 30, 31] 4-(3,4-Dihydroxybenzoyloxymethyl) phenyl-O-β-d-glucopyranoside (DBPG), a polyphenolic glycoside of *Origanum vulgare*, has been shown to have the capacity to scavenge 1,1-diphenyl-2-picrylhydrazyl (DPPH). [32]

Oregano oil is a possible substitute for the synthetic antioxidants now used in the industry because of its strong antioxidant qualities, which have been shown in several research conducted in recent years. [33, 34, 35, 36] Rosemary acid ester, found in oregano oils, has strong antioxidant qualities. Ruberto analyzed the components of oregano essential oils from four different Algerian regions and discovered that all four types of essential oils showed strong antioxidant qualities, even at very low concentrations [100 ppm (1 ppm=1 mg/L)].[37, 38, 39]

Anti-microbial activity

Studies on natural resources and essential oils have shown varied levels of antibacterial activity as a result of growing knowledge of the benefits of employing natural antimicrobials rather than manufactured ones. [40, 41, 42] The hunt for new antimicrobial agents has become essential due to the development of resistance to the already recognized antimicrobial compounds. There is a dearth of research on the production and antibacterial properties of economically important aromatic crops grown in the Western Himalayas. [43] Numerous dangerous bacteria, including both Gram-positive and Gram-negative species, have been demonstrated to be successfully killed by *origanum vulgare* essential oil, sometimes referred to as oregano oil. [44, 45] Two substances that make up a sizable amount of the oil, carvacrol and thymol, are primarily responsible for its antibacterial qualities. These substances cause the bacterial cell membranes to become more permeable, which results in the loss of vital ions and molecules and, eventually, the death of the bacteria.[46, 47, 48, 49]. Many active metabolites of Origanum, including as p-cymene, c-terpinene, thymol, and carvacrol, have antibacterial qualities. Thymol and carvacrol are the main components of oregano oil, and both have antibacterial qualities. [50, 51, 52] The main phenolic components of OEO are most suited to treat salmonella infections and can also successfully cure bacterial disorders in the digestive tracts of animals and poultry, especially those caused by intestinal Escherichia coli. Oregano essential oil can also help prevent coccidiosis. [53]

Antifungal activity

Storage molds known as Penicillium species are frequently isolated from stored goods. Their substrate moisture requirements are lower (13–18%), but their temperature requirements are higher. [54, 55]At an extract concentration of 2.5 mL/100 mL, the growth of P. *aurantiogriseum*, P. *glabrum*, and P. *brevicompactum* was completely inhibited throughout the course of 14 days of incubation. At the same dose, the growth of *Fusarium proliferatum*(81.71%), F. oxysporum(85.84%), F. *verticillioides*(86.50%), P. chrysogenum(86.2%), and F. *subglutinans* (88.85%) was suppressed. [56]

RESULT

There are several significant considerations when contrasting oregano as a therapeutic agent with traditional medications:

Spectrum of Activity

Conventional medications: Conventional medications often target specific bacteria or illnesses and have well-defined procedures. While certain antibiotics, like penicillin, target the production of bacterial cell walls, others, like ciprofloxacin, impede DNA gyrase. These drugs are often designed to effectively treat certain illnesses. [75]

Oregano

Oregano contains thymol, carvacrol, and other compounds that have broad-spectrum antibacterial properties. Among other pathogens, they are effective against bacteria, fungi, and viruses. This broad action can be advantageous for many illnesses.

Mechanism of Action

- Conventional drugs: The structures or functions of microbes are often the target of conventional drug mechanisms. However, these targeted pathways can sometimes lead to resistance as bacteria adapt.

- Oregano: Among other things, oregano disrupts microbial communication, degrades cell membranes, and suppresses enzyme function. These diverse activities may reduce the likelihood of resistance development.

Resistance Development

- Conventional drugs: One major problem is antibiotic resistance. Overuse and misuse cause resistant strains to evolve, making sickness treatment more difficult.
- Oregano: Although it is not impervious to resistance, its complex combination of active ingredients may offer a lower risk of resistance than single-target synthetic drugs. Research on oregano's ability to prevent resistance is ongoing.

Side Effects and Safety

Conventional medications: Conventional medications can have major side effects that vary from modest gastrointestinal issues to severe allergic responses or long-term health consequences. The safety profiles of the medication and the patient may differ.

Oregano

Oregano has fewer documented side effects and is generally considered safe when used as directed. However, excessive usage or high dosages may cause gastrointestinal upset or allergic responses in certain individuals.

Regulatory Status and Standardization

- **Conventional Drugs**: Health agencies, such as the FDA and EMA, have strict testing, regulation, and approval procedures for conventional drugs. Their efficacy, safety, and potency are standardized.
- **Oregano**: Since oregano is a natural product, its quality can differ according on the extraction process, plant source, and preparation methods. Less strict standardization may result in variations in safety and efficacy.

Applications

- **Conventional Drugs**: Based on substantial clinical research and data, they have set dosages, indications, and treatment procedures.
- **Oregano**: An herb used in cooking as well as medicine. Although promising, its therapeutic applications are not as well defined, and more research is needed to determine the best dosages and treatment plans.

Complementary Use

- **Conventional Drugs**: Frequently employed in medicine as first-line therapies.
- **Oregano**: Has the potential to improve overall therapeutic outcomes and lessen dependency on medications when taken in conjunction with traditional treatments. The focused efficacy and proven safety profiles of conventional medications are still not replaced by oregano, despite the fact that it presents a promising natural substitute with broad-spectrum activity and a possible decreased risk of resistance. More research is required to completely comprehend its significance in modern medicine, although its usage as a supplemental treatment may bring extra benefits.

CONCLUSION

With its active ingredients thymol and carvacrol and others, oregano makes a strong case for being a natural antibiotic with broad-spectrum effectiveness. Its prospective uses in the treatment of fungal and bacterial infections demonstrate its worth as a supplemental or alternative therapy in contemporary medicine. Oregano also demonstrates its effectiveness as an antiviral, anticancer, and antioxidant substitute for medications. Though encouraging, it is crucial to utilize it carefully and under professional supervision to optimize positive effects and reduce negative ones

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Table: 1 – Description of oregano's formulation and studies performed

SR. NO.	Dosage Form	Used for	Mechanism	References
1	Powder	Anti-viral activity	To evaluate the reduction in Herpes simplex virus type-1 (HSV-1) infection, an antiviral experiment was conducted.	Santoyo S, Jaime L, García-Risco MR, Ruiz-Rodríguez A, Reglero G. Antiviral properties of supercritical CO2 extracts from oregano and sage. International journal of food properties. 2014 May 28;17(5):1150-61.[57]
2	Nanocubosomes	Alopecia areata treatment	A gel laden with finasteride, oregano oil, and nanocubosomesproduced a high release of finasteride, which enhanced drug penetration for a more potent therapeutic effect.	Hosny KM, Rizg WY, Alfayez E, Elgebaly SS, Alamoudi AJ, Felimban RI, Tayeb HH, Mushtaq RY, Safhi AY, Alharbi M, Almehmady AM. Preparation and optimization of aloe ferox gel loaded with Finasteride-Oregano oil nanocubosomes for treatment of alopecia. Drug Delivery. 2022 Dec 31;29(1):284-93. [58]
3	Powder	Hyperglycaemia & Hypertension	Combined with 3-7% chitosan oligosaccharide to increase antioxidant capability. Combining oregano with vitamin C results in a 1–10% increase in the inhibition of the alpha glucosidase enzyme. Combining oregano with vitamin C improves the inhibition of angiotensin converting enzyme by 40–5%.	Sarkar D, Pinto MD, Shetty K. Targeted Screening and Improvement of the Medicinal Properties of Oregano and Rhodiolawith Chitosan Oligosaccharide and Vitamin C Using In vitro Assays for Hyperglycemia and Hypertension Linked to Type 2 Diabetes. Journal of Herbs, Spices & Medicinal Plants. 2017 Oct 2;23(4):347-62. [59]
4	Powder	Coccidiosis	Growth inhibition of Clostridium perfringensin hens given a combination of oregano and food.	Waldenstedt L. Effect of vaccination against coccidiosis in combination with an antibacterial oregano (*Origanumvulgare*) compound in organic broiler production. ActaAgriculturaeScandinavica, Section A-Animal Science. 2003 Jun 1;53(2):101-9. [60]
5	Oil	Antibacterial activity	The total bacterial count dropped to 7.33% after eggshells were sterilized with oregano oil. Furthermore, the	Bekhet G, Khalifa AY. Essential oil sanitizers to sanitize hatching eggs. Journal

			hatchability of viable eggs increased by 96.21% in comparison to the control group.	of Applied Animal Research. 2022 Dec 31;50(1):695-701.[61]
6	Oil	Transient Receptor Potential channel activation	The method of in-situ hybridization was used. By increasing intracellular Ca2a+ levels, carvacrol, which is present in oregano, significantly activates and sensitizes the transient receptor potential (TRPV3).	Xu H, Delling M, Jun JC, Clapham DE. Oregano, thyme and clove-derived flavors and skin sensitizers activate specific TRP channels. Nature neuroscience. 2006 May;9(5):628-35.[62]
7	Oil	Antioxidant	The response surface method was used to extract Naringenin supercritical CO2 from oregano. Simulating gastrointestinal digestion reduces the antioxidant activity of naringenin.	Picos-Salas MA, Leyva-López N, Bastidas-Bastidas PD, Antunes-Ricardo M, Cabanillas-Bojórquez LA, Angulo-Escalante MA, Heredia JB, Gutiérrez-Grijalva EP. Supercritical CO2 extraction of naringenin from Mexican oregano (Lippiagraveolens): its antioxidant capacity under simulated gastrointestinal digestion. Scientific Reports. 2024 Jan 11;14(1):1146. [63]
8	Oil	Hepatic encephalopathy	High blood ammonia levels, oxidative stress, inflammation, brain swelling, and alterations in neurotransmitter levels are some of the causes of hepatic encephalopathy (HE), a disorder that can alter behavior and brain function. Oregano, or Origanumvulgare, is a plant that may help protect the liver and brain by lowering ammonia levels, avoiding severe liver damage, and easing neurological symptoms and inflammation. Consuming oregano may help reduce the onset of HE since research indicates that its preventive benefits are similar to those of silymarin, a recognized liver-protective chemical.	Abdelghffar EA, El-Nashar HA, Fayez S, Obaid WA, Eldahshan OA. Ameliorative effect of oregano (*Origanumvulgare*) versus silymarin in experimentally induced hepatic encephalopathy. Scientific Reports. 2022 Oct 25;12(1):17854. [64]
9	Nanoparticles	Insect repellent activity & insecticidal activity	Carvacrol and linalool nanoparticles showed insecticidal and repellent effects on Tetranychusurticea and Helicoverpaarmigera..	Campos EV, Proença PL, Oliveira JL, Pereira AE, de Morais Ribeiro LN, Fernandes FO, Gonçalves KC, Polanczyk RA, Pasquoto-Stigliani T,

				Lima R, Melville CC. Carvacrol and linalool co-loaded in β-cyclodextrin-grafted chitosan nanoparticles as sustainable biopesticide aiming pest control. Scientific Reports. 2018 May 16;8(1):7623. [65]
10	Oil	Bactericidal activity	Carvacrol exhibited bactericidal activity by rupturing the cell membranes of four different strains of Streptococcus pyogenes: ATCC 19615, ATCC 49399, a clinical isolate from a patient with pharyngitis, and Spy 1558.	Wijesundara NM, Lee SF, Cheng Z, Davidson R, Rupasinghe HV. Carvacrol exhibits rapid bactericidal activity against Streptococcus pyogenes through cell membrane damage. Scientific reports. 2021 Jan 15;11(1):1487. [66]
11	Nanocapsules	Antioxidant & anticancer activity	It was discovered that HepG2 and THLE2 cells were more vulnerable to the cytotoxicity of thymol and carvacrolnanocapsules. The DPPH radical scavenging experiment demonstrated thatOriganumglandulosumexhibited greater antioxidant activity.	Ali H, Al-Khalifa AR, Aouf A, Boukhebti H, Farouk A. Effect of nanoencapsulation on volatile constituents, and antioxidant and anticancer activities of Algerian OriganumglandulosumDesf. essential oil. Scientific Reports. 2020 Feb 18;10(1):2812. [67]
12	Oil	Antioxidant & Blood brain barrier decreased permeability	Carvacrol 200 mg/kg decreased cerebral edema and preserved the blood-brain barrier in traumatic brain injury-affected rats by increasing superoxide dismutase and total antioxidant capacity and decreasing reactive oxygen species and malondialdehyde.	Abbasloo E, Khaksari M, Sanjari M, Kobeissy F, Thomas TC. Carvacrol decreases blood–brain barrier permeability post-diffuse traumatic brain injury in rats. Scientific Reports. 2023 Sep 4;13(1):14546. [68]
13	Nanoemulsion	Oral microbiata infection treatment	Improved oral hygiene resulted from the antibacterial and antifungal activity of a natural oil-based oregano nanoemulsion with droplets 150 and 500 nm in size, up to 19 and 17 nm, respectively.	Hosny K, Asfour H, Rizg W, Alhakamy NA, Sindi A, Alkhalidi H, Abualsunun W, Bakhaidar R, Almehmady AM, Akeel S, Ali S. Formulation, optimization, and evaluation of oregano oil nanoemulsions for the treatment of infections due to oral microbiota. International Journal of Nanomedicine. 2021 Aug 13:5465-78. [69]
14	oil	Antibacterial activity	Antimicrobial activity against MSRA (Methicillin-resistant Staphylococcus aureus), a skin	Cui H, Zhang C, Li C, Lin L. Antibacterial mechanism of oregano essential oil.

			infection that spreads easily.	Industrial Crops and Products. 2019 Nov 1; 139:111498. [70]
15	Oil	Antiviral activity	Within one hour of exposure, oregano oil successfully inactivates the murine norovirus by first affecting the viral capsid and then the RNA.	Gilling DH, Kitajima M, Torrey JR, Bright KR. Antiviral efficacy and mechanisms of action of oregano essential oil and its primary component carvacrol against murine norovirus. Journal of applied microbiology. 2014 May 1;116(5):1149-63. [71]
16	Vapour of oregano oil	Microbial decontaminant	Surfaces contaminated by Staphylococcus aureus DSM 799 were in contact with food. Later, essential oil vaporsfrom oregano were used as a microbiological decontaminant. The proliferation of cells decreased.	Pinto L, Cervellieri S, Netti T, Lippolis V, Baruzzi F. Antibacterial Activity of Oregano (*Origanumvulgare* L.) Essential Oil Vapors against Microbial Contaminants of Food-Contact Surfaces. Antibiotics. 2024 Apr 18;13(4):371. [72]
17	Oil	Antifungal activity	The development of S. cerevisae was considerably suppressed by an oregano solution at a dose of 50 mg/ml for 24 hours (mean zone of inhibition = 29.10 mm).	Yotova I, Ignatova-Ivanova T. In vitro study of antifungal activity of oregano (*Origanumvulgare*). [73]
18	Oil	Antibacterial activity	Origanumvulgare L. (DIZ: 80 mm, MIC: 0.625µL/mL, MBC: 2.5µL/mL) and Origanumheracleoticum L. (DIZ: 39.67 ± 0.81 mm, MIC: 0.625µL/mL, MBC: 1.25µL/mL) essential oils may also exhibit similar effects to the positive medication Penicillin/Streptomycin 100X (DIZ: 34.13 ± 0.85 mm, MIC: 0.78125 µL/mL, MBC: 6.25 µL/mL).	Yuan Y, Sun J, Song Y, Raka RN, Xiang J, Wu H, Xiao J, Jin J, Hui X. Antibacterial activity of oregano essential oils against Streptococcus mutans in vitro and analysis of active components. BMC complementary medicine and therapies. 2023 Feb 21;23(1):61. [74]

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RESEARCH ARTICLE

Development and Evaluation of a Multipurpose Herbal Skin Cream for Dermatological Applications

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ABSTRACT

Herbal cosmetics are the kind of preparations used to improve a person's appearance. The current study set out to create a herbal cream with the potential to lighten, nourish, and moisturize skin while treating a range of skin conditions. The composition of the herbal cosmetics is harmless and can be applied as a barrier to shield skin. There are around 24 herbal ingredients I have discovered in these preparations. It was found that the product was stable, showing no symptoms of phase separation or color change. The cream was made by fusion method by using borax, liquid paraffin, and bees wax. A number of criteria, including appearance, pH, viscosity, washability, spread ability, and greasiness, were assessed for the created cream. In addition, the composition was simple to wash and did not produce redness or irritation in the tests of irritancy. The composition contains a few well-known herbs with hidden medicinal benefits, including liquoricemyrobalan , ringworm senna, Bawchan seed, and asthma plant. While working in the formulation of herbal cream that I found the medicinal significance of these plants. Herbal cosmetics are becoming more and more popular worldwide, and they are priceless gifts from nature. With 24 distinct herbal plant elements, I attempted to create a versatile herbal cream as a result.

Keywords: Herbal Drugs, Mango butter, Ring worm senna, Herbal multipurpose cream, Evaluations.

INTRODUCTION

Cream is a semisolid dosage form that has one or more pharmaceutical ingredients dissolved or distributed throughout an appropriate base. It is a skin-application preparation. Compared to the ointment, they have a lighter body and softer substance. There are two kinds of creams: aqueous and oily. These aqueous creams are o/w emulsions [1]. These are useful bases since they are water-washable. Herbal formulations have always drawn a lot of attention [2]. The term "herbal cosmetics" refers to cosmetics made with herbal elements that exhibit desired physiological effects, such as healing, appearance smoothing, stimulating, and conditioning qualities. The market for herbal cosmetics is growing right now. The materials known as cosmetics were developed to be applied to the human body in order to cleanse, beautify, enhance attractiveness, and change appearance without modifying structures or functions of the body [2]. Because they are used regularly in daily life and do not have the adverse effects that are frequently associated with synthetic products, herbal cosmetics are considered to have inherent acceptance and efficacy. The hydrating and viscoelastic qualities for the skin are enhanced by the herbal cosmetics. The herbs are rich in phytoconstituents with inherent goodness to meet the various needs of the skin. The current study attempted to create an herbal cream with 27, medicinal herbs that will nourish, lighten, moisturize, and treat a range of skin conditions. The composition of herbal cosmetics is harmless and can be applied as a skin-protecting barrier [3]. The 27 medicinal herbs are shown in [Table: 1] [4-27].

MATERIALS AND METHODS

Collection of leaf Materials

Herbal leafs are collected by hand pricking method.(NEEM, TULSI, AMMAN PACHARISI, RINGWORM SENNA, PHYLLANTHUS).The leafs are cleaned. Broken leaves and earthy materials are removed.

Drying of Leaves

After collection, the leaves are dried under shade (or) indoor method by spreading them in a thin layer. Drying takes place about 7-10 days under shade. The shade drying is preferred to maintain or minimize loss of color and texture. Low temperature should be employed, in case of medicinal plant material containing volatile substance. Drying condition should be recorded. After drying, the leaves are grind to fine powder. The powder is sieved by using suitable sieve with finest sieve number.

Collection of flower

Chrysanthemum flower - collected by Hand pricking method.

Drying of flower

Chrysanthemum flower -dried under shade (or) by indoor method.

Some further drug collections: (BAWCHAN SEED, FENUGREEK and BLACK CARAWAY)

The above drugs are collected from local medical shops. They are in dried solid form. These drugs are grinded and convert to smallest particle. Then sieved under finest sieve number to get finest form of these drugs.

Collection and preparation of Aloe Vera gel

Remove 3-4 leaves at a time, choosing thick leaves from the outer section of the plant. Ensure the leaves are neatly and free of any mold or damage. Cut them close to the stem, most of the beneficial nutrients are found at the base of the leaves. Avoid the roots. Wash and dry the leaves. Trim the pricky edges with knife. Using a knife (or) your fingers, separate the interior gel from the outside of leaf. The interior gel is the part of aloe that should be used. Allow the yellow sap to drain from the leaf; that is aloe vera latex. Then remove the latex, because it causes some irritation

effect. Cut the aloe into slices (or) cubes. And then put the slices (or) cubes in to blender or grinded well; to get the smooth gel; and collected it.

Method of preparation

Steps carried out in the preparation of multi-purpose skin cream were as follows. This skin cream was prepared by FUSION METHOD[28]. Weigh accurately all the ingredients [as mentioned in Table: 2] separately for oil and aqueous phase.

Preparation of oily phase

Take a china dish, in that Bees wax, Mango butter is melted, then to this add liquid paraffin and raise the temperature to 70^0 C. After that add the all ingredients and stir well.

Preparation of Aqueous phase

Take a beaker, dissolve the borax (weighed quantity) in the purified water, and add all the ingredients as weighed quantity. And heat the mixture; raise the temperature to 70^0C, and stir well. After the preparation of these two phases, they are placed in a separate container and covered with aluminum foil paper. Allow to stand for a week (7 days). During this period, the active constituents of the drugs get down into the appropriate phases. Because of this, the therapeutic activity of the formulation gets increased, and gives more beneficial results when it's applied, compare to normal method of preparation.

Mixing of phases

After a week, reheat the two phases separately up to the temperature 70^0C.And then, oil and aqueous phase was filtered by using muslin cloth separately. Then the aqueous extract was added to the oil phase in the 7:3 ratios. Stir well, it should be in uniform direction to avoid breaking of the emulsion, so care must be taken, and stir until to get the creamy texture.

ADDITION OF EXCIPIENTS

Other excipients (Jojoba oil, Almond oil, Amla oil, Rosemary oil, Grape seed oil, Carrot seed oil, and few drops of rose water) are added, at the temperature between 40^0C to 45^0C and stirred, until the cream has set. Stirring should be properly with even direction. Care must be taken to avoid excessive aeration as the preparation starts to thicken. Transfer the cream into well cleaned, dried container and close tightly to prevent dehydration.

EVALUATION OF CREAM [29]

1. **Physical properties**: The cream as observed for color, odour and appearance.
2. **Test for Thermal Stability:** Thermal stability of the formulation was determined by the humidity chamber controlled at 60-70% RH and 37±1^0C.
3. **Determination of pH:** _ 5± 0.01 g of the Cream was weighed accurately in a 100 ml beaker. 45 ml of water was added & dispersed the Cream in it. The pH of the suspension was determined at 27^0C using the pH meter.
4. **Stability studies:** Stability testing of drug products begins as a part of drug discovery and ends with the demise of the compound or commercial product. To assess the drug and formulation stability, stability studies were done according to ICH guidelines. The stability studies were carried out as per ICH guidelines. The cream filled in bottle and kept in humidity chamber maintained at 30± 2^0C/65±5%RH and 40±2^0C/75±5% RH for six months. At the end of studies, samples were analyzed for the physical properties and viscosity.
5. **Patch test:** About 1-3gm of material to be tested was placed on a piece of fabric or funnel and applied to the sensitive part of the skin e.g. skin behind ears. The cosmetic to be tested was applied to an area of 1sq.m of the skin. Control patches were also applied. The site of patch is inspected after 24 hrs.
6. **Spreadability studies:** An important criteria for semisolids is that it posses good spreadability. Spreadability is a term expressed to denote the extent of area to which the cream readily spreads on application to the skin. The therapeutic efficacy of a formulation also depends on its spreading value. Samples were placed between two slides and crushed to a consistent thickness using a specific weight for a predetermined amount of time to

determine the prepared cream's spread ability. Spreadability was the measurement of the amount of time needed to divide the two slides. A shorter separation period between two slides indicated improved spreadability.

The spreadability was then calculated from the following formula

Spreadability = m ×l/t

m=weight tied to the upper slide

l=length of glass slide

t=time taken in seconds

7. **Test for microbial growth in herbal cream:** The formulated creams were inoculated on the plates of agar media by streak plate method and a control was prepared by omitting the cream. The plates were placed in to the incubator and are incubated at 37^0C for 24 hrs. After the incubation period, plates were taken out and check the microbial growth by comparing it with the control.
8. **Irritancy:** Mark the area ($1cm^2$) on the left-hand dorsal surface. Then the cream was applied to that area and the time noted. Then it is checked for irritancy, erythema, and edema if any for an interval up to 24 hr and reported.
9. **Dye test:** The test was done by mixing the cream with red dye the place the drop of cream was placed on a slide and covered with cover slip, observed under microscope. If the dispersion phase appears in red colored globules the cream was O/W type. If the continuous phase appears red color the cream was W/O type.
10. **Smear type:** The test was conducted after the application of cream on the skin the smear formed was oily or aqueous in nature.
11. **Removal:** The removal of the cream applied on skin was done by washing under tap water with minimal force to remove the cream.

RESULTS

The multipurpose herbal cream was prepared was shown in Figure.1 and evaluated. The evaluated parameters are given below.

1. **Physical properties ;** In this test, the cream was found to be of a pale green color and has characteristic odor and semi-solid creamy texture.[Table:3]
2. **Thermal stability and pH determination**: In this test, the thermal stability (at RH65% and 30±400C) was stable and no oil suspension. The pH of cream was found to be 6 to 8. [Table:4]
3. **Spread ability:** The spread ability of the herbal cream was compared with market cream. According to the results herbal cream (Spreadability-14.1, Time-15 sec) is more spreadable than market cream (Spreadability-13.7, Time-15 sec). [Table: 5]
4. **Irritancy test:** Mark the area (1cm) on left hand dorsal surface. Then the cream was applied to that area and the time was noted. No abnormal changes was found.[Table:6]
5. **Washability test:** Washability test was carried out by applying a small amount of cream on the hand and then washing it with tap water. The results was found to be easily washable.[Table:7]
6. **Accelerated stability studies:** The stability studies of various parameters like visual appearance, nature; pH of the cream was checked. The results were found to be no significant variation after 2, 4 and 6 months.
7. **Test for microbial growth in herbal cream:** Also this cream was tested for the presence of pathogenic micro-organisms by culturing it with agar medium. There was no signs of microbial growth after incubation period of 24 hrs at 37^oC.[Table: 8]
8. **Dye test of herbal cream:** The test was done by mixing the cream with red dye then place the drop of cream was placed on a slide and covered with cover slip, observed under microscope. The result was found to be no reaction. Also smear and patch test was checked. The result was found to be no reaction .[Table: 9]

DISCUSSION

The multi-purpose herbal skin cream of natural crude drugs with the best properties and having nutritional value was prepared by simple method with less equipment and effect. The prepared herbal creams have anti-oxidant and anti-bacterial activity due to this, it retards aging, signs and pimple formation on the face. It was found that this type of formulation of the multipurpose herbal cream was not prepared earlier. Cream was formulated using natural ingredients and was evaluated. From the study, it can be concluded that this cream can be used as a multipurpose cream and the ingredients mixed can produce synergistic effect of the other.

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CONFLICT OF INTERESTS

Declare none.

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Table 1: List of ingredients with its medicinal uses.

SI.NO	INGREDIENTS	ROLE
1.	Mango butter [4]	Active ingredients in skin care formulation & Active against UV sunlight rays and used as skin cream
2.	White bees wax [5]	Emollient, Emulsifier, Improvement of appearance, Consistency and Sensitivity to melting
3.	Liquid Paraffin [6]	Cleansing agent, Hydrating agent &Emollient
4.	Amman pacharisi powder [7]	Wound healing, Free radical, Scavenging, Anti-viral & Anti-microbial
5.	Tulsi powder [8]	Anti-oxidant, Anti-bacterial, Anti-viral & Anti-fungal
6.	Neem powder [9]	Treatment of eczema, Ringworm infection, Scabies & Psoriasis
7.	Bawchan seed powder [10]	Anti-bacterial, Anti-fungal, Anti-oxidant & Treat skin disease
8.	Ring worm senna Powder [11]	Astringent, Anti-bacterial, Fungicidal & Treat skin disease

9.	Nutmeg Seed powder [12]	Flavoring agent, Carminative & Anti spot
10.	Red Sandal powder [13]	Reduce or lighten pigmentation, Marks or scares. Anti- aging agent. Skin glowing, Control oiliness in face, Tighten the skin pores Anti-wrinkle property Prevent acne/pimples. Treatment of suntan and sun burns (Soothening).
11.	Turmeric powder [14]	Anti-microbial agent, Lightening agent & Moisturizer
12.	Wild turmeric powder [14]	Anti-acne, Anti-oxidant & Wound healing
13.	Chrysanthemum flower powder [15]	Anti-oxidants, Anti-wrinkle agents, Lightening and Whitening agents. UV filters sun screens Anti-bacterial activity & Anti-microbial action
14.	Fenugreek powder [16]	Anti-oxidant, Emollient, Skin healing, Whitening, Moisturizing, Skin smoothening & Anti-wrinkle effection
15.	Phyllanthus powder [17]	Anti-viral, Anti-bacterial Anti-microbial, Anti-oxidant & Astringent
16.	Myrobalan seed powder [18]	Anti-oxidant, Anti-cellular ageing, Astringent(melanin inhibition) & Depigmentation
17.	Black caraway powder [19]	Anti-aging, Anti-microbial, Anti-oxidant &Sun protection.
18.	Liquorice powder [20]	Anti- viral, Anti- bacterial, Skin whitening & Anti-oxidant.
19.	Aloe vera juice [21]	Moisturizing agent, Softening agent, Useful for healing & Provide UV protection.
20.	Jojoba oil [22]	Elasticity of the skin. Shortness of the surface lines and wrinkles. Skin became more elastic and smooth. This oil has a chemical composition similar to skin produces the sebum. It has moisturizing and soothing agent.
21.	Almond oil [23]	Anti-wrinkle, Moisturizer & Flavoring agent
22.	Amla oil [24]	Free radical assaying property, Prevent UV radiation on skin (photo aging) Impress elasticity of skin & Act against pimples
23.	Grape seed oil [25]	Clear greasy, Congested and acne skin while also helping the tissues get rid of cellulite & Drain acne excess retained wax.
24.	Carrot seed oil[26]	Anti-aging, Revitalizing, Rejuvenating. It promotes the formation of new cells and helps in reducing wrinkles. Natural toner and rejuvenator for skin.
25.	Rosemary oil [27]	Anti-microbial, Astringent, Antiseptic, Anti-oxidant, Hydrate and balance dry and oily skin, Eczema, Inflammation and acne
26.	Rose water [27]	Flavoring agent, Cooling agent & Emollient

Table.2: Ingredients and its Quantity for Formulation

SI.NO	INGREDIENTS	QUANTITY
1.	Mango butter	5 gm
2.	White bees wax	5 gm
3.	Liquid Paraffin	30 ml
4.	Amman pacharisi powder	1.5 gm
5.	Tulsi powder	1.5 gm
6.	Neem powder	1.5 gm
7.	Bawchan seed powder	1.5 gm
8.	Ring worm senna Powder	1.5 gm
9.	Nutmeg Seed powder	1.5 gm
10.	Red Sandal powder	1.5 gm

11.	Turmeric powder	1.5 gm
12.	Wild turmeric powder	1.5 gm
13.	Chrysanthemum flower powder	1.5 gm
14.	Fenugreek powder	1.5 gm
15.	Phyllanthus powder	1.5 ml
16.	Myrobalan seed powder	1.5 ml
17.	Black caraway powder	1.5 ml
18.	Liquorice powder	1.5 ml
19.	Aloe vera juice	9.5 ml
20.	Jojoba oil	Quantity sufficient
21.	Almond oil	Quantity sufficient
22.	Amla oil	Quantity sufficient
23.	Grape seed oil	Quantity sufficient
24.	Carrot seed oil	Quantity sufficient
25.	Rosemary oil	Quantity sufficient
26.	Rose water	Quantity sufficient
27.	Borax	0.5 gm

Table: 3 Physical properties of herbal cream

PROPERTIES	OBSERVATION
Color	Pale green
Odour	Characteristic
Appearance	Semi-solid creamy texture

Table 4: Thermal stability and pH determination

PARAMETERS	OBSERVATION
Thermal stability(at RH65% and 30±40^{0}C)	Stable, No oil suspension
pH (at 27^{o}C±2^{o}C)	6-8

Table 5: Spreadability test

FORMULATION	TIME(sec)	SPREADABILITY (gm/sec)
Herbal cream	15	14.1
Market cream	15	13.7

Table 6: Irritant test for herbal cream

FORMULATION	IRRITANT EFFECT	ERYTHEMA	EDEMA
Herbal cream	Nil	Nil	Nil

Table 7: Washability test for herbal cream

FORMULATION	WASHABILITY
Herbal cream	Easily washable

Table 8: Accelerated Stability Studies

MONTH/ TEST	HERBAL CREAM		
	AFTER 2 MONTH	AFTER 4 MONTH	AFTER 6 MONTH
Physical appearance	Semi-solid	Semi-solid	Semi-solid

Texture	Ok	Ok	Ok
Colour	Pale Green	Pale Green	Pale Green
Odour	Characteristic	Characteristic	Characteristic
pH value	6-8	6-8	6-8
Thermal Stability	Ok	Ok	Ok
Degradation of product	Nil	Nil	Nil

Table 9: Dye test, Patch and Smear test for herbal cream

PARAMETERS	OBSERVATION
Dye test Scarlet red	Nil
Patch test	No reaction
Smear test	No reaction



Figure.1 : Formulation of Herbal Cream

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RESEARCH ARTICLE

A Study on the Role of Economic Empowerment of Women in Rural and Semi-Urban Areas

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ABSTRACT

In the economic empowerment of women in rural and semi-urban settings is examined in this study, with a particular emphasis on socioeconomic determinants that affect their financial independence and involvement in income-generating activities. It looks at government policies, education, skill development, microfinance, and resource access that are meant to increase women's economic chances. The study analyzes the effects of self-help groups, job efforts, and entrepreneurship using both qualitative and quantitative methods, such as surveys. The study also looks at how self-help groups, or SHGs, have affected women's socioeconomic advancement in India, emphasizing gains in social standing, income, and household decision-making.

Keywords: qualitative and quantitative methods, empowerment of women, business growth , skill development

INTRODUCTION

In the process of giving women the abilities, assets, chances, and rights to fully engage in economic activity, make their own financial decisions, and enhance their financial well-being is known as economic empowerment of women. It guarantees women equal access to financial services, entrepreneurship, education, work, and real estate, allowing them to support social and economic advancement.

REVIEW OF LITERATURE

In the concept of microfinance and women empowerment is studied in many countries.

- **Ghosh, M., & Goswami, R:** It highlights improvements in household decision-making, increased income, and enhanced social status.
- **Ramya, L. P., & Kalluraya, P. S:** This review assesses various studies on SHGs and their impact on women's socio-economic empowerment, emphasizing poverty alleviation and financial inclusion.
- **Kanungo, R., & Agesty, M. P:**This case study investigates the role of SHGs in the economic empowerment of women in Ganjam District, Odisha, highlighting increased household income and active participation in decision-making processes.

NEED OF THE STUDY

Women in rural and semi-urban areas often face significant barriers to financial independence, including limited access to credit, lack of financial literacy, and socio-economic constraints. These challenges hinder their ability to start or expand businesses, invest in productive activities, and achieve long-term economic stability. Fusion Finance Limited, as a non-banking financial institution (NBFI), plays a crucial role in addressing these issues through targeted financial solutions.

SCOPE OF THE STUDY

The scope of this study includes:

Geographical Coverage

The study will focus on rural and semi-urban areas where Fusion Finance Limited operates.

Target Population

The study will examine women who have accessed financial services from Fusion Finance Limited.

Key Areas of Analysis

- Access to credit and financial services
- Impact on women's income and business growth
- Role of financial literacy and skill development
- Social and economic empowerment outcomes

OBJECTIVE OF THE STUDY

- To study the importance of fusion finance ltd in the economic empowernment of women in rural & semi-urban areas.
- To examine the process involved in fusion finance Ltd in the economic empowernment of women in rural & semi-urban areas.
- To analyse the methods used by fusion finance Ltd in the economic empowernment of women
- To study the different approaches of fusion finance Ltd in the economic empowernment of women
- To determine the benefits of fusion finance Ltd in the economic empowernment of women in rural & semi-urban areas.
- To study the roles of fusion finance Ltd in the economic empowernment of women.

LIMITATION OF THE STUDY

It is quite hard to manage the research work with the academics. The limitations of the study are:

- Time constraint is one of the major limitation so in depth research was not made possible.
- Respondents were very busy in their work so they gave answers in a hurry.

- The sample size is only 75, so the opinion may not reflect the exact scenario.
- In this study the survey was conducted to only FFL customers in Parameswaranallur, at Chidambaram branch.

RESEARCH DESIGN

It aims to provide an accurate portrayal of the subject under investigation without attempting to establish causal relationships. The study is intended to analyse "THE ROLE OF FUSION FINANCE LTD IN THE ECONOMIC EMPOWERNMENTOF WOMEN IN RURAL & SEMI-URBAN AREAS" Hence, analytical study has been adopted.

RESEARCH APPROACH

The survey approach is used during the research. Separate structured Questionnaire was used for achieving the aim of the study.

SAMPLING TECHNIQUES

Convenience sampling is used for this study.

SAMPLE SIZE

This study was carried out through FFL customers in Parameswaranallur, at Chidambaram branch.

SOURCE OF DATA

The data was collected through:

- Primary sources
- Secondary sources

Questionnaire

A Questionnaire comprising of 30 questions with multiple choices was framed for this study. The questionnaire was distributed to FFL customer's in Chidambaram branch.

Secondary sources

- Internet
- Magazines
- Journals
- Published records

STATISTICAL TOOLS

Statistical tools used in this study

- Mean
- Regression
- Coefficient of correlation
- U-Test

MEAN

The mean, often referred to as the average, is a measure of central tendency in a set of data. **OBJECTIVES**

To find out mean of monthly income

STEP 1:

MONTHLY INCOME	MIDPOINT (x)	NO. OF RESPOONDENTS (f)	(fx)
Below 5000 INR	2500	47	117500

5000 – 10000 INR	7500	13	97500
10000 – 20000 INR	15000	15	225000
Above 20000 INR	25000	0	0
TOTAL		**75**	**440000**

STEP 2:

$$\bar{x} = \frac{\sum fx}{N}$$

$$= \frac{440000}{75}$$

= 5866.67

CONCLUSION

The calculated value of mean is ₹5866.67

U – TEST

It assesses whether one group tends to have larger values than the other, without assuming a normal distribution of the data.

Null hypothesis (H_0)

There is no significant relationship between the transparency of hidden charges associated with the services provided by Fusion Finance Ltd Vs. would recommend the financial services of fusion finance to other women in the community.

The alternative hypothesis (H_1)

There is a significant relationship between the transparency of hidden charges associated with the services provided by Fusion Finance Ltd Vs. would recommend the financial services of fusion finance to other women in the community.

Transparency Of Hidden Charges	6	18	38	10	3
Recommend The Financial Services	30	18	15	7	5

STEP 1:

Transparency of Hidden Charges	**Recommend The Financial Services**
6	30
18	18
38	15
10	7
3	5

STPE 2:

Find the R_1 R_2

$n_1 = 5$, $n_2 = 5$

DATA = 6, 18, 38, 10, 3, 30, 18, 15, 7, 5

ASSENDING ORDER = 3, 5, 6, 7, 10, 15, 18, 18, 30, 38

R_1 = 1+3+5+7+10 = 26

R_2 = 2+4+6+8+9 = 29

Find U_1 U_2

$$\boldsymbol{U_1 = R_1 - \frac{n_1(n_1+1)}{2}}$$

$$= 26 - \frac{5(5+1)}{2}$$

$$= 26 - \frac{5\,(4)}{2}$$

$$= 26 - \frac{20}{2}$$

$$= 26 - 10$$

$$= 16$$

$$\boldsymbol{U_2 = R_2 - \frac{n_2(n_2+1)}{2}}$$

$$= 29 - \frac{5(5+1)}{2}$$

$$= 29 - \frac{5\,(4)}{2}$$

$$= 29 - \frac{20}{2}$$

$$= 29 - 10$$

$$= 19$$

$n_1 = 5$

$n_2 = 5$

Level of significant = 0.05
Two tailed U table value 2
Calculated value > Tabulated value
2 < 16
H1 is accepted.

CONCLUSION

Here is a**statistically significant relationship** between the transparency of hidden charges associated with the services provided by Fusion Finance Ltd and the respondents would recommend these financial services to others in the community.

CORRELATION OF COEFFICIENT

Correlation is used almost everywhere in statistics.

Null hypothesis (H_0)

There is no significant relationship between the interest rates and fees charged by Fusion Finance Ltd is comparatively less Vs. would recommend the financial services of fusion finance to other women in the community.

The alternative hypothesis (H_1)

There is significant relationship between the interest rates and fees charged by fusion finance ltd is comparatively less Vs. would recommend the financial services of Fusion Finance Ltd to other women in the community.

Interest Rates And Fees Charged	48	20	3	2	2
Recommend The Financial Services	30	18	15	7	5

STEP 1:

Interest Rates And Fees Charged (X)	Recommend The Financial Services(Y)	XY	X^2	Y^2
48	30	1440	2304	900
20	18	360	400	325
3	15	45	9	225
2	7	14	4	49
2	5	10	4	25
$\sum X = 75$	$\sum Y = 75$	$\sum XY = 1869$	$\sum X^2 = 2721$	$\sum Y^2 = 1524$

STEP2:

$$r = \frac{n(\sum xy) - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x)^2][n\sum y^2 - (\sum y)^2]}}$$

$$r = \frac{5(1869) - (75)(75)}{\sqrt{[5\,(2721) - (75)^2][5\,(1524) - (75)^2]}}$$

$$r = \frac{9345 - 5625}{\sqrt{(13605 - 5625)(7620 - 5625)}}$$

$$r = \frac{3720}{(7980)(1995)}$$

$$r = \frac{3720}{\sqrt{15{,}920{,}100}}$$

$$r = \frac{3720}{3990}$$

$$r = 0.932$$

CONCLUSION

There is a very high degree of positive correlation of interest rates and fees charged by fusion finance ltd is comparatively less andwould recommend the financial services of fusion finance to other women in the community.

REGRESSION

It aims to estimate the strength and direction of the relationship, as well as predict the value of the dependent variable based on the values of the independent variables. The most common type of regression is linear regression, but there are other types such as logistic regression for binary outcomes and polynomial regression for nonlinear relationships.

Null hypothesis (H_0)

There is no significant relationship between participating in financial education and training programs offered by Fusion Finance Ltd Vs. able make better decisions about savings and investments.

The alternative hypothesis (H_1)

There is a significant relationship between participating in financial education and training programs offered by Fusion Finance Ltd Vs. able make better decisions about savings and investments.

Participating In Financial Education And Training Program	56	6	7	4	2
Make Better Decisions About Savings And Investments	9	14	36	9	7

STEP 1:

Participating In Financial Education And Training Program (X)	**Make Better Decisions About Savings And Investments (Y)**	**X^2**	**Y^2**	**XY**
56	9	3136	81	504
6	14	36	196	84
7	36	49	1296	252
4	9	16	81	36
2	7	4	49	14
$\sum x = 75$	$\sum y = 75$	$\sum x^2 = 3241$	$\sum y = 1703$	$\sum xy = 881$

STEP2:

$$\bar{x} = \frac{\sum x}{N}$$

$$= \frac{75}{5} = 15$$

$$\bar{y} = \frac{\sum y}{N}$$

$$= \frac{75}{5} = 15$$

Regression coefficient of X on Y

$$bxy = \frac{N\Sigma xy - (\sum x)(\sum y)}{N\Sigma y^2 - (\sum y)^2}$$

$$= \frac{5\,(881) - (75)(75)}{5\,(1703) - (75)^2}$$

$$= \frac{4405 - 5625}{8515 - 5625}$$

$$= \frac{1220}{2890}$$

Regression coefficient of X on Y= 0.42

Regression equation of X on Y

$$x - \bar{x} = bxy(y - \bar{y})$$

$X - 15 = 0.42$ (y —15)

X —15 = 0.42 y — 6.3

x= 0.42y – 6.3 + 15

x = 0.42y + 21.3

Regression coefficient of Y on X

$$byx = \frac{N\Sigma xy - (\sum x)(\sum y)}{N\Sigma x^2 - (\sum x)^2}$$

$$= \frac{5\,(881) - (75)(75)}{5\,(3241) - (75)^2}$$

$= \frac{4405-5625}{16205-5625}$

$= \frac{1220}{10580}$

Regression coefficient of Y on X= $\mathbf{0.11}$

Regression equation of Y on X

$\mathbf{y - \bar{y} = bxy(x - \bar{x})}$

$Y - 15 = 0.11\ (X - 15)$

$Y - 15 = 0.11\ X - 1.65$

$Y = 0.11\ X - 1.65 + 15$

$\boldsymbol{Y = 0.11\ X + 13.35}$

$\sqrt{\boldsymbol{bxy} \times \sqrt{\boldsymbol{byx}}}$

$= \sqrt{0.42} \times \sqrt{0.11}$

$= 0.64 \times 0.33$

$= \mathbf{0.2112}$

CONCLUSION

There **is a positive relationship** between participating in financial education and training programs offered by Fusion Finance Ltd and making better decisions about savings and investments and so H1 is accepted

FINDINGS

- The majority (64%) of the respondents are using micro loans.
- The study shows the services provided by Fusion Finance Ltd are highly satisfactory with a majority (36%) of the respondents have rated as strongly agree.
- The study indicated that the overall performance of Fusion Finance Ltd in meeting the financial needs and expectations are highly satisfactory with a majority (51%) of the respondents.
- The study observed that the information provided by Fusion Finance Ltd is clear and easy to understand with a majority (44%) of the respondents.
- The study reveals that the majority (50%) of the respondents have stated that, Fusion Finance Ltd provides fair and transparent terms and conditions.

SUGGESTIONS

Access to Education and Skill Development

Suggestions

- Expand vocational training programs tailored to local industries (e.g., agriculture, handicrafts, small-scale manufacturing).
- Encourage participation in entrepreneurship development programs, especially for women-led startups.

Financial Inclusion and Access to Credit

Suggestions

- Facilitate access to microfinance institutions, self-help groups (SHGs), and cooperative banks with low-interest loans.
- Provide training on financial planning, savings, and investment strategies.

CONCLUSION

Economic empowerment of women in rural and semi-urban areas is a key driver of sustainable development, poverty reduction, and gender equality. By providing women with access to education, financial resources, skill development, and employment opportunities, societies can achieve inclusive economic growth. This study highlights

that economic empowerment not only enhances women's financial independence but also strengthens families, communities, and national economies. Women who have control over resources and decision-making contributes to higher household incomes, improved education for children, better healthcare, and overall social progress. However, challenges such as lack of financial access, cultural barriers, inadequate infrastructure, and limited education still hinder women's full participation in economic activities. Addressing these issues through targeted policies, financial inclusion programs, entrepreneurship support, and legal reforms is essential for long-term success. To conclude with empowering women economically in rural and semi-urban areas is not just a matter of social justice but a strategic investment in economic development. Governments, NGOs, and private sectors must collaborate to create sustainable solutions that promote women's entrepreneurship, workforce participation, and financial stability. Ensuring women's active participation in the economy will lead to stronger, more resilient communities and a more equitable society.

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RESEARCH ARTICLE

Intuitionistic Fuzzy Pseudo Ideals in d- Algebras

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ABSTRACT

There has been some recent interest in applying Intuitionistic Fuzzy Pseudo ideals in d-algebras. Motivated by this, in this paper we define the notion of intuitionistic fuzzy pseudo ideal, intuitionistic fuzzy k-pseudo ideal, intuitionistic fuzzy c-pseudo ideal, intuitionistic fuzzy complete k-pseudo ideal. We have introduced and illustrated several ideals that evaluate their relationship in a d-algebra. Related properties of them are investigated.

Keywords: d -algebra, IF pseudo ideal and IF complete pseudo ideal, IF k-pseudo ideal, IF c- pseudo ideal

INTRODUCTION

Y. Imai and K. Iseki [6,7] Introduced two classes of abstract algebras: $\boldsymbol{BCK}$-algebras and $\boldsymbol{BCI}$- algebras .It is known that the class of $\boldsymbol{BCK}$-algebras is a proper subclass of the class of $\boldsymbol{BCI}$-algebras. P. Bhattacharya, N.P. Mukherjee and L. A. Zadeh [12] are introduced fuzzy relations and fuzzy groups. In particular, Q. Zhang, E. H. Roh and Y. B. Jun [9] studied the fuzzy theory in BH-algebras. L.A. Zadeh [12] introduced notion of fuzzy sets and A. Rosenfeld [7] introduced the notion of fuzzy group. O.G. Xi [4,5] introduced the notion of fuzzyalgebras, after that studied Characterization of fuzzy subalgebras by their level subalgebras on $\boldsymbol{BCK}$-algebras. In this paper we will describe

some of the new types of IF-pseudo ideal, called (IF pseudo ideal, IF ***k***-pseudo ideal, IF complete ***k***-pseudo ideal) Also, we introduced and illustrated the proposition that defines the relationship among them in ***d***-algebra.

PRELIMINARIES

Definition 2.1. [2,6, 7,8] An algebra $(X,*, 0)$ of type (2,0) is known as a BCK-algebra if it satisfies the subsequent conditions:

1. $((\alpha * \beta) * (\alpha * \gamma)) * (\gamma * \beta) = 0$
2. $(\alpha * (\alpha * \beta)) * \beta = 0$
3. $\alpha * \alpha = 0$
4. $\alpha * \beta = 0, \beta * \alpha = 0 \Rightarrow \alpha = \beta$
5. $0 * \alpha = 0$ for all $\alpha, \beta, \gamma \in X$

Definition 2.3. [11] A nonempty set X with a consistent and a twofold operation $*$ is called a d - polynomial math in case it fulfills the taking after sayings.

1. $1.\alpha * \alpha = 0$
2. $0 * \alpha = 0$
3. $\alpha * \beta = 0, \beta * \alpha = 0 \Rightarrow \alpha = \beta$ for all $\alpha, \beta \in X$

Definition 2.4. Let X be a d -algebra. Define a binary relations ($" \leq "$) on X by taking $\alpha \leq \beta$ if and only if $\alpha * \beta = 0$. In this Case $(X, \leq)$ is a partially ordered.

Definition 2.5.[3]Let X be a d -algebra. A non-empty subset I of X is said to be a q-ideal of X if it satisfies
(I1) $0 \in I$
(I2) $\alpha * (\beta * \gamma) \in I$ and $y \in I imply\, \alpha * z \in I$ for all $\alpha, \beta, \gamma \in X$.

Definition 2.6. A pseudo d -algebra is a non-empty set X with a constant 0 and two binary operations $*$ and $\circ$ satisaying the following axioms.

1. $1.\alpha * \alpha = \alpha \circ \alpha = 0$
2. $0 * \alpha = 0 \circ \alpha = 0$
3. $\alpha * \beta = \beta \circ \alpha = 0$, imply for each$\alpha, \beta \in X$.

Note that if $(X, *, 0)$ is a d -algebra, then letting $\alpha \circ \beta := \alpha * \beta$, produces a pseudo d -algebra $(X,*,\circ, 0)$. Hence , every d-algebra is a pseudo d-algebra in a natural way.

Definition 2.7 [1,10] An intuitionistic fuzzy set (IFS for short) A in a set N is object having the form $a = \{< n, \eta(n), \mu(n) >: n \in N\}$.

Some type of intuitionistic fuzzy pseudo ideal

In this section, IF complete pseudo ideal, IF $\mathcal{K}$ -pseudo ideal, IF c-pseudo ideal are defined and some properties have been discussed.

Definition 3.1. Let $\mathcal{N}$ be a pseudo d- algebra . An intuitionistic fuzzy set A of $\mathcal{N}$ is called an intuitionistic fuzzy pseudo ideal if it satisfies:

1. $\eta_A(0) \geq \eta_A(n)\ \forall n \in \mathcal{N}$,
2. $\eta_A(n) \geq Min\{\eta_A(n * b), \eta\eta_A(n \odot b), \eta(b)\}\ , b \in \mathcal{N}$,
3. $\mu_A(0) \leq \mu_A(n)\ \forall n \in \mathcal{N}$,
4. $\mu_A(n) \leq Max\{\mu_A(n * b), \mu_A(n \odot b), \mu(b)\}\ , b \in \mathcal{N}$,

Example 3.2. Let $\mathcal{N} = \{0, a, b, c\}$

*	0	a	b	c
0	0	0	0	0
a	a	0	0	0
b	b	b	o	a
c	c	c	0	0

$\odot$	0	a	b	c
0	0	0	0	0
a	a	0	0	0
b	b	c	o	c
c	c	c	0	0

Then $(\mathcal{N},*,0)$ and $(\mathcal{N},\odot,0)$ are not d-algebra since
$(b * a) * c = a \neq 0 = (b * c) * 0 \quad and \ ((b \odot a) \odot c = a \neq 0 = (b \odot c) \odot 0)$,
but $(\mathcal{N},*,\odot,0)$ is pseudo d- algebra.
Define the fuzzy set $\eta(m) = \begin{cases} 0.8 \ if \ n = 0, a \\ 0.6 \ if \ n = b, c \end{cases}$
Then η is a fuzzy pseudo ideal, $since \ \eta(0) \geq \eta(n) \ \forall n \in \mathcal{N}$ and
$\eta(n) = 0.6 \geq Min\{\eta(n * b), \eta(n \odot b), \eta(b)\} = 0.6 \ \forall n, b \in \mathcal{N}, \{0, a\} \ and \ \forall \ b \in \mathcal{N}$
While $\phi(n) = \begin{cases} 0.7 \ if \ n = 0, a, b \\ 0.5 \quad if \ n = c \end{cases}$ is not fuzzy pseudo ideal of $\mathcal{N}$,
Since $\phi(c) = 0.5 \not\geq Min\{\phi(c * 0), \phi(c * b), \phi(b)\} = 0.7$

$\eta_A(n) = \begin{cases} 0.8 \ if \ n = 0, a \\ 0.6 \ if \ n = b, c \end{cases} \mu_A(n) = \begin{cases} 0.2 \ if \ n = 0, a \\ 0.4 \ if \ n = b, c \end{cases}$

Then A is intuitionistic fuzzy pseudo ideal since,
$\eta_A(0) \geq \eta_A(n) \ \forall n \in \mathcal{N}$,
$\eta_A(b) = 0.6 \geq Min\{\eta_A(n * b), \eta A(n \odot b), \eta(b)\} = 0.6$, $\mu_A(0) \leq \mu_A(n) \ \forall n \in \mathcal{N}$,
$\mu_A(b) = 0.4 \leq M\,ax\{\mu_A(n * b), \mu_A(n \odot b), \mu(b)\} = 0.4 \quad \forall n \in \mathcal{N}$, and $\forall \ b \in \mathcal{N} \setminus \{0, a\}$

Definition 3. 3. Let I be a c-pseudo ideal of a pseudo d- algebra $(\mathcal{N},*,\odot,0)$. An intuitionistic fuzzy set A is called intuitionistic fuzzy complete pseudo ideal at I (briefly, IF c-pseudo ideal) if
1. $\eta_A(0) \geq \eta_A(n) \ \forall n \in \mathcal{N}$,
2. $\eta_A(n) \geq Min\{\eta_A(n * b), \eta_A(n \odot b), \eta(b)\} \ , n \in \mathcal{N}, \ b \in I$
3. $\mu_A(0) \leq \mu_A(n) \ \forall n \in \mathcal{N}$,
4. $\mu_A(n) \leq M\,ax\{\mu_A(n * b), \mu_A(n \odot b), \mu(b)\} \ , n \in \mathcal{N}, \ b \in I$

Example 3.4. Let $\mathcal{N} = \{0, a, b, c\}$be a set with the tables below

*	0	a	b	c
0	0	0	0	0
a	a	0	0	0
b	b	b	o	a
c	c	c	0	0

$\odot$	0	a	b	c
0	0	0	0	0
a	a	0	0	0
b	b	c	o	c
c	c	c	0	0

Then $(\mathcal{N}, *, \odot, 0)$ is a pseudo d-algebra, and the set -pseudo ideal of $\mathcal{N}$.
Let A be the intuitionistic fuzzy set defined on $\mathcal{N}$ defined by
$\eta_A(n) = \begin{cases} 0.5 \ if \ n = 0, a, c \\ 0.4 \ if \ n = b \end{cases} \mu_A(n) = \begin{cases} 0.5 \ if \ n = 0, a, c \\ 0.6 \ if \ n = b \end{cases}$
Then A is intuitionistic fuzzy c-ideal on $\mathcal{N}$, since it satisfied
$\eta_A(0) \geq \eta_A(n) \ \forall n \in \mathcal{N}$,
$\eta_A(b) = 0.4 \geq Min\{\eta_A(n * b)$,
$\eta_A(n \odot b), \eta(b)\} = 0.4 \ \forall b \in I, \mu_A(0) \leq \mu_A(n) \ \forall n \in \mathcal{N}$,

Proposition 3.5. Every intuitionistic fuzzy pseudo ideal of a pseudo d-algebra is an intuitionistic fuzzy c-pseudo ideal.

Proof. Suppose that I be a c-pseudo ideal and A is intuitionistic fuzzy pseudo ideal of a pseudo d-algebra $\mathcal{N}$ then by definition (2.8) we have,

1. $\eta_A(0) \geq \eta_A(n)\ \forall n \in \mathcal{N}$,
2. $\eta_A(n) \geq Min\{\eta_A(n * b), \eta_A(n \odot b), \eta(b)\}\ , n, b \in \mathcal{N}$,
3. $\mu_A(0) \leq \mu_A(n)\ \forall n \in \mathcal{N}$,
4. $\mu_A(n) \leq M\,ax\{\mu_A(n * b), \mu_A(n \odot b), \mu(b)\}\ , n, b \in \mathcal{N}$

Since $\subseteq \mathcal{N}$, then

$\eta_A(n) \geq Min\{\eta_A(n * b), \eta_A(n \odot b), \eta(b)\}\ and$

$\mu_A(n) \leq M\,ax\{\mu_A(n * b), \mu_A(n \odot b), \mu(b)\}\ \forall b \in I.$

Thus A is intuitionistic fuzzy c-pseudo ideal of $\mathcal{N}$.

Remark 3.6. The following example shows that the converse of proposition (3.5) is not true in general.

Example 3.7. In example (3.2), notice that A is intuitionistic fuzzy pseudo ideal because

$\eta_A(b) = 0.4 \not\geq Min\{\eta_A(b * c),$

$\eta_A(b \odot c), \eta(c)\} = 0.5$

Proposition 3.8. Let I be a c-pseudo ideal of a pseudo involuntary pseudo d-algebra $\mathcal{N}$. An intuitionistic fuzzy set A is intuitionistic fuzzy c-pseudo ideal if and only if satisfies:

1. $\eta_A(0) \geq \eta_A(n)\ \forall n \in \mathcal{N}$,
2. $\eta_A(n) \geq Min\{\eta_A(n^{**} * b), \eta A(n^* \odot b^\circ), \eta(b)\}$
3. $\eta_A(n^\circ) \geq Min\{\eta_A(n^* * b^\circ), \eta A(n^{\circ\circ} \odot b), \eta A(b)\} \forall, n, b \in \mathcal{N}$,
4. $\mu_A(0) \leq \mu_A(n)\ \forall n \in \mathcal{N}$,
5. $\mu_A(n) \leq M\,ax\{\mu_A(n^{**} * b), \mu_A(n^* \odot b^\circ), \mu(b)\}$

$\mu_A(n^\circ) \leq M\,ax\{\mu A(n^* * b^\circ), \mu_A(n \odot b), \mu A(b)\}\ \forall, n, b \in \mathcal{N}$

Proof. By definition (2.7) and definition (3.3)

Definition 3.9. An intuitionistic fuzzy set A in bounded pseudo d- algebra $(\mathcal{N}, *, \odot, 0)$ is called intuitionistic fuzzy $\mathcal{K}$-pseudo ideal, if

1. $\eta_A(0) \geq \eta_A(n)\ \forall n \in \mathcal{N}$,
2. $\eta_A(n^*) \geq Min\{\eta_A(n^* * b), \eta_A(n * \mathrm{b}\circ), \eta_A(b)\}$
3. $\eta_A(n^\circ) \geq Min\{\eta_A(n^\circ \odot b), \eta_A(n \odot b^*), \eta_A(b)\} \forall, n, b \in \mathcal{N}$,
4. $\mu_A(0) \leq \mu_A(n)\ \forall n \in N$,
5. $\mu_A(n^*) \leq M\,ax\{\mu_A(n^* * b), \mu_A(n * b^\circ), \mu(b)\}$
6. $\mu_A(n^\circ) \leq M\,ax\{\mu_A(n^\circ \odot b), \mu_A(n \odot b^*), \mu_A(b)\}\ \forall, n, b \in \mathcal{N}.$

Example 3.10.

1. Every intuitionistic fuzzy constant in bounded pseudo d-algebra $\mathcal{N}$ is intuitionistic fuzzy $\mathcal{K}$ -pseudo ideal.
2. Let $\mathcal{N} = \{0, p, q, r, s\}$be a set with the table below:

*	0	p	q	r	s
0	0	0	0	0	0
p	p	0	0	0	p
q	q	0	0	q	q
r	r	0	r	0	q
s	s	0	s	0	0

*	0	p	q	r	s
0	0	0	0	0	0
p	p	0	0	p	p
q	q	0	0	0	0
r	r	0	s	0	s
s	s	0	s	0	0

Then $(\mathcal{N},*,\odot,0)$ is bounded pseudo d-algebra with unit μ and define an intuitionistic fuzzy A by
$\eta_A(n) = \begin{cases} 0.9 \ if \ n = 0,p \\ 0.3 \ if \ n = q,r,s \end{cases} \mu_A(n) = \begin{cases} 0.1 \ if \ n = 0,p \\ 0.7 \ if \ n = q,r,s \end{cases}$
Then A is intuitionistic fuzzy $\mathcal{K}$ -ideal at I in $\mathcal{N}$, because
$\eta_A(0) \geq \eta_A(n) \ \forall \ n \in \mathcal{N}$,
$\eta_A(n^*) = 0.9 \geq Min\{\eta_A(n^* * b), \eta_A(n * b^\circ), \eta_A(b)\} is \ hold \ \forall \ n \in \mathcal{N} \ also \ \eta_A(n^\circ)$
$= 0.9 \geq Min\{\eta_A(n^\circ \odot b), \eta_A(n \odot b *), \eta_A(b)\} \ \forall, n, b \in \mathcal{N}$,
$\mu_A(0) \leq \mu_A(n) \forall \ n \in \mathcal{N}$,
$\mu_A(n^*) = 0.1 \leq M \ ax\{\mu_A(n^* * b), \mu_A(n * b^\circ), \mu(b)\} \ and$
$\mu_A(n^\circ) = 0.1 \leq M \ ax\{\mu_A(n^\circ \odot b), \mu_A(n \odot b^*), \mu_A(b)\} \ \forall, n, b \in \mathcal{N}$.

Proposition 3.11. Every intuitionistic fuzzy pseudo ideal of a bounded pseudo d-algebra is an intuitionistic fuzzy $\mathcal{K}$ -pseudo ideal

Proof. Let A be an intuitionistic fuzzy pseudo ideal of a bounded pseudo d-algebra then by definition (3.1) we have,
1. $\eta_A(0) \geq \eta_A(n) \forall \ n \in \mathcal{N}$
2. $\mu_A(0) \leq \mu_A(n) \forall \ n \in \mathcal{N}$
3. $\eta_A(n) \geq Min\{\eta_A(n * b), \eta_A(n * b), \eta_A(b)\} \ then$
$\eta_A(n^*) \geq Min\{\eta_A(n^* * b), \eta_A(n * b^\circ), \eta_A(b)\} \forall \ n \in \mathcal{N}$,
$= Min\{\eta_A(n^* * b), \eta_A(n * b^\circ), \eta_A(b)\} \forall \ n, b \in \mathcal{N}$,
$also \ \eta_A(n^\circ) \geq Min\{\eta_A(n^\circ \odot b), \eta_A(n \odot b^*), \eta_A(b)\}$
$= Min\{\eta_A(n^\circ \odot b), \eta_A(n \odot b^*), \eta_A(b)\} \forall \ n, b \in \mathcal{N}$,
4. $\mu_A(n) \leq M \ ax\{\mu_A(n * b), \mu_A(n * b), \mu_A(b)\} \ then$
$\mu_A(n^*) \leq M \ ax\{\mu_A(n^* * b), \mu_A(n * \odot b), \mu_A(b)\} \forall \ n \in N$
$= Max\{\mu_A(n^* * b), \mu_A(n * b^\circ), \mu_A(b)\} \forall \ n, b \in \mathcal{N}$,
$also \ \eta_A(n^\circ) \leq M \ ax\{\eta_A(n^\circ * b), \mu_A(n^\circ \odot b), \mu_A(b)\}$
$= M \ ax\{\mu_A(n^\circ \odot b), \mu_A(n \odot b^*), \mu_A(b)\} \forall \ n, b \in \mathcal{N}$,

Remark 3.12. In general, the converse of proposition (3.11) need not be true as shown in the following example.

Example 3.13. IN Example 3.10-2 A is intuitionistic fuzzy $\mathcal{K}$-pseudo ideal in $\mathcal{N}$, but not intuitionistic fuzzy pseudo ideal in $\mathcal{N}$, because
$\eta_A(q) = 0.3 \not\geq Min\{\eta_A(q * p), \eta_A(q \odot p), \eta_A(p)\} = 0$

Proposition 3.14. Every intuitionistic fuzzy $\mathcal{K}$-pseudo ideal in a pseudo involuntary pseudo d-algebra $\mathcal{N}$ is intuitionistic fuzzy pseudo ideal.
Proof. Assume that A be an intuitionistic fuzzy k-pseudo ideal of $\mathcal{N}$.
Since $\mathcal{N}$ is pseudo involuntary pseudo d-algebra, then
$\eta_A(n) = \eta_A(n^* *) \geq Min\{\eta_A(n^{**} * b), \eta_A(n^* * b \circ), \eta_A(b)\}$
$= Min\{\eta_A(n * b), \eta_A(n \odot b), \eta_A(b)\} \ and$
$\mu_A(n) = \mu_A(n^{**}) \leq M \ ax\{\mu_A(n^{**} * b), \mu_A(n^* * b \circ), \mu_A(b)\}$
$= M \ ax\{\mu_A(n * b), \mu_A(n \odot b), \mu_A(b)\} \ \forall \ n, b \in \mathcal{N}$

Proposition 3.15. Let A be intuitionistic fuzzy $\mathcal{K}$-pseudo ideal of a bounded pseudo d-algebra $\mathcal{N}$,then

1. $\eta_A(n^*) \geq \eta_A(e)\ and\ \eta_A(n^\circ) \geq \eta_A(e), \forall\ n \in \mathcal{N}$
2. $\mu_A(n^*) \leq \mu_A(e)\ and\ \mu_A(n^\circ) \leq \mu_A(e)$
3. $If\ n^* \leq b, then\ \eta_A(b) \geq \eta_A(n^*)\ also\ \mu A(b) \leq \mu_A(n^*)$
4. $If\ n^\circ \leq b, then\ \eta_A(b) \geq \eta A(n^\circ)\ also\ \mu A(b) \leq \mu_A(n^\circ)$

Proof.

1. Since $\boldsymbol{A}$ is intuitionistic fuzzy $\boldsymbol{\mathcal{K}}$ -pseudo ideal, we have

$\eta_A(n^*) \geq Min\{\eta_A(n^* * e), \eta_A(e^\circ * n), \eta_A(e)\} = Min\{\eta_A(0), \eta_A(e)\} = \eta_A(e)\ and$
$\eta_A(n^\circ) \geq Min\{\eta_A(m^\circ \odot e), \eta_A(e^* \odot n), \eta_A(e)\} \quad = Min\{\eta_A(0), \eta_A(e)\} = \eta_A(e)$

2. Since A is intuitionistic fuzzy $\mathcal{K}$ -pseudo ideal, we have

$\mu_A(n^*) \leq M\ ax\{\mu_A(n^* * e), \mu_A(e^\circ * n), \mu_A(e)\} = M\ ax\{\mu_A(0), \mu_A(e)\} = \mu_A(e)$ and
$\mu_A(n^\circ) \leq M\ ax\{\mu_A(m^\circ \odot e), \mu_A(e^* \odot n), \mu_A(e)\} = M\ ax\{\mu_A(0), \mu_A(e)\} = \mu_A(e)$

3. If$m^* \leq b\ i.e\ n^* * b = 0\ and\ n^* \odot b = 0, then$

$\eta_A(n^*) \geq Min\{\eta_A(n^* * b), \eta_A(b^\circ * n), \eta_A(b)\}\ \forall\ n, b \in \mathcal{N} = Min\{\eta_A(0), \eta_A(b)\} = \eta_A(b)$ (Since A is intuitionistic fuzzy k-pseudo ideal) and

$\mu_A(n^*) \leq M\ ax\{\mu_A(n^* * b), \mu_A(b^\circ * n), \mu_A(b)\}\ \forall\ n, b \in \mathcal{N} = M\ ax\{\mu_A(0), \mu_A(b)\} = \mu_A(b)$ (Since A is intuitionistic fuzzy k-pseudo ideal)

4. Is similar to the proof of (3)

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RESEARCH ARTICLE

Study on Seasonal Changes in Soil Heavy Metal Content and Potential Risk Around a Municipal Solid Waste Dumpsitein Jaipur, India

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ABSTRACT

The increasing population and transformation in consumption patterns have become major causes of environmental pollution. In most developing countries, there is no proper waste management, and municipal solid waste (MSW) is discarded openly on land instead of engineered sanitary landfills. The heterogeneous and unsorted MSW is a rich source of heavy metals. The metals enter the soil through waste which contains considerable proportions of discarded metal objects, plastic, batteries, etc. The current research aims to determine the heavy metal pollution in the soil around an MSW dumpsite in Jaipur, Rajasthan, India, and the associated risk. The results reveal that metals like Cu, Zn, Pb, Cd, and Fe were highest in the summer season and were found in the following order of abundance: Fe>Zn>Cu>Pb>Cr>Cd, and their concentration increased with the increasing soil depth. The contamination factor for most metals was low to moderate but was high for Zn in the summer season.

Keywords: Municipal solid waste, open dump, heavy metals, contamination factor, potential ecological risk index.

INTRODUCTION

The increasing population and transition in consumption patterns have become major causes of environmental pollution. Due to the scarcity of natural resources, our dependency on synthetic, non-biodegradable, and potentially toxic items is increasing, which have replaced natural, reusable, and eco-friendly products. The problem of foul air, land, and water associated with improper waste management is encountered in several parts of the world, especially in developing nations. A huge amount of solid waste is generated every year. According to a report published by

the United Nations Environment Programme (2024), the generation of municipal solid waste (MSW) is projected to reach 3.8 billion tonnes by the year 2050 from 2.1 billion tonnes in 2023 [1].Efficient management and handling of large amounts of MSW is difficult due to its qualitative and quantitative characteristics. In most developing countries, systematic waste management practices are not followed, and unsegregated MSW is discarded openly on land without pre-treatment[2]. The leachate is produced in landfills and dumpsites as a byproduct of biochemical processes involved in the waste decomposition, precipitation, surface run-off, and moisture content of wastes [3]. This leachate travels in surrounding soil along the gradient and carries soluble minerals, toxins, metals, chemicals, etc., to underlying soil and groundwater causing pollution[4]. The heterogeneous and unsorted municipal solid waste contributes to a large variety of heavy metals due to significant proportions of discarded metal objects, plastic, batteries, electronic items, paper, etc. present in the waste[5]. Many studies have established a link between health problems and environmental pollution caused by open dumps. Evaluation of metals in areas surrounding the MSW dumpsites helps in the assessment of pollution of soil as well as groundwater resources and provides important information on anthropogenic sources of metals and potential risks to the people living in the vicinity of such areas [6]. Soil acts as a dynamic receptor and source of metal ions, which may subsequently enter the food chain through plants. The metal abundance and distribution depend upon the nature and amount of waste as well as the physico-chemical quality of the soil or sediment [6].Soil analysis concerning toxic metals due to anthropogenic sources gives an insight into the pollution level of an area, its transport in the different environmental components, and its potential hazards to living organisms. The current research work aims to (a) find the metal content in the soil around an unmanaged dumpsite in Jaipur city, Rajasthan, India(b) study the seasonal variation in concentration of selected heavy metals in the soil (c) evaluate the potential risk posed by the same.

Makuleke and Ngole-Jeme[7] studied the soil properties around an abandoned landfill in Zimbabwe and observed the following order of metals in terms of their concentration: Fe>Zn>Cu>Cr>Ni>Cd. The heavy metal concentration did not correlate with the soil properties, indicating their non-geogenic origin. A health risk assessment of MSW dumpsite in Nigeria showed the soil heavy metal concentration during the rainy season in the following order: Zn>Mn>Ni>Pb>Cd>Cr, and the following order in the dry season: Zn>Mn>Cd>Ni>Pb>Cr [8]. In a seasonal study conducted to find the soil metal content at a MSW dumpsite (Enugu, Nigeria),iron and lead had the highest concentrations out of the ten metals studied and most of the metals became nearly constant at a depth of 1m [9]. The heavy metal contamination in soil around an open dumpsite at Tiruchirappalli, Tamil Nadu, India was reported in the order: Mn>Pb>Cu>Cd [10]. A study was conducted to assess the physicochemical parameters and heavy metal contents of soil at a municipal solid waste dumpsite in Allahabad, Uttar Pradesh, India. The study showed the following order of metal abundance at the dumpsite: Pb>Zn>Fe>Ni>Cu>Cr>Cd [11]. In another study [12] done around a MSW dumpsite in Nigeria high organic carbon and nitrogen content were observed in the soil. The highest concentration was that of Fe, while Cd was below the detection limit. The surface soil was more likely to accumulate Zn than the subsurface soils, while copper was among the least mobile elements [12]. Several other studies stating the occurrence of heavy metals in the soil of MSW dumpsite are summarised in Table 1.

MATERIAL AND METHODS

Study area

Rajasthan is the largest state of India in terms of area and is located between 23º3′ and 30º12′ N latitude and 69º30′ and 78º17′ E longitude, covering an area of about 342,239 square km. Jaipur is the capital city of Rajasthan. The winter season commences in December and continues till February, followed by the summer season, which continues up to June. The summer season is hot and dry with temperature ranging between 40 °C and 47 °C, while the winters are very cold with the lowest temperature range of 4 °C and 9 °C. The average daily temperature in summer months is 30 °C. Heat waves are common in summer, while mist and fog are usual phenomena in the morning hours during winter. Monsoon season starts by the end of June till September, and Jaipur receives over 650 mm of rainfall on average. Jaipur district, with an area of 11,117.8 square km, has an average population density of 470 persons per sq. km. and comprises 47.6% rural and 52.4% urban population [13]. Around 1000 tons of municipal solid waste is

generated per day in Jaipur and is discarded in open dumpsites [14].Out of the three open dumpsites, one is located at Mathuradaspura village in Jamwa Ramgarh Tahsil, about 17 km away from Jaipur city [14]. An area of176 bigha has been allocated for the disposal of MSW and it receives 400-410 Tons per Day of unsorted MSW (Figure 1).

Sampling

Random soil samples were collected at different depths (0-15 cm and 15-30 cm) and varying distances from the dumpsite. A total of 36 samples were collected from 18 sites (16 from around the dumpsite and 2 from the core dumpsite area)from 0-15 and 15-30 cm depths, seasonally. Uniform sampling distance was difficult to maintain because of private ownership of land, construction activities, huge waste heaps, etc. The sampling site was cleared of dried leaves, plastic, and waste material and the appropriate amount of sample was collected with the help of an auger and trowel from different depths. The soil samples were tightly sealed and brought to the laboratory for analysis. Before analysis, the samples were dried in an oven at 30 °C for 24 hours.

Preparation of samples for metal analysis

Soil samples were disaggregated with the help of a pestle and mortar, screened through a 2mm sieve, and digested using the tri-acid mixture. Acid digestion involved the addition of HNO_3, H_2SO_4,and $HClO_4$ mixture (5:1:1 v/v/v) in 1 g dried soil sample[15] and heating at 80 ºC on a hot plate until 5–10 mL clear, transparent extract was left in the beaker. The digested samples were then cooled and filtered through Whatman No. 42 filter paper and the extract was made up to 100 mL with distilled water. The samples were then analyzed for selected metals using an atomic absorption spectrophotometer (Thermofisheri CE 3000 AA01134805 v1.30).

Soil contamination indices

The following soil pollution indices are used to find out the contamination level due to various heavy metals in the soil. These indices are calculated using different formulas as summarised in Table 2. These values obtained by these indices are grouped into various classes to depict the level of toxicity and for interpretation of the contamination levels. Contamination Factor (CF^i) is a measure to determine the contamination of a certain toxic substance in the environment [16]. The background values of the metals used in the present study were previously reported for sedimentary rocks [17][18]. The contamination degree(C_d) was proposed to facilitate the prevention of pollution [16]. C_d is the sum of the contamination factor of each sample and the degree of anthropogenic contamination is identified based on the classification of C_d in different levels. The potential contamination index (Cp)is an index to assess the soil contamination due to toxic substances by finding the ratio between the maximum concentration of any metal in soil and the mean background value of the same metal [19]. To determine the impact of contaminants on the ecology of an area, the potential ecological risk (E_r^i)is used. It involves the determination of the toxic effect of a contaminant on the biological systems. It is the product of the metal contamination factor and the toxic response factor of a particular metal and is different for all contaminants. The toxic response factor (T_r^i) values of 5, 1, 5, 30, and 2 are considered for Cu, Zn, Pb, Cd, and Cr, respectively [16].The E_r^i values are classified in five classes to explain the ecological risk imposed by heavy metal pollution. To find out the overall ecological impact of heavy metals, another index called the potential ecological risk index (RI or PERI) was devised [16]. This index helps evaluate the impact of toxic elements and the sensitivity of biological forms due to the presence of toxic elements in a contaminated area. The potential ecological risk (E_r^i) of an individual metal is the product of the toxic response factor (T_r^i) of individual metals and the contamination factor (CF^i) of that metal. The T_r^i value for the metals are already mentioned above. RI is divided into four classes to interpret the contamination due to metals.

RESULT AND DISCUSSION

Metals like Cd, Cu, Pb, and Fe are usually high in samples with high organic matter content since these metals tend to be retained in the organic phase of the soil [20][21]. The minimum, maximum, and average concentrations of metals are mentioned in Table 3 for pre-monsoon, monsoon, and post-monsoon seasons. The metal concentration in the current study was in the following order of abundance:

Fe>Zn>Cu>Pb>Cr>Cd in the pre-monsoon and post-monsoon seasons
Fe>Zn>Cu>Cr>Pb>Cd in monsoon season
The average metal values obtained in the current study compared with the soil standard [31],are depicted in Figure 2 (A-C). The average concentration of Cu, Zn, Pb and Cd exceeded the limits prescribed by Aggarwal [31] in all the seasons. However, the concentration of all metals was found to be very low compared to the limits set for organic compost [50]. The Cu concentration was much elevated in the current study, as also reported in other similar studies [25] [26]. However, lesser Cu content was reported in some studies [22][23][24] as compared to the results of the current study. Cu enters waste from the batteries, waste of pigments used in polymer processing [27]. It has been observed that just like other metals, the availability of Cu decreases with an increase in soil pH. The humic acids constituting a pertinent portion of the soil organic matter, get associated with Cu to form insoluble complexes and make it less available [28]. According to Lagerwerff et al. [29], the stability constant of metal chelate has the following order: Cu>Pb>Zn>Cd. Thus, an increase in the available Cu content in soil solution is much smaller than that for Zn. Due to its high density, Cu is less mobile and accumulates in topsoil layers, hence, low mobility and availability of Cu enhances its persistence in soil. Very high Cu content in soil may cause Cu toxicity by inducing an inhibitory and degenerative effect on soil microbes [30].

Higher Zn content was reported in the present study, as also obtained in other studies [32][33][34][35]. However, Zn content was much elevated in the current study as compared to the results obtained by [22][23][36], which may be due to the waste characteristics and composition. Elevated levels of Zn in the soil may be attributed to the dumping of pharmaceutical waste, expired medicines, galvanized metal scraps, old building waste, paints, inks, toner, and wood preservatives in the MSW dumpsites [9] [36]. High levels of Zn may induce phytotoxicity, reduce microbial biomass, and replace soil macronutrients like phosphorus [39]. The range of lead was higher in this study than reported by [8][24], while some other studies reported a higher mean value of lead than the current study in the waste dump soil [41] [9] [42]. Lead enters the waste through discarded batteries, oil, and grease from automobiles, cathode ray tubes, discarded paint materials, rubber products gasoline, etc. Excessive Pb in soil affects soil microflora and fauna, reducing its fertility. Pb is a toxic metal and even in less concentration, it disrupts the activities of enzymes (like catalase, urease, invertase, acid phosphatase, etc.), that severely affect the metabolic activities of organisms [37][43]. Pb also causes interference in the water balance and mineral and nutrient availability in plants. This leads to the depletion of available soil nutrients and reduces soil fertility [44].

The concentration of Cd was less in the current study as compared to the values obtained by [9] [34] [36] [45][46]. Jalali and Arfania[38] reported high Cd content in the upper soil layer, which agrees with the current study. Cd enters the waste from discarded batteries, stabilizers, preservatives, catalysts, ink, paints, printer and photocopier toner, plastics, adhesives, paper, stainless steel, tanned leather, fabrics, dysfunctional electrical equipment such as alloys[27]. Excessive amount of Cd in the soil also decreases nitrogen and sulphur availability and disrupt the functioning of enzymes like protease, urease, etc., ultimately obstructing the metabolism of soil microbes [33] [43]. The maximum level of Cr was higher than the levels given by Kabata-Pendias and Mukherjee (2007)[48]in pre-monsoon and monsoon seasons and also as reported by [8][34]. Plating of plastic moulding dies and surface finishing of plastic materials involves the use of Cr [49]. It also enters the dumpsite soil through discarded rechargeable batteries, stainless steel, fungicides, pesticides, dyes, paints, tanned leather, fabrics, dysfunctional electrical equipment, alloys, chrome pigment containers, and anticorrosive agents. The concentration of iron was maximum in the current study, as also obtained in some studies[51][8][42]. Elevated levels of iron in soil may be because of the presence of metallic scrap in solid waste, and its concentration usually decreases in the lower soil layer [52]. High iron content in soil may not categorically be related to MSW alone, however, some natural causes like local geology may also lead to elevated iron in soil.

Seasonal Variation in metal content
In the current study, the average concentration of all metals except Cr was highest in the pre-monsoon season, similar results were reported in several studies [53][9][54]. A study [55] also reported high metal content during the pre-monsoon season at a soil depth of 0-15 cm, while at a depth of 30–40 cm, the highest metal content was in the post-

monsoon season. Higher Pb content in the pre-monsoon season was also reported by Ihedioha et al. [8]. Metal content in soil is closely related to the soil pH, soil organic matter, characteristics of MSW, amount of rainfall, temperature, etc. The soil pH in the study area ranges between 7.76 and 8.37 (Figure 2D), and the mobility of metals in alkaline soil is low and increases in acidic soil. Cu, Cd, and Fe were least in the monsoon season, indicating metal retention in the summer season while increased mobility in the rainy season. Metals usually bind to the clay fraction of soil, hydrous oxides, organic matter, etc. Higher pH and low soil moisture in arid regions result in low decomposition of organic waste and consequently, low organic carbon content that reduces the mobility or leachability of metals [9][55]. Increased metal content in soil may affect microbial activity thus, inhibiting degradation of soil organic matter [56]. Decreased metal content in monsoon season may be due to runoff and leaching of metals from the waste. With the onset of the rains, the vegetation increases leading to a somewhat higher organic fraction in soil, a slight reduction in soil pH, and hence metal uptake by the plants. This may continue till the post-monsoon season for some metals like Zn, Pb, and Cr as their concentration was lowest in the post-monsoon season. However, due to a reduction in rainfall in the post-monsoon season some metals like Cu, Cd, and Fe again start to increase in soil. The concentration of all metals was below the limits as per the FCO [50], thus the dumpsite soil may be used for composting.

Vertical profile of metals

The studied metals readily accumulated in the surface layer as compared to the lower layers, which may be due to the capacity of metals to bind with the organic fraction of the soil, which is also concentrated in the surface layers. Metal availability and retention are controlled by high soil pH, low rainfall, and re-adsorption of heavy metals on the clay content of the soil and physicochemical properties of the soil [52]. The current study shows that the concentration of all metals was less in the lower layer than the surface layer. It has been observed that Cu and Zn are the least mobile trace elements [37] [38]. Cu might be retained in the soil through exchange and specific adsorption mechanisms [57]. In the current study, the Cr content decreased down the soil profile; nevertheless, a study [12] reported an increase in Cr content around MSW dumpsite soil down the soil profile. This indicates that Cr is less mobile in the current study. Pb content also declined with increasing soil depth, which is in line with results obtained by [37][45][53]. Usually, Cd does not accumulate in the topsoil, but due to anthropogenic activities, it tends to persist in the topsoil [47].The lower concentration of metals in the soil depth of 15-30 cm indicates reduced vertical mobility of metals.

Soil pollution Indices

The contamination factor (CF^i) of metals in the study area is summarized in Table 4. The CF^i of Zn in the pre-monsoon season was very high in the surface layer (since $CF^i > 6$) and considerable in the lower layer (since $1 < CF^i < 6$) but showed moderate contamination levels in the rest of the seasons. The highest CF^i value for Zn was obtained in the current study, as also reported by [26].The metals like Cu and Pb had moderate contamination levels in all seasons, but their continued entry in the soil through waste and consequent deposition may lead to a high contamination factor in the future. Cd, Cr, and Fe showed low contamination in the study area in all seasons. Proper segregation of waste at the source is necessary to reduce the concentration of heavy metals in the soil. The values of contamination degree (C_d) indicate that the area is moderately polluted in the pre-monsoon season as the values of contamination degrees are more than 6 (Table 5). However, the C_d values in the monsoon and post-monsoon seasons are less than 6, indicating a low metal retention in the soil and increased leachability. The potential contamination index (Cp)values of Cu, Zn, and Pb are much higher than 3, indicating severe contamination (Figure 3). This is because the maximum metal concentration in the vicinity of the dumpsite is much higher than the background concentration of these metals. The Cp values of Cd, Cr, and Fe are less than 1 in all seasons hence they show low contamination levels (Figure. 3B). Since the metal concentration in the current study was higher in the summer season Cp values are also high in the this season, but for Pb the Cp values were highest in the monsoon season and for Cr, it was highest in monsoon but only at 15-30 cm depth. The potential ecological risk (E_r^i) of the metals is detailed in Table4, while RI values in Table 5. All the values of E_r^i are below 40, indicating low ecological risk in the study area. The RI values are below 50, indicating low contamination due to the metals studied.

CONCLUSION

The pH of the soil samples was in the alkaline range. This indicates that the soil is affected by unsegregated municipal solid waste, which is in the methanogenic stage of decomposition. There is a clear sign that the municipal waste dumpsite is a potential source of metals in the soil. However, the high metal content in the soil does not indicates its bioavailability. The pollution indices indicate moderate pollution in the study area. The potential contamination index indicates high pollution due to metals like Cu, Zn, and Pb. The soil metal content in the arid regions behaves differently and must be taken into consideration along with the seasonal and geochemical properties of the disposal site. There is an urgent necessity for source separation and segregation of the solid waste into decomposable organic fraction and inorganic fraction that may be further treated or disposed of in a sustainable manner. The organic fraction in the waste may be used for the preparation of compost and may be used in agricultural lands in place of chemical fertilizers. The 'balance approach' should be put in place in which the amount of nutrients as well as the pollutants added in the soil are sufficient and not in excess to maintain soil fertility. Moreover, the open dumps must be replaced with well-engineered landfills because the MSW is a potential contributor of heavy metals in soil and aquifers in the long run.

Statements and Declarations

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Table 1. Studies showing heavy metal concentration in municipal solid wasted umpsite/landfill (mg kg^{-1})

Dumpsite location	Depth	Cu	Zn	Pb	Cd	Cr	Reference
Tehran	10-50 cm	0.86-1.15	-	0.71-1.09	0.06-0.07	-	[24]
Kinshasa, Democratic Republic of the Congo	2-10 cm	8.42–233.27	189.09–57,330.38	18.79–1239.42	0.2–13.93	4.96–124.33	[26]
Baglung, Nepal	-	100.32-254.54	228.19-997.61	34.80-64.23	3.15-10.37	0-24.23	[35]
Sialkot, Pakistan	0.5-60 cm	30-125	-	17-55	0.1-1.0	65-535	[58]
Potiskum, Yobe State Nigeria	15-30 cm	63.01-150.41	38.94-265.74	11.54-850.57	0.07-1.75	28.07-60.87	[46]
Kabylia, Algeria N. Africa	0-3 m	18.8-80.1	43-92.8	7.3-60.4	0.5-1.6	76-98.9	[23]
Czech Republic	0-20 cm	32.43-58.62	25.67-72.46	2.57-8.53	0.07-0.20	64.06-190.73	[22]
Varanasi, India	-	7.4-313.0	7.9-45.0	17-429.7	0.17-1.67	0.1-0.4	[25]
Islamabad, Pakistan	0-9 inches	1.62-119.73	93.91-1607.34	38.65-236	1.38-20.65	0-7.97	[59]
Lagos State, Nigeria	0-15 cm	597-1468	827-1836	361-457	10-28	-	[32]
Tijuana, Mexico	0-60 cm	8-5282.4	-	7.2-883.35	0.5-3.30	BDL-9.3	[41]

Table 2: Soil contamination indices

S.No.	Soil Contamination Index	Formula	Contamination classes
1.	Contamination Factor (CF^i)	$CF = C_m/C_b$ C_m =mean metal concentration in sample	$CF^i < 1$:low; $1 < CF^i < 3$: moderate; $3 < CF^i < 6$: considerable;

		C_b=background value of the metal	CF^i> 6: very high.
2.	Contamination degree (C_d)	$C_d = \sum_{i=0}^{n} CF^i$ CF^i = contamination factor of each metal	C_d< 6: low contamination; 6 < C_d< 12: moderate contamination; 12 < C_d< 24: considerable contamination; C_d> 24: high contamination.
3.	Potential contamination index (Cp)	Cp= $Metal_{max}$/ $Metal_B$ $Metal_{max}$= maximum concentration of a metal in soil $Metal_B$= is the background value of that metal	Cp < 1: low contamination; 1 < Cp < 3: moderate contamination; Cp > 3: severe or very severe contamination.[17]
4.	Potential ecological risk (E_r^i)	$E_r^i = T_r^i \times CF^i$ T_r^i = toxic response factor for the metals CF^i = the contamination factor of metal	E_r^i<40: low ecological risk; 40<E_r^i<80: moderate ecological risk; 80<E_r^i<160: considerable ecological risk; 160<E_r^i<320: high ecological risk; 320<E_r^i: very high ecological risk.
5.	Potential Ecological Risk Index (RI)	$RI = \sum_{i=1}^{n} E_r^i = \sum_{i=1}^{n} T_r^i \times CF^i$ E_r^i= potential ecological risk of an individual metal T_r^i =the toxic response factor of individual metals CF^i =the contamination factor of that metal.	RI ≤ 50: Low contamination; 50 ≤ RI ≤ 100: moderate contamination; 100 ≤ RI ≤ 200: considerable contamination; RI > 200: high contamination.

Table 3. Seasonal variation in soil heavy metal content (mg kg^{-1})

Max-maximum concentration, Min-minimum concentration, SD- Standard Deviation, BDL=Below Detection Limit; mean±SD, n=18

Depth (cm)	Cu	Zn	Pb	Cd	Cr	Fe	
Pre-monsoon season							
Max	0-15	355.59±0.69	955.35±5.07	89.74±0.62	2.97±0.47	89.16±0.55	6874.48±0.82
	15-30	322.84±0.31	839.64±2.08	49.05±0.92	2.11±0.55	51.55±0.62	5063.86±4.36
Min	0-15	17.66±0.67	99.02±0.89	1.32±0.48	BDL	10.06±0.07	2409.75±0.67
	15-30	11.99±0.06	80.95±0.57	BDL	BDL	09.33±0.44	753.94±0.06
Average	0-15	148.75	468.91	26.19	0.64	31.26	4485.40
	15-30	127.57	353.2	19.32	0.33	26.87	3171.80
Monsoon season							
Max	0-15	270.82±6.24	323.66±0.30	111.36±0.04	1.60±0.66	83.28±0.74	4489.11±4.06
	15-30	219.54±9.15	288.19±0.32	93.22±0.02	0.96±0.08	75.74±0.36	4201.14±4.22
Min	0-15	10.19±0.57	26.14±1.58	0.97±0.03	BDL	7.95±0.11	1909.12±0.22
	15-30	6.48±0.35	30.76±0.98	BDL	BDL	4.32±0.05	744.82±7.07
Average	0-15	63.81	194.62	19.77	0.23	31.28	3294.50
	15-30	59.64	149.12	13.21	0.11	27.83	2748.10
Post-monsoon season							
Max	Surface	278.25±0.65	261.76±0.73	60.89±0.72	1.62±0.06	20.62±0.55	4559.45±13.12
	15-30	194.97±0.87	258.38±0.15	33.83±0.51	0.52±0.01	17.06±0.52	4328.63±87.16
Min	Surface	18.47±0.03	31.59±0.59	BDL	BDL	7.45±0.66	2101.74±0.36

	15-30	11.11±0.09	14.07±0.17	BDL	BDL	4.59±0.36	1842.51±0.41
Average	Surface	100.96	121.39	18.74	0.37	13.84	3602.40
	15-30	76.41	109.26	12.62	0.16	11.18	3274.00
Metal Limits							
Aggarwal [31]	20	50	10	0.06	100	-	
Awasthi [40]	135-270	300-600	250-500	3-6	-	-	
WSA* [48]	25	-	25	0.5	54	-	
FCO# [50]	300	1000	100	5	50	-	
*WSA= World Soil Average(Kabata-Pendias and Mukherjee, 2007)							
#FCO standard for organic compost (1985)							

Table 4. Contamination Factor (CF^i) and Potential Ecological Risk (E_r^i)

Metal	Depth (cm)	Pre-monsoon		Monsoon		Post- monsoon		Background value (mg kg^{-1})*
		CF^i	E_r^i	CF^i	E_r^i	CF^i	E_r^i	
Cu	Surface	2.71	13.55	1.16	5.80	1.84	9.20	55
	15-30	2.32	11.60	1.08	5.40	1.39	6.95	
Zn	Surface	6.70	6.70	2.78	2.78	1.73	1.73	70
	15-30	5.05	5.05	2.13	2.13	1.56	1.56	
Pb	Surface	2.10	10.50	1.58	7.90	1.50	7.45	12.5
	15-30	1.55	7.75	1.06	5.30	1.01	5.05	
Cd	Surface	0.03	0.96	0.01	0.36	0.02	0.57	20
	15-30	0.02	0.51	0.01	0.18	0.01	0.24	
Cr	Surface	0.31	0.63	0.31	0.63	0.14	0.28	100
	15-30	0.27	0.54	0.28	0.56	0.12	0.22	
Fe	Surface	0.08	-	0.06	-	0.06	-	56,300
	15-30	0.06	-	0.05	-	0.06	-	
**Taylor and McLennan (1995)[17]*								

Table 5. Contamination degree (Cd) and Potential ecological risk index (RI)

Pollution Index	Depth (cm)	Pre-monsoon	Monsoon	Post monsoon
C_d	Surface	11.92	5.90	5.29
	15- 30 cm	9.25	4.60	4.14
RI	Surface	32.34	17.47	19.23
	15- 30 cm	25.45	13.57	14.02



Figure 1.Location of study area
(a) Map of Jaipur city showing Jamwaramgarh

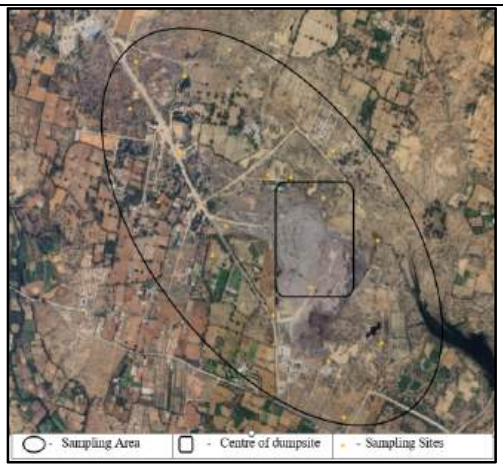
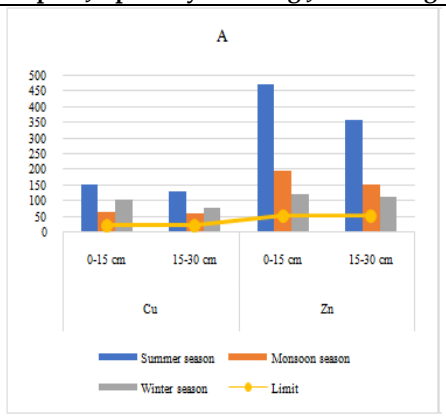
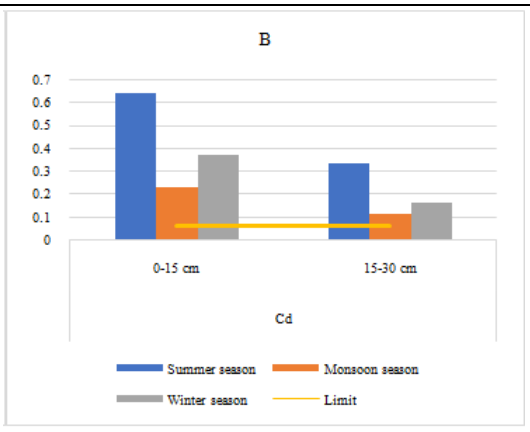
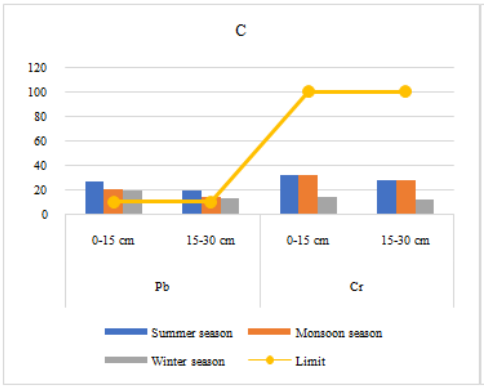


Figure 1. (b) Satellite view of the dumpsite







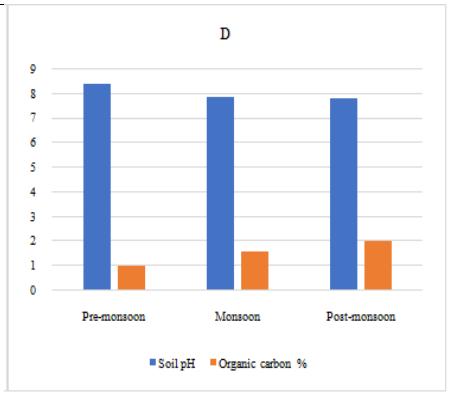


Figure 2.Graphs showing average seasonal metal content (mg kg^{-1})in soil compared with the permissible limits[31]. A,average seasonal Cu and Zn content compared; B, average seasonal Cd content in soil compared; C, average seasonal Pb and Cr content compared; D,average seasonal pH and organic carbon (%) of soil (*n=18*)

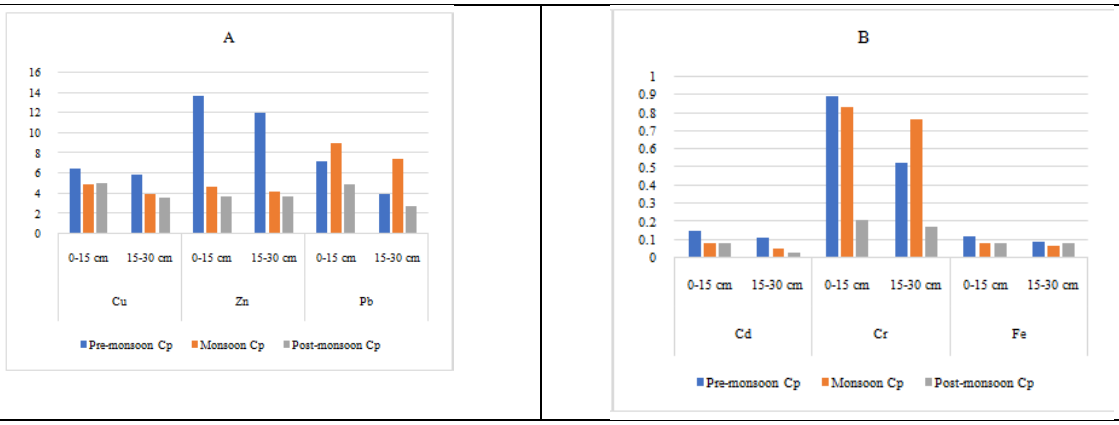


Figure 3.Potential Contamination Index (Cp) of metals in the study area.

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RESEARCH ARTICLE

A Study on the Role of Hr in Managing Employee Health and Safety in the Workplace

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ABSTRACT

This research examines the significant duties of the Human Resources (HR) department in facilitating or monitoring the health and safety of employee health and safety within the workplace. HR performs a fundamental duty in compliance with safety regulations, health programs, and facilitating a culture of well-being which leads to employee satisfaction and organizational productivity. This paper will discuss several approaches that HR has, such as risk assessments, developing policies, training programs and emergency preparedness, that support physical and mental health safety. The research will further explore the benefits and issues faced by HR departments in implementing workplace safety policies. A case study of HR's role at a manufacturing company serves to understand how HR practices and policies promote employee voluntary engagement in health & safety; prevent workplace accidents; while meeting the health & safety legal minimum standards. The research indicates, while HR plays an important role in creating a safe workplace and promoting employee health & well-being and employee engagement; HR is challenged by communication barriers within the organization; because of employees' health & safety concerns; competing priorities; and limited resources. This paper will provide recommendations to enhance HR health and safety practice to not only improve employee health & safety but record improved organizational health & successfully visible, employee health & productivity.

Keywords: Human Resources, Employee Health, Workplace Safety, Compliance, Wellbeing Initiatives.

INTRODUCTION

Human Resource (HR) is critical in driving employee health and safety in order to create an environment where employees feel secure, respected, and supported. As employee well-being becomes more prevalent, many HR departments have moved beyond just human resource administrative actions to be involved in the development and implementation of health and safety measures that contribute to organizational objectives and highlight both

physical and psychological health. With HR departments leading in respect to occupational safety and health policies, training, changes and concerns regarding hazards, their work will undoubtedly impact the overall productivity and success of the organization. This study focuses on manufacturing company as the area to examine HR's role in the management of health and safety, based on the analysis of empirical data obtained from employees' response

Aims of the Study

- To ensure effective communication of health and safety policies to employees.
- To establish compliance with the relevant aspects of the Factories Act and safety regulations.
- To promote employee health through occupational health projects such as medical checkups and hygiene maintenance.
- To enhance the knowledge of risk management through risk assessment, training and emergency planning, and health surveillance.
- To respond to employee concerns about health and safety-taking actions where there is a concern, by applying methods to support interdepartmental collaboration.
- To determine employee health and safety satisfaction levels with the current HR responses.
- To suggest possible improvements based on employee feedback and best practices developed internationally.

Need for the Study

There is a growing realization that employee health/safety contributes to operational efficiency, human capital retention, and brand reputation. With an increase in industrial automation and strain becoming more acute in certain sectors like manufacturing, we need to examine how HR can continue to forge safer and more adaptable workspaces. Specifically, we want to examine how HR aligns its functions with the above advancements, not only in doing so legally, but as a means of engaging a fruitful workforce.

Scope of the Study

The study covers a myriad of HR roles related to safety, including but not limited to:

- Health and safety policy implementation
- Training and risk reduction strategies
- Legal Obligations
- Mental and physical wellness initiatives
- Evacuation preparation• Engagement of other departments
- Feedback and employee engagement

Essential Role of HR in Health and Safety

Employee health and safety are fundamentally important to organisations now (and in the future). The role of HR is essential in fostering a proactive safety culture by finding hazards and preventing harm. By taking all necessary precautions and professionally managing risk with regard to regulation, like as the Health and Safety at Work Act, organisations avoid large fines and penalties. One aspect of workplace wellness can also include psychological well-being, so making sure that workplace mental health is given attention valuation alongside workplace physical health. Therefore, HR is a holistic approach, even though Employee Health, Safety and Wellbeing are intertwined there are different treatment options depending on the issue that may arise. HR's involvement reduces employee accidents but enhances employee morale, resulting in more engaged and productive employees. When the two variables - employee engagement and productivity are perceived positively creates an organisational culture. Health and safety strategies as defined by HR were limited to policies formalised in law, not formalising adequate employee health and safety measures in action rather than just words.

Main Tasks of HR in Managing Workplace Health and Safety

Developing Policies and Claim Legal Compliance

HR need to develop all health and safety policies that are consistent with applicable national legislation, and the best example is the Health and Safety at Work Act which together with the Factories Act and statute & regulations of OSHA provide accountable responsibility to be able to create a framework to protect employees from harm within working conditions.

Risk Assessment and Safety Audits

Regular audits and inspections coordinated by HR teams assist in monitoring possible risks in the workplace. Identifying and eliminating hazards before they become full-blown accidents lowers the risk of accidental injuries in that workspace.

Employee Training and Awareness

HR plays an essential role in developing safety training activities. By participating in these training activities with their employees, employees become familiar with safety protocols, such as addressing an emergency, and also have regular training to remind them about practicing safe hazardous safety methods. Training activities also assist in safety refreshers, as well as educate employees to support safety practices.

Prospective Mental and Physical Wellness

HR has an essential role in an organization, as they can facilitate wellness programs including stress reduction classes or workshops, fitness challenges, and mental health options. HR is aware of both mental and physical wellness, thus making sure that they support employees holistically.

Crisis preparedness and risk mitigation

HR plays an important part in developing and maintaining effective emergency response strategies. HR prepares employees for potential crises leaving them better equipped to react through evacuation procedures, fire/emergency drills, and (intentionally executing procedures) which help mitigate misunderstandings when real emergencies occur.

Working synergistically with other departments

HR has a working relationship with various departments across the organization (operations, security, etc), which helps communicate all safety measures appropriate to each identified areas hazards. This relationship must be maintained to ensure safety measures are distributed appropriately throughout the organization and prohibiting hazards from being missed.

Policies Used to Manage Health and Safety

The development of a safe and healthy work environment requires a combination of preventive and reactive policies that are clear. In a manufacturing business, HR is responsible for converting legal requirements and safety expectations into enforceable policy that will actively protect employees day to day.

Workplace Safety Policy

In order to eliminate mechanical accidents, and to promote safety when operating, the company has developed strict rules regarding the use of equipment and standard to which the facility and machines must be maintained. Machinery is locked and fenced in, in order to reduce physical hazard; and high-risk equipment can only be operated by trained, and authorized personnel. Personal protective equipment is provided as required; including gloves, helmets, goggles, and respiratory masks; and signage is prominent. There is continuous monitoring of the physical environment with regard to light, ventilation and temperature.

Health Oriented Policy

Providing hygienic conditions and promoting the general well-being of employees will be a central commitment of the organization safety culture. There are drinking water stations placed at easy access points throughout departments, and areas are cleaned on a regular basis. Waste disposal systems are safely supported so that waste does not pose a contaminating hazard. For employees who are potentially exposed to chemicals or hazardous materials, planned medical checks will be organized to monitor their ongoing health.

Fire and Emergency Preparedness Plan

Preparedness is paramount in workplace safety. Fire extinguishers, smoke detectors and alarms are placed appropriately throughout the facility. Fire drills and educational sessions are scheduled regularly. Employees will be trained in emergency response measures to enable them to react as fast as possible without impending panic. Emergency signage will be posted prominently, and escape routes will be kept clear in the event of a hazard.

Risk Assessment in Workplace Safety

Human Resources and safety personnel conduct regular evaluations, to identify potential hazards in the workplace. Evaluations will lead to the creation of Standard Operating procedures (SOP's) for hazardous tasks or materials. All employees will receive relatively good training of hazard prevention. The goal is to establish a safety culture of proactive safety, identifying risks to resolution before they become an incident.

Employee Welfare Policies

The company has implemented welfare based programs to enhance comfort and care that fall outside the standard definition of safety. The workplace is equipped with additional amenities, including restrooms that are clean, canteens, and first-aid stations to enhance employee health. In addition, the organization has appropriate policies that stipulate working hours as well as rules that allow for overtime pay and sick leave options, and paid time off, according to labour law regulations. Overall, these efforts contribute to encouraging employee morale, while also contributing to long-term health and job satisfaction.

Incident Reporting and Response Mechanisms

Transparency and accountability are foundational components of the accident reporting system. Every time there is a workplace injury or near miss, it should be documented and reported through the standard procedures. Each event triggers a comprehensive investigation to discover why it occurred, and what corrective actions are required. Each process follows the cycle of continuous improvement, suggesting the probabilty of similar events occurring has been reduced.

Training and Safety Awareness Programs

Ongoing training is crucial to maintaining safe and effective work environments. Employees attend workshops/stand up meetings, that cover aspects of machine safety, ergonomics, chemical handling, and emergency procedures etc., on a regular basis. Although completely reliant on training, visual reminders are part of the workplace equipment; reminders (i.e. posters, safety charts or other digital notifications), are used to remind safe practice and maintain safety awareness throughout the day.

HR Strategies in Health and Safety Management

1. **Develop Health & Safety Policies:** Commit to developing policy in the realm of health and safety as concerning national safety standards while adding value to the workplace's goals.
2. **Continuous Education and Safety Programs:** Provide employees with terminology and safety protocols to keep them informed and prepared with the most current standards and procedures. The best way to accomplish this is through ongoing training sessions.
3. **Risk Management and Emergency Planning:** The company must make an effort to do regular hazard assessments and document those hazards. Emergency planning must also be documented and mutually agreed upon.

4. **Employee Participation and Feedback:** The company should ask for direct observation of the health and safety program from employees and formally acknowledge concerns which may come forth.
5. **Wellness Programs:** Consider wellness initiatives that can be integrated into the culture of the workplace to include physical health (for example, fitness programs) and workforce mental health (for example, counselling service(s)).

Benefits and Disadvantages to Human Resources Involvement in Workplace Health and Safety

Benefits

- **Healthier Employees**: HR can accomplish an overall improved campus in relation to employee health; thus, less absenteeism, and likely improved job satisfaction.
- **Reduction in Workplace Accidents:** HR can greatly contribute to the decrease in workplace accidents through preventive ergonomics measures and regular training for workplace-related activities.
- **Adherence to legal requirements:** Following all safety laws minimizes any legal liability.
- **Improved Productivity:** When a worker feels safe and valued, their need for motivation and overall productivity should increase.
- **Employee trust and engagement:** A health and safety program that is implemented well can be the basis for trust from employees to HR.

Disadvantages

- **Communication Barriers**: Lack of safety policies communication can lead to confusion for employees or the potential for non-compliance.
- **Resources and Budget Limitations:** There may be times when HR cannot offer exemplary and comprehensive safety programs because of limitations in budget and resources.
- **Employee Pushback:** There may be resistance from employees, who might view new safety measures as additional red tape or inconvenience.
- **Inconsistent Monitoring:** Often, safety audits may not occur consistently over time, or there may not be consistent monitoring after the fact, which can lead to voids in maintaining safety or quality standards.
- **Compliance Issues Over Internal Cultural Change:** There may be times when HR is only complying with statutory requirements and regulations rather than undertaken to change any internal culture into a safety culture.

HR Responsibility for addressing workplace health challenges

Aside from the physical safety aspect of well-being of the employee, HR is also responsible for ensuring that employees' mental health concerns are addressed in the workplace too. Stress, burnout, and mental health challenges can greatly impact the employee's performance and overall quality of life in the workplace. HR can put programs in place such as stress management programs, mental health campaigns, and flexible workdays to ensure employees have the support and opportunities necessary for them to cope with their situation. Mental health is as important as an aspect of overall health as physical health in creating supportive and safe organizations.

Problems with HR Managing Employee Health and Safety

HR has a number of problems with managing health and safety and following through on effective health and safety management. For example:

- **HR's Budget:** Depending on the funding available to implement a health and safety program can be a clear obstacle to success as HR lacks adequate budgets to convey an effective policies organization wide.
- **HR Resistance**: Foes HR appreciate it when employees resist safety policies and do not engage within health and safety training programs
- HR have no effective communication; mostly HR has not communicated health and safety policies so the employee is confused, or does not understand the need for compliance.

LITERATURE REVIEW

1. Researchers Smith et al. (2023) highlighted that the coordination of HR practices with health and safety policy is critical for a safe and even effective, work environment. They suggested that it is vital for HR practitioners to develop policies that reflect the health and safety requirements of the workplace. Effective implementation of health and safety policies requires continuous engagement of the employee to ensure that workplace hazards are minimized.
2. Mendez & Ramirez (2024) highlighted the importance and effectiveness of the integration of daily HR operations and risk management practices. They established the connection showing the HR practitioners providing safety training, assess workplace hazards, and establishing a culture of safety - reduces the risk of accidents occurring.
3. Nguyen et al. (2023) analyze the influence workplace safety has on employees' mental health and the role played by human resources addressing mental health issues. They highlight human resources' job of considering both the physical and emotional safety of employees with regards to mental health by formulating safety procedures and protocols that promote employees' overall health, by implementing a holistic health outlook of workplace safety.
4. Wilson & Brown (2024) feel human resources cannot just offer training for employees regarding workplace safety. It is also important to keep feedback channels open between human resources and employees as this keeps employees engaged and shared experiences allow safety protocols and exercised policies to improve over time.
5. Thompson and Williams (2023) believe the role of HR is more than just satisfying the regulations around workplace safety. They argue the HR role should concentrate on health and safety policy making to ensure that workplace health and safety are long-term goals for future employees as part of their culture.
6. Roberts & Evans (2024) focus on the operational and financial benefits of HR-led workplace health and safety programs. Their findings show that organizations that introduced extensive programs for workplace safety measures performed better than their competition in terms of lost work hours, insurance premiums, and employees operating satisfactorily.
7. Nguyen & Patel (2023) examine HR's role in health campaigns and health awareness activities. They show that when HR steps outside of its normal boundaries with wellness activities, HR is able to better engage employees and build their level of involvement in maintaining a healthy lifestyle.
8. Huang & Zhao (2022) explore the role of HR in facilitating vaccination programs in the workplace. They show the ability of HR to educate employees on the impact of vaccinations in preventing the spread of transmissible diseases in the office.
9. Patel et al. (2024) support the involvement of HR in undertaking health risk assessments for employees working in a high-risk environment. They indicate that proactive risk assessments are fundamental to reducing the chances of accidents occurring in the workplace.
10. Morris & Grant (2023) indicate that HR's proactive actions in establishing health promotion programs facilitate a safer workplace. They state that when organizations adopt a holistic approach to employee well-being, these organizations experience fewer injuries and absenteeism.

Data Analysis and Interpretation

Method

The study used mixed-method research design:

Purpose

To evaluate the effectiveness of HR practices in the health and safety of workers at a manufacturing company.

Primary Data Collection

- Offline (questionnaire) surveys

- Observational visits to workstations

Secondary Data Sources

- Internal compliance reports of the company
- Safety and labour law frameworks (FCA)

Sampling

- Size: 102 respondents
- Scope: all departments employees located in the manufacturing facility.

T-Test: Gender and Health and Safety Protocols

- Null Hypothesis (H_0): There is no difference in mean perceptions of safety protocols based on gender.
- Calculated t = 6.3740
- Critical t = 2.015, df = 5
- Conclusion: Because t > 2.015 → Reject H_0
- Interpretation: Gender-based differences exist in the way employees perceive HR's communication of safety protocols.

Correlation: Qualification and HR Feedback

- r = -0.4555
- Interpretation: Weak negative correlation, meaning as qualification increases, the amount of positive capacity in HR feedback consideration redistributes to the negative side slightly.

F-Test: Qualification and Risk Management Perception

- F = 2.1016, Critical F = 6.59
- Conclusion: Because F < Critical F → Fail to reject H_0
- Interpretation: Qualification does not influence employee perceptions of how HR functions in monitoring and updating risk management practices.

Chi-Square Test: Department vs. HR

- χ^2 = 10.4642, df = 16
- Critical χ^2 = 26.296
- Conclusion: Because χ^2 < Critical χ^2 → Fail to reject H_0
- Interpretation: Employee departmental associations do not influence employee perceptions of HR working with departments.

Regression: Age and HR Feedback

- Equation (x on y): x = -0.9471y + 39.7208
- Equation (y on x): y = -0.855x + 37.8420• Conclusion: Negative slope demonstrates a negative relationship.
- Interpretation: Older employees are less likely to feel that HR has incorporated their feedback when developing health-related initiatives.

Findings of this report

- The majority of employees are aware of the safety policies and training protocols in place.
- Safety drills and completed risk assessments are routinely practiced
- HR has mixed communication on updates with positive feedback reports. Some areas for improvement was in the area of chronic illness support, some outlines not being clearly shared with staff.
- Overall acceptable satisfaction of HR safety role, with room for improvement on inclusive follow-up on feedback.

Recommendations

1. To put into practice health and safety training or delivery regularly, with all employees aware of work risks and prevention
2. To set up communications channels for all health and safety concern reporting without any fear of adverse retaliation.
3. To regularly conduct safety assessments and audits of workplaces and risk assessments to identify hazards and controls to eliminate or reduce.
4. To encourage mental health awareness and access to counselling services / or wellness pathway.
5. To establish emergency plans with all staff informed of exit plans during emergencies.
6. To encourage a safety culture within your organization and develop rewards for employee's safe practises.
7. To observe and implement specific health and safety and other applicable laws, national and local requirements.
8. To provide ergonomic workspaces, breaks, and rest areas for employees to recover and recharge.
9. To work with the operations managers for each department to establish their health and safety protocol, based on operational risk level.

CONCLUSION

In summary, the findings of this research demonstrate the importance of human resources in creating and maintaining a safe and healthy workplace. Human resource departments do not simply fulfill legal obligations, they play an important role in creating a safety culture that considers physical safety and mental well-being for workers. High levels of employee satisfaction regarding HR-led initiatives such as safety training, health programs, and communication processes suggest that HR departments are having success in creating a culture of health and safety. Conversely, research findings clearly show that HR practitioners need to be aware of the various needs of workers because these needs depend on various demographic factors. HR practitioners must fill in the gaps where they exist such as providing support for chronic conditions, and providing more transparent and clearer lines of communication regarding health and safety policies and procedures. In conclusion, HR must take a proactive, inclusive, and cooperative approach to develop health and safety as part of a workplace culture because it can help protect workers, and ultimately can drive sustainable business success and growth.

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REVIEW ARTICLE

Current Treatments and Strategies for Management of Oral Ulcers: A Review

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ABSTRACT

The present article explores various methods and strategies to treat mouth ulcers. It describes the etiology and pathogenesis of mouth ulcer. It also highlights the association of mouth ulcers with underlying systemic and autoimmune diseases. A brief discussion regarding the significance of stomatological preparations and dosage forms to treat mouth ulcers has been made. Recent advancements in the field of novel drug delivery systems, to deliver drugs directly at the site of ulceration, are described in detail. Additionally, improved herbal remedies and possible drug repurposing are listed. The role of oral probiotics in maintaining proper oral health is discussed. Emerging treatments like laser therapy, ozone therapy, biologics and role of 3D- printing have been highlighted. The potential efforts of personalized medicine tailored to meet the needs of individual patient and oral biomarkers are noted. A comparative study of marketed products to treat oral ulcers is conducted in this article.

Keywords: Mouth Ulcers, Oral Health, Therapeutic Management, Biologics, Herbal Medicine

INTRODUCTION

Recurrent apthous stomatitis (RAS), commonly called as mouth ulcers, is a concern in dental health. It is an oral condition characterized by small, open sores or lesions on the mucous membrane of the oral cavity. These sores are non-contagious and appear as white to reddish inflamed spots and generally lack pus (1). Oral ulcer is the most common oral concern prevalent among the global population. It can be observed in people of all ages. About 20- 25%

of the global population is estimated to be affected by RAS, whereas more than 85- 90% of people are exposed to minor oral ulcers at regular intervals (2). The oral ulcers can be classified as acute and chronic ulcers. Acute oral ulcers do not last more than two weeks. Chronic and recurrent oral ulcers fail to heal and last for more than two weeks (3).

Etiology

The etiology of mouth ulcers has not been clearly defined. It is considered to be multifactorial, with contributing factors including stress, trauma, injury due to biting of the mucosal layer, spicy or highly acidic foods, genetic makeup, poorly fitted dental appliances etc. (1). It may be due to nutritional deficiencies of riboflavin, niacin, folic acid, cobalamin, ascorbic acid, iron and calcium (4). The erosion of the oral mucosal membrane may occur due to rough brushing, harsh dental care routine or damage caused on chewing, eating etc. The oral ulcers may develop as a result of underlying systemic diseases or medications administered to treat those diseases (5). STIs of the mouth involve the pathogenic action of varied microbes, thus resulting in the erosion of oromucosal membranes and cause oral ulcers (6).

Pathogenesis

The pathogenesis is complex, often involving the release of inflammatory mediators such as TNF-α and microbial infections. Gene mapping and possible gene alteration using GWAS showed the possible genes involved in oral ulceration (7). A Mendelian randomization study found out the possible connection between microbial taxa (*Holdemania, Oxalobacter, Ruminococcaceae)* of gut microbiota and mouth ulcers (8). Genetic polymorphisms of several alleles were identified and analyzed for determination of role of genetics in RAS (9). Recent advancements in exosome research have highlighted their pivotal role in oral health diagnostics through liquid biopsy of oral fluids like saliva. Exosomal markers like miR-21 and p53 proteins in saliva can predict the progression of pre-cancerous lesions to oral squamous cell carcinoma. These tools focus on the ability of exosomes to serve as non-invasive biomarkers for diagnosing and monitoring various oral diseases, including oral ulcers and oral cancers (10,11). Nanobiosensors have gained limelight in detection of biomolecules in saliva for possible oral concerns (12). Artificial intelligence- based models are being developed to diagnose and categorize oral ulcers, without any invasive techniques, and can aid dentists (13).

STOMATOLOGICAL PREPARATIONS

Stomatology ("*stoma*" means "mouth" or "hole") refers to the branch of dentistry associated with the study of mouth and its associated diseases. Stomatologicals refer to the drug substances or preparations used to prevent, treat or mitigate oral disorders (14). According to the Anatomical Therapeutic Chemical (ATC)/ Defined Daily Dose (DDD) Classification System, **'s**tomatological preparations' are classified under the code A01**,** which fall within Group A**,** designated for drugs related to the 'Alimentary Tract and Metabolism'. A01 is further classified as follows as shown in Table 1 (15). The ATC/ DDD system, which is endorsed by the WHO, standardizes drug classification (ATC) and measurement (DDD) for global drug utilization studies. This system is vital for drug auditing and monitoring healthcare outcomes. This enables consistent analysis of prescribing trends, promotes rational drug use, and supports access to essential medicines (15).

ASSOCIATION OF GENERAL HEALTH AND MOUTH ULCERATION

Mouth Ulcers due to Systemic and Autoimmune Disorders

Oral diseases have been linked to systemic diseases and autoimmune disorders, with a well-established relationship between their occurrence and the presence of systemic conditions (16,17). Oral ulcer can be a symptom of pernicious anaemia caused due to deficiency of Vitamin B_{12} (18). Oral ulcers are the most common clinical manifestation of numerous systemic diseases (3). Individuals with cardiometabolic diseases often experience xerostomia, altered immune functioning and increased oxidative stress, thus are prone to mouth ulcers (19,20). STI- causing pathogens such as HPV, *Neisseria gonorrhoeae, Treponema pallidum,* HSV and *Chlamydia trachomatis* can cause systemic infections as well as manifest in terms of cold sores/ recurrent oral sores/ chancres, thus affecting the oral mucosal lining (21). Oral ulcers are associated with diseases such as rheumatoid arthritis, Behçet's disease, Crohn's disease, systemic

lupus erythrematosus, celiac disease, pemphigus vulgaris and oral lichens (22). Oral ulcers and lesions form the principal symptoms in Behçet's disease (23). Worsening of Crohn's disease results in formation of oral ulcers (24). Oral ulcers appear frequently in patients with SLE and is a criterion in classification of lupus (25).

Drug- Induced Oral Ulcers

Oral ulcers may develop due to the adverse effects of medications. NSAIDs are the most common medications which inhibit the release of prostaglandins which are essential for formation of the oromucosal lining (26). Chemotherapeutic agents such as methotrexate and 5- flurouracil are invariably associated with formation of mouth ulcers during treatment of cancer (27,28). Oral ulcers are seen as adverse effects of methotrexate when indicated as anti-neoplastic and anti-rheumatic agent (29). Mouth ulcer is a side effect of pantoprazole as it reduces the absorption of Vitamin B_{12} and causes its deficiency (30). Anti- hypertensives and anti- anginal drugs can lead to severe mouth ulcers (31,32). Hormonal therapy based on estradiol, tamoxifen- based treatment have been found to induce mouth ulcers (33). Bisphosphonates used to treat bone-related disorders can cause oral mucosal erosion and ulceration (34). Vidagliptin, a dipeptidyl peptidase-4 inhibitor used to treat diabetes mellitus, can induce oral ulcers in rare cases due to altered oral environment (35). Anti-depressants can trigger the ulceration in oral cavity (36). Table 2 summarizes different categories of medications with examples which are known to cause mouth ulcers as adverse effects. Necessary directions should be given by the medical practitioners to the patients during administration of these drugs.

RECENT ADVANCEMENTS IN TREATMENTS AND STRATEGIES

The conventional medications to treat mouth ulcers include topical anaesthetics, such as benzocaine, which acts as by blocking the nerve transmission and reduces the pain sensation (37). Mouthwashes containing chlorhexidine, dexamethasone are useful in relieving mouth ulcers (38). Oral cryotherapy is the easiest method to treat mouth ulcer during its initial stage (39). This section describes the current trends and advancements in formulations and delivery systems to treat mouth ulcers. Strategies through NDDS, herbal medicines, probiotics and nutraceuticals have been explored to treat mouth ulcers. Emerging drugs such as biologics, laser and ozone- based therapies have been described.

Novel Drug Delivery Systems

Novel drug delivery systems enable patient- targeted therapy for each individual. The dosage forms such as mucoadhesive films, buccal patches, oral wafers, oral dissolving strips, lipososmes, nanotechnology- based preparations and hydrogel are gaining importance in prevention and treatment of oral ulcers (14). A Swedish startup called Mucort has developed an intra-oral patch that absorbs tissue fluid containing inflammatory mediators, bacteria, and pathogens involved in ulcer formation. The patch absorbs tissue fluid up to 20-25 times its original weight and turns into a biodegradable gel within 3 to 4 hours. It is designed to reduce inflammation, stimulate healing and offer a hygroscopic effect to support oral ulcer recovery (40). Dissolving microneedle patches loaded with combination of betamethasone sodium phosphate and betamethasone dipropionate (BSP-BDP) along with hyaluronic acid was reported to have therapeutic effect against mouth ulcers. BSP- BDP promotes cell proliferation whereas hyaluronic acid facilitates oral ulcer healing (41). Similarly, microneedle patches containing triamcinolone acetonide showed better bioavailability and physical properties when formulated with mesoporous polydopamine nanoparticles. It is a unique dressing for treating oral mucositis (42). Mucoadhesive gel, prepared using naturally obtained polynucleotides (from the fish tissues) and sodium hyaluronate, was explored as a novel approach in treating oral ulcer as a Class III CE0373 medical device. Polynucleotides restore the innervated oral tissues and hyaluronate promotes wound healing (43). Cuttlefish ink is reported to have antimicrobial, antioxidant, anti-ulcerogenic and anti-neoplastic properties (44). This natural bioactive ingredient was combined with nanoparticle-based biopolymer in treating oral ulcers developed in diabetic patients (45). Dexamethasone loaded into HPC- based oral dissolving films was found to regulate PI3K/Akt signalling pathway to produce anti oro-ulcerogenic action (46). Antimicrobial peptides- modified polycaprolactone- collagen nanosheets provide better adhesion and improve the healing of oral ulcers (47).

Herbal Remedies

There is an increased demand for herbal drugs for treating oral ulcers. Drugs such as aloe, guava, liquorice and turmeric have been reviewed for anti- oral ulcerogenic activity (48). Clinical trials have shown that extract of *Punica granatum* is rich in polyphenolic compounds and provides anti- inflammatory activity against oral ulcers (49). Polyherbal oral patches comprising extracts of areca nut, gambier and green betel leaf were found to reduce the diameter of oral lesions (50). Extract of *Moringa oleifera* was found to confer the wound healing property against oral ulcers (51). Clinical trials showed that oil pulling therapy using pumpkin seed oil was effective in reduction of RAS (52). Essential oils such as tea tree oil, clove oil, bergamot oil, rosemary oil can act as better excipients in improving therapeutic activity of stomatological preparations against oral ulcers (53). Nutraceuticals have to be tapped as preventive measures against mouth ulcers. These serve as sources of essential nutrients and help prevent deficiencies associated with induction of mouth ulcers. Legumes, green leafy vegetables, citrus fruits are excellent sources of folic acid (54). Deficiency of Vitamin B_{12} and niacin can be reduced by sufficient of intake of sea food, dairy products, eggs and meat (55). Products such as Becosules (capsules containing B-Complex & Vitamin C), Bioven Zinc (oral spray infused with Vitamin C can be indicated as supplements to prevent mouth ulcers (56,57).

Probiotics

Probiotics have shown promising results in managing mouth ulcers (58). They can be used as adjuvants to existing antibiotics to improve the healing rate of mouth ulcers (59). A topical nano-formulation containing *Lactobacillus reuteri* was found to reduce the size of oral lesion and severity of pain (60). Hydrogel composed of calcium alginate/ fucoidan and *Lactobacillus rhamnosus* showed good antimicrobial activity and oro-ulcer healing capacity (61). An oleogel, composed of several probiotics of *Lactobacillus* species such as *L. rhamnosus, L. casei, L. fermentum and L. acidophilus,* showed the ability of skin repairing in wounds such as diabetes- induced oral ulcers (62). *Lactobacillus brevis* CD2 and *Bacillus clausii* was found to be effective in treating oral ulcers (63,64). A patented therapy shows that α- hydroxy organic acids (lactic acid, glycolic acid) or their salts can be used in treatment of mouth ulcers (65). Marketed product such as ORASORE® tablets are formulated using lactic acid bacteria along with nutrients such as niacinamide, folic acid and riboflavin (66).

Biologics

Biologics, such as monoclonal antibodies, have therapeutic effect against oral ulcers. The mouth ulcers occur as adverse effects when drugs are administered against underlying autoimmune diseases such as rheumatoid arthritis, Behçet's diseases, ulcerative colitis etc. Monoclonal antibodies have been established to treat oral mucosa- related diseases and produce anti-oral ulcer activity at optimal doses (67). A single infusion of infliximab was found to have positive results in treating refractory oral ulcers (68). Etanercept, a TNF inhibitor, was administered subcutaneously (25 mg, twice weekly) and found to be effective in treating oral ulcers (69). Ustekinumab is extensively used in treating oral ulcers and lesions (a classic symptom of Behçet's disease) by inhibition of IL-12 and IL-23 (70). Anakinra, an IL-1 inhibitor, is found to be useful in treating mucocutaneous lesions developed in oral cavity and genital region (71). Abatacept reduces the diameter of oral ulcers, count of PMNL and MNL, along with decreased migration of inflammatory cells, thus accelerating the rate of healing of oral ulcers (72). Potential connection between granulamatosis with polyangitis causes oral mucositis and vasculitis. Avacopan is a C5a- receptor inhibitor, targeted against ANCA- associated vasculitis, to combat oral lesions and ulcers (73). Canakinumab, a IL-1β blocker, is useful in treating mouth ulcer by minimizing the release of inflammatory mediators (74).

Miscellaneous Therapies

Studies have shown that photobiomodulation or low- level laser therapy as an effective adjunctive treatment against mouth ulcers, dental procedures and oral concerns (75,76). Low level laser therapy is a non- invasive and painless therapeutic intervention. It is significant due to properties such as biomodulation, disinfection of the oral sores and their recovery by stimulating new collagen synthesis (77). Clinical trials have shown that ozone therapy can be used as an unique solution against RAS. Delivery of ozone for about 60 seconds at the site of RAS was found to minimize the pain associated with oral ulcers (78). Ozonized olive oil was found to provide therapeutic effect to cure RAS (79).

Role of 3D- Printing

3D- printing of pharmaceuticals has been a boon in manufacturing of dosage forms tailored as per the patient requirements. It can be explored to produce chewable tablets, lozenges, orodispersible films, patches and semi-solid dosage forms to exclusively treat mouth ulcers. It provides an opportunity for multi-drug delivery along with personalized drug dosing. Dexamethasone acetate based buccal patches were prepared using fused deposition modeling - 3D-printing technology to treat RAS (80). Capsaicin, a naturally occurring alkaloid, is found to have analgesic, anaesthetic and anti-inflammatory properties (81). 3D- printed candy containing 0.05% capsaicin and 10% capsaicin- loaded ultrafine fiber film was found to have excellent healing properties against mouth ulcers (82,83).

Drug Repurposing

Drug repurposing has been successful in identifying drugs for treating mouth ulcers. Suramin, an antiparasitic drug used to treat African sleeping sickness, was found to be effective in treating oral mucositis (84). Thalidomide is an immunomodulator which acts by TNF-α suppression, opposes angiogenesis by reducing the expression of VEGF and inhibits the surge of pro-inflammatory mediators (85). This drug was found to be effective in treating oral ulcers, (developed as secondary infection), in HIV- affected patients. Amlexanox, an anti- inflammatory drug, previously used to treat asthma, showed effective response (as 5 % mucoadhesive paste) against mouth ulcers. However, it was discontinued in USA due to severe adverse effects. Efforts were made to develop amlexanox- loaded nanoliposomes for localized oromucosal delivery which was successful in minimizing the release of inflammatory cytokines associated with oral ulceration (86).

MARKETED PRODUCTS

The global market value of dental care products was valued around USD 35 billion in 2023 and is expected to reach USD 95 billion in 2032 (87). The estimated global market value of mouth ulcer treatment was valued at USD 1.5 billion in 2023 and expected to cross the USD 2.25 billion mark in 2030 at a CAGR of 3.5% (88). Some of the eminent global market players in the mouth ulcer treatment include 3M, Colgate- Palmolive, GSK, Blistex, Bristol Myers Squibb Company, Church & Dwight and Dental Herb etc. (89,90). Table 3 presents various marketed products available for therapeutic management of oral ulcers.

CONCLUSION

The management of mouth ulcers has evolved significantly, with numerous advancements aimed at improving both the effectiveness and patient experience of treatment. The growing understanding of the complex etiology and pathogenesis of oral ulcers, including the role of inflammatory mediators, infections, and systemic health conditions, has paved the way for more targeted therapies. Novel drug delivery systems have revolutionized treatment by allowing for precise, localized drug delivery with controlled release, minimizing systemic side effects and enhancing healing. The incorporation of herbal remedies, probiotics, laser therapy and biologics offers promising alternatives for inflammation reduction and healing. Despite these advancements, a comparative analysis of existing treatments reveals variability in efficacy, underscoring the need for continued innovation and individualized care. A multidisciplinary approach combining personalized medicine and improved patient education will be essential in providing effective and long-term solutions for mouth ulcer management. The future of treatment lies in optimizing these strategies to enhance therapeutic outcomes and improve patient quality of life.

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CONFLICT OF INTEREST

None

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Abbreviations

RAS- Recurrent Aphthous Stomatitis	FDA- Food & Drug Administration
ATC- Anatomical Therapeutic Chemical	GWAS- Genome Wide- Association Studies
DDD- Defined Daily Dose	HPC- Hydroxypropyl Cellulose
WHO- World Health Organization	STI- Sexually Transmitted Infections
NDDS- Novel Drug Delivery System	HPV- Human Papilloma Virus
3D- 3 Dimensional	NSAIDs- Non- Steroidal Anti- Inflammatory Drugs
USD- United States Dollar	CAM- Complementary and Alternative Medicine
CAGR- Compound Annual Growth Rate	USA- United States of America
TNF- Tumour Necrosis Factor	HIV- Human Immunodeficiency Virus
IL- Interleukin	HSV- Herpes Simplex Virus
CTLA- Cytotoxic T-Lymphocyte Antigen	BSP-BDP- Betamethasone Sodium Phosphate and Betamethasone Dipropionate
ANCA- Antineutrophil Cytoplasmic Antibody	VEGF- Vascular Endothelial Growth Factor

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Table 1: Classification of Stomatological Preparations

Subgroup	Class of Drugs
A01AA	Prophylactic agents, such as fluoride preparations, to prevent anti-caries.
A01AB	Anti-infectives, such as tetracyclines, to treat stomatitis and gingivitis.
A01AC	Corticosteroidal preparations such as triamcinolone, dexamethasone, prednisolone and hydrocortisone etc, for treating gingivitis and stomatitis.
A01AD	Miscellaneous agents used in dentistry.

Table 2: List of some of the drugs which can induce mouth ulcers (26- 36)

S. No.	Class of Medication	Examples
1.	NSAIDs	Ibuprofen, Piroxicam, Naproxen
2.	Anti-neoplastic	Methotrexate, 5- Flurouracil
3.	Anticonvulsants	Lamotrigine
4.	Antihypertensives	Bisoprolol, Propranolol
5.	Anti-anginal	Nicorandil
6.	Hormonal therapy	Tamoxifen-based therapy
7.	Bisphosphonates	Alendronate, Risendronate
8.	Anti-diabetics	Vildagliptin
9.	Anti-depressants	Nortryptyline
10.	Proton pump inhibitors	Pantoprazole

Table 3: List of some of the marketed products to treat oral ulcer

S.No.	Dosage Form	Brand Name	Comments	References
1	Gel	Orasore Smyle	It contains lignocaine hydrochloride and choline salicylate along with benzalkonium chloride, spearmint, fennel, glycerine. It is a polyherbal Ayurvedic product.	(91,92)

2	Tablet	Oracool	It contains folic acid, riboflavin, niacinamide and lactic acid bacteria.	(93)
3	Mouthwash	Orajel	It contains hydrogen peroxide and menthol. It acts as an oral debriding agent.	(94)
4	Drops	Rinsout	It is a polyherbal,, alcohol-containing, Homeopathic product, which comprises the extracts of *Calendula officinalis, Echinacea angustifolia* and *Hydrastis anadensis*	(95)
5	Paste	Tess Lexanox	It contains triamcinolone acetonide. It contains amlexanox.	(96) (97)
6	Patch	DenTek	It provides relief from oral sores by acting as a physical barrier. It also contains Vitamin E. It is a chemically tested stomatological preparation.	(98)
7	Oral dissolving discs	CankerMelts	It contains benzocaine, hyaluronic acid and cobalamin. These ingredients facilitate wound healing of oral wounds and ulcers	(99)
8	Lozenge	Tantum , Verde	These products contains benzydamine hydrochloride and treat inflammatory and irritatory conditions associated with mouth and throat.	(100)
9	Spray	GUM, AftaClear	These products are polyherbal and alcohol- free.	(101)
10	Pastilles	Iglu	It is a sugar-free dosage form which contains benzalkonium chloride and compound benzoin tincture.	(102)

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RESEARCH ARTICLE

Utilizing the CoCoSo -CBA Method to Analyze the Chola Period's Finest Temple in Interval Value Intuitionistic Fuzzy Set in Multi-Criteria Decision-Making

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ABSTRACT

This study employs the Combined Compromise Solution (COCOSO) method, integrated with the Cost benefit Analysis (CBA) approach, under Interval Value Intuitionistic Fuzzy Set (IFS) framework to analyse and rank the most remarkable Chola-period temples. The COCOSO-CBA method effectively handles multi-criteria decision-making (MCDM) by aggregating various evaluation criteria from expert opinions, while Interval value in intuitionistic fuzzy sets (IFS) incorporate uncertainty in expert judgments. The methodology involves defining criteria, assigning weights using the intuitionistic fuzzy set, and applying the expected value method to convert IVIFS values into crisp values. Finally, the temples are ranked based on the aggregated scores derived from the COCOSO-CBA method. The aim is to prioritize the finest temple that has withstood the test of time.

Keywords: Interval value in intuitionistic fuzzy sets (IFS), Expected Value Method, Combined Compromise Solution (COCOSO) method, Cost benefit Analysis (CBA).

INTRODUCTION

The Chola period's is marvels of architecture and also a timeless example for creativeness and technical works process in construction. Selecting the best temple requires thoughtful examination of a few fundamental factors. For managing such intricate duties, Multi-Criteria Decision-Making (MCDM)[6] methodologies combine a qualitative and quantitative approach. This study applies the COCOSO-CBA method algorithm [5][6][10] in an interval value intuitionistic fuzzy set[1-3] with MCDM (multicriteria decision making). The Expected Value Method [11] methodology combines the advantages of weighted sum and compromise ranking methods to make the interval values clear. COCOSO, which was first presented by Yazdani et al. [10], balances various ranking techniques for effectively synthesize decision-making criteria to identify the most desirable options. In order to obtain a thorough ranking of criteria within the context of MCDM, the method employs three aggregation strategies: multiplicative utility, compromise ranking, and additive weighting. In assessing alternatives, CBA[4] is essential. CBA[11] offers a structured method for evaluating financial viability and overall benefits by quantifying trade-offs, value-driven benefits, and qualitative values to both positive and negative aspects. This allows decision-makers to evaluate an option's overall feasibility and desirability. This integration improves the accuracy of decisions, especially as it pertains to large-scale infrastructure development, cultural conservation, and historical architectural study.

Aim of the research /objective

- To provide a range of possible outcome, help the decision maker to understand uncertainty associate with expected value method in Fuzzy environment.
- With the integrated algorithm can provide a realistic representation of uncertain data in real life decision- making problem.

RESEARCH DESCRIPTION

The intricate architectural details of Chola's temple during the epic era are examined. identifying the best architecture by the architect or people lead to uncertainty where several areas of architecture are focused on the modern world. The probabilities and consequences of IVIFS 's uncertainty are can also manage the algorithm in decision making

APPROACH FOR COCOSO & CBA ALGORITHM

The Algorithm is framed for quantify ranking of chola architecture by combining Intuitionistic fuzzy set with COCOSO method and CBA method, method is outlined below [8,9].

Step1: For the expert Linguistic Variable, the alternative and criteria values were subsequently transformed into Interval value Intuitionistic Fuzzy values.

Step 2: fuzzy decision matrix evolved from the interval value intuitionistic fuzzy decision matrix[11].

[a, b] [c, d] = [ac, bd]

$\frac{ac+bd}{2}$ ...(2)

To perform stages 3, 4, and 5, the phyton code is utilized.

Step 3: To obtain precise values for the decision-making, the values in the matrix are normalized from the stage before them[6][5]

$T_{eij} = \frac{x_{ij}-min\,x_{ij}}{max\,x_{ij}-min\,x_{ij}}$ ... (3)

Step 4: The weight of the matrix's sum and power are determined using [6]

$(T_s) = \sum_{j=1}^{n}(wj\ teij)$ ...(4)

$(T_p) = \sum_{j=1}^{n}(teij)^{wj}$ ...(5)

for the comparability of alternative weights.

Step 5: Three strategies for accumulating assets

$(P)_{i_1} = \frac{t_s + t_p}{\sum_{i=1}^{m}(t_s + t_p)}$ ...(6)

$(Q)_{i_2} = \frac{t_p}{t_s} + \frac{t_s}{t_p}$ ...(7)

$(R)_{i_3} = \frac{t_s + (1+\lambda)(t_p)}{max\ t_s + (1-max\ t_p)}$ $0 \le \lambda \le 1$ for $\lambda = 0.5$ ...(8)

Step 6: Organizing the choices according to the (k) Assessment

$K = (P \times Q \times R)^{\frac{1}{3}} + \frac{1}{3}(P+Q+R)$ ...(9)

Step 7: The score arrangements' systematic progression, the order in which the score arrangements are presented.

Step 8: Quantifying the sequence order by Cost Benefit Analysis method[11][4].

IMPLEMENTING THE ALGORITHM FOR RANKING

The linguistics value of decision maker, the expert and IFS value are tabled. The value converts it into Ifs number using table1 and each attribute's IFS value has a crisp value i: e fuzzy decision matrix form, according to the expert the given Weight values are W1 = W2 = W3= W4= W5= 0.5 hence the weight age of the temple for millennium is constant Stated from the step3 the alternative (temples)as T be Brihadeshwara temple, Gangaikonda cholapuram, Åiravatesvara temple, Vijayalaya choleeswaram and their criteria as I where Architectural designs, Materials, Patterns, Visual and feel, Intricacies. [Table 2] The table to matrix form as:

$$\begin{bmatrix} 0.10 & 0.31 & 0.1 & 0.31 & 0.31 \\ 0.34 & 0.31 & 0.34 & 0.1 & 0.19 \\ 0.10 & 0.1 & 0.31 & 0.31 & 0.10 \\ 0.1 & 0.1 & 0.19 & 0.34 & 0.19 \end{bmatrix}_{4\times5}$$

By utilizing the phyton, these operations are accessible for Step 3,4&5 syntax for formulae is given below .

Step3:

```
    for j in range(len(mat[0])):
        val=(mat[i][j]-find(mat,'min',j))/(find(mat,'max',j)-ind(mat,'min',j))
Matrix Multiplication :
for j in range(len(mat1[0])):
        vsum = vsum + (mat1[i][j]*mat2[0][j])
Power of Matrix :
if(operation == 'min'):
        val=min(val,mat[i][col])
    elif(operation == 'max'):
        val=max(val,mat[i][col])
for j in range(len(mat1[0])):
        val =  (mat1[i][j]+mat2[i][j])/(findsum(mat1,j)+findsum(mat2,j))
        val =  (mat1[i][j]/find(mat2,'min',j))+(mat2[i][j]/find(mat1,'min',j))
    for j in range(len(mat1[0])):
  val=((0.5*mat1[i][j])+(1.5*mat2[i][j]))/((0.5*find(mat1,'max',j))+(1-find(mat2,'max',j)))
```

Approaching on the beneficial criteria from step 3, the normalizes value is done.

Weight	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
Min	0.1	0.1	0.1	0.1	0.10
Max	0.0.34	0.31	0.34	0.34	0.31

$$t_{eij} = \begin{bmatrix} 0 & 1 & 0 & 0.8749 & 1 \\ 1 & 1 & 1 & 0 & 0.42857 \\ 1 & 0 & 0.8749 & 0.8749 & 0 \\ 0 & 0 & 0.3749 & 1 & 0.42857 \end{bmatrix}_{4\times5}$$

Python is used to run the code, and the results are provided below.

Sum of weight and the matrix $\begin{bmatrix} 1.4375 \\ 1.7143 \\ 1.3749 \\ 0.9017 \end{bmatrix}$

Product of the matrix and weight $\begin{bmatrix} 2.9354 \\ 3.6547 \\ 2.87072 \\ 2.2669 \end{bmatrix}$ here the given weights constant from the expert.The Score arrangements of the matrix are evaluated below, are ordered in ascending .from step5 &6.

P Matrix:	Q Matrix:	R Matrix:	*K-VALUES*	RANKING
$\begin{bmatrix}1.0\\1.0\\1.0\\1.0\end{bmatrix}$	$\begin{bmatrix}2.5317\\2.6009\\2.5669\\2.9118\end{bmatrix}$	$\begin{bmatrix}4.2098\\3.5266\\4.2201\\4.7192\end{bmatrix}$	$\begin{bmatrix}5.8452\\5.8644\\5.8869\\6.5839\end{bmatrix}$	**1** **2** **3** **4**

RESULTS AND DISCUSSIONS

Cost benefit method, Benefit > cost , in case of these criteria has shaped the society with with benefits of 1.Human Devotions, 2. Cultural Identity, and 3. Architectural Ingenuity [8] here the temple is considered as centre of economic activities for education- arts and culture . The cost value is 100 per head [9]in above temple are hub of learning materials for scholars and philosophers it also has role of local art and craftmanship. Showcase the skills and growth of region. The 3 values made Brihadeshwara temple to stand firm – both in cost and benefits.

Work

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Table 1: Intuitionistic fuzzy value for Linguistic value

LINGUISTIC VALUE	IVIFS
Excellent	[0.8 0.9], [0.25 0.01]
Very Good	[0.70.5], [0.6 0.4]
Good	[0.50.5], [0.1 0.3]
Neutral	[0.5 0.4], [0.8 0.7]
Undecidable	[0.2 0.5], [0.6 0.5]

Table 2: Expected value method for fuzzy normalized value

T- TEMPLES \ I- CRITERIA	I_1	I_2	I_3	I_4	I_5
T_1	0.10	0.31	0.1	0.31	0.31
T_2	0.34	0.31	0.34	0.1	0.19
T_3	0.10	0.1	0.31	0.31	0.10
T_4	0.1	0.1	0.19	0.34	0.19

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RESEARCH ARTICLE

A Study on the Quality of Work Life and Job Satisfaction among Women in the Textile Industry, with a Focus on Thirupur District, Tamil Nadu

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ABSTRACT

The workforce includes female employees. In addition to producing commodities and services, women are the main source of advancement for the human species. Women were only permitted to perform specific tasks in factories at first, thus their labour was not directly comparable to that of men. One of the district of Tirupur's traditional industries is the textile industry. The cotton is produced by the textile proprietors through a contract arrangement. Without taking into account factory regulations and working conditions, the contractors employ a large number of contract women workers. Since women make up the majority of the workforce in the textile business, textile owners are obliged to provide them with the necessities. Women workers start working in the cotton sector every day at eight in the morning and finish at the end of the day.

Keywords: Work Force, Contract, Working Conditions, Women Workers.

INTRODUCTION

The final emotion that a person has after completing a work is job satisfaction. A person's job will be fulfilling if it satisfies his dominant wants and is in line with his expectations and ideals. The emotion could be either pleasant or negative, contingent on the extent to which the need is met. Job satisfaction is not the same as morale or motivation. Motivation is the state of being willing to work. Contrarily, satisfaction denotes a happy emotional state. A overall attitude towards one's job and workplace is implied by morale. In contrast to job satisfaction, which is a personal experience, this phenomena is collective. Morale can be a source of satisfaction as well as a dimension that job satisfaction can have Predispositions known as attitudes cause a person to act in a specific manner. The other hand, job satisfaction is the final emotion that can impact behaviour in the future. So, a worker's overall attitude towards his work is what determines job happiness. A person's motivation to work is derived from their desire to work,

which is referred to as job satisfaction. Here, it's never just about happiness, contentment, or fulfilment; it's always about the work.

OBJECTIVES OF THE STUDY

- To examine the views of women workers in the textile industry.
- To anlaysethe perception of women workers about the wages and economic benefits of the textile industry.
- To evaluation of the quality of life work performed bywomen workers in the textile industry in Tirupur district.

SCOPE OF THE STUDY

This study took a long time, many problems occurred, and it became a challenge for the researcher to complete the data collection. Collecting objective data takes a lot of time and care. However, the time and interest for many respondents was insufficient due to a lack of interest from their employers. Therefore, the study's conclusions are subject to inherent limitations in both primary and secondary data. In addition to these other restrictions are: 1. The results of this study are related to the textile sector in Tirupur district and cannot be generalized for the textile manufacturing sector as a whole.

STATEMENT OF THE PROBLEM

For this study, the term quality of work life refers to the values and attitudes in the life of each employee. "The purpose of work life" includes many factors, such as pay, promotion, opportunities for growth and continued safety, benefits, possible wages, safe and healthy work practices, management, personnel and supervision, nature of work, Social integration in work management, legal principles in work management, work and the whole area of life, and social interaction in in working life. Everyone has their own way of evaluating work life. Maintaining the health of the organization and the satisfaction of the employees from time to time is one of the main factors for the success of the organizations and the sustainability of the organizations.

The present study is descriptive. Data were collected using a questionnaire. The sample group for the study was textile industry workers in Tirupur city. Both primary and secondary data have been used in this study. Respondents were selected using a non-probability “Participation” sampling method. 500 employees were available to contact the petitioner for data collection.

RESEARCH METHODOLOGY

The present study is descriptive. Data were collected using a questionnaire. The sample group for the study was textile industry workers in Tirupur city. Both primary and secondary data have been used in this study.

Respondents were selected using a non-probability “Participation” sampling method. 500 employees were available to contact the petitioner for data collection.

DATA ANALYSIS AND INTERPRETATION

From the above table, it is seen that the level of satisfaction, varied between a minimum of 1to maximum of 5. The highest mean was found for wage (4.6171) followed by recognition of achievement (3.1240). The lowest mean was found for work load (2.9121).

FINDINGS OF THE STUDY

- Rewarding and celebrating achievements contributes to employee satisfaction.
- There is a relationship between employees' perceptions of job satisfaction with age, gender, marital status, education, family membership and family income.
- Respondents belonging to the age group between 20-25 years agree more about employee satisfaction as compared to respondents belonging to the age group 45-55 years.
- Unmarried respondents were more likely to agree about happiness than widowed respondents.
- Respondents who are educated to a higher level agree more favourably than uneducated respondents.

SUGGESTIONS

This means employees have a happier life and a better work life. Events should emphasize eating the right food at the right time, getting plenty of rest, deep sleep and exercise. Employees feel that these two things only increase their performance. Therefore, employers should pay attention to these two areas. Costs play an important role in determining QWL among all sectors of the textile industry. Employers must give fair and reasonable wages to their employees based on work, experience and cost of living.

CONCLUSION

It helps to improve the quality of work life and work efficiency and increase productivity. The purpose of this study is to understand the quality of work life in textile companies in Tirupur city. In this study, it has been found that out of eleven elements, only two related to the employer-employee relationship and stress management have a role in QWL, a good employee and both. Employees want to be satisfied with receiving fair compensation and recognition of achievements at work.

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Table 1: opinion of women workers present jobs in textile Industry

QWL Factors	Mean	S.D
Fair wages	4.6171	0.7134
Healthcare	3.3821	0.7085
Recreational Facilities	3.6560	1.2132
Flexible work hours	2.9121	1.1001
Opportunities	3.6560	2.1884
Working environment	3.7060	1.0343
Fair performance appraisal	3.3840	1.0839
Flexibility of working hour	4.5220	2.0468
Job security and job satisfaction	4.0520	0.7001
Relationship with co-workers and supervisor	3.7320	0.8341
Recognition of achievement	3.1240	0.7532

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RESEARCH ARTICLE

Exploring the Biological Activities of *Crotalaria juncea* Whole Plant for Its Therapeutic Potential

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ABSTRACT

Crotalaria juncea whole Plant was evaluated for *in-vitro* antioxidant, anti-inflammatory and *in-vivo* anti-anemic activities in Anaemia Induced Rats. The whole plant extract exhibited significant biological activities when compared with standard reference drugs. The different methods adopted are of standard. *In-vitro* anti-oxidant activity was evaluated using DPPH and Reducing power assay, *in-vitro* anti-inflammatory activity was evaluated using Protein denaturation method and Human RBC standard methods. Anemia induction by Phenylhydrazine injection to Albino rats lead to significant decrease in Hemoglobin and Red Blood Cells, these decreased level significantly exalted with the treatment of *Crotalaria juncea* whole plant.

Keywords: *Crotalaria juncea,* anti-oxidant, anti-inflammatory, anti-anemic activities.

INTRODUCTION

Ayurveda is considered to be the most ancient medicinal system known to mankind [1]. Plants and their secondary metabolites derived may be the important source of Pharmaceutical drugs to exhibit physiological activity[2-8]. *Crotalaria juncea* commonly familiar as Sun hemp, abaundantly available in many parts of Andhra Pradesh, India. This whole plant is being used by many tribal community and also natives of forest areas of East Godavari district,

traditionally using this medicinal plant for the treatment of pain, as a blood purifier, astringent and for skin diseases [9-12].

MATERIALS AND METHODS

Collection of *Crotalaria juncea*

The whole plant was collected from different regions of Rampachodavaram, Maredumalli and Jaddangi forest of East Godavari region. The plant has been identified and approved by botanist Dr. T. Raghuram, Maharani College, Peddapuram. The Plant was dried under shade for 10 days and pulverized to coarse crude powder and stored in air tight container. The required amount of coarse powder was subjected to Soxhlet Extractor for continuous hot extraction with ethanol for 8 to 10 hours. Then the extract was filtered and the filtrate was evaporated to dryness

Chemicals and Apparatus

Chemicals used are of Analytical grade with standard Glassware.

***In-vitro* Antioxidant activity:**[13-18]

(i) **DPPH method:** Gallic acid was used as a reference standard while making 0.002% of DPPH in methanol to perform the free radical scavenging activity. With the aid of methanol, various quantities of Standard Gallic acid 2.5 ug/ml and *Crotalaria juncea* whole plant extract (100 and 200 ug/ml) were produced. One millilitre each of the extract and standard concentrations are combined with one millilitre of 0.002% DPPH. After 30 minutes in the dark, the produced combinations' OD at 517 nm was measured. Finally the % inhibition of DPPH activity is calculated from using the formula DPPH Scavenged (%) = [(Acontrol - A test)/Acontrol]x100

(ii) **Reducing power Assay:** The standard agent Gallic acid (2.5 ug/ml) and different concentrations of the *Crotalaria juncea* whole plant extract (100 and 200ug/ml) were prepared using distilled water, 1% potassium ferricyanide, 10% trichloro acetic acid, 0.1% ferric chloride, and 0.2M phosphate buffer. As a point of reference, gallic acid was utilized. Subsequently, 1 millilitre of each concentration of the extract and standard were taken individually and combined with 1 millilitre of potassium ferricyanide and 0.2 millilitre of phosphate buffer (pH 6.6). For 20 minutes, incubate each of these samples at 500C. After that, add 1 millilitre of 10% trichloroacetic acid and centrifuge for 10 minutes at 2000 RPM. Next, drain the top layer (2.5 ml), and add 0.5 ml of freshly made ferric chloride along with 2.5 ml of distilled water. At 700 nm, measure the absorbance immediately.

***In-vitro* Anti-inflammatory activity:[19-22]**

(i) **Protein denaturation method:** Test solution, 0.5 ml consists of 0.45 ml of Bovine Serum Albumin (BSA) and 0.05ml of test sample of different concentrations [100 µg/ml and 200 µg/ml]. Test control solution, 0.5 ml consists of 0.45 ml of Bovine Serum Albumin (BSA) and 0.05ml of test sample of distilled water. Product control solution, 0.5 ml consists of 0.45 ml of distilled water and 0.05ml of test sample of different concentrations [100 µg/ml and 200 µg/ml]. Standard solution, 0.5 ml consists of 0.45 ml of Bovine Serum Albumin (BSA) and 0.05ml of test sample of different concentrations [10 µg/ml and 2.5 µg/ml of Diclofenac sodium]. All the above solutions were adjusted to pH 6.3 using 1N Hcl. The samples were incubated at 37°C for 20 mins and the temperature was increased to keep the samples 57°C for 3 mins. After cooling 2.5 ml of Phosphate buffer was added to the above solutions. The absorbance was measured using UV-Visible Spectrophotomter at 416 nm. The percentage inhibition of Protein denaturation was calculated.

$$\text{Percentage inhibition of Protein denaturation} = 100\,\frac{[\text{OD of test solution} - \text{OD of Product control}]}{[\text{OD of Test Control}]} \times 100$$

The control represents 100% Protein denaturation and the results are compared with standard Diclofenac sodium. Protein denaturation method is the most versatile method of *In vitro* Anti-inflammatory method which is used to assess the anti-inflammatory properties of *Crotalaria juncea* whole plant extract at 150 and 300 µg/ml concentrations.

(ii) **Human RBC method:** *Human RBC Preparation [HRBC Suspension]* - An equivalent volume of sterilized Alsever's solution (2% Dextrose, 0.5% Sodium Citrate, 0.05% Citric Acid, and 0.42 % Sodium Chloride in water) was combined with freshly drawn whole human blood. After centrifuging the blood for 15 minutes at 3000 rpm, the packed cells were rinsed three times with iso-saline (0.85% at pH 7.2). The blood's volume was measured and then reconstituted using iso-saline in a 10% v/v suspension. One of the most adaptable techniques used for assessing in vitro anti-inflammatory activity is HRBC membrane stabilization.

***In-vitro* anti-anemic activity:**[23-28]

Phenylhydrazine is a gifted sample used to induce anemia. Phenylhydrazine hydrochloride solution was produced in-situ, neutralized in 0.1 M Potassium phosphate buffer, filtered and maintained at a pH of 7.4. Anemia is induced by intra-peritoneal injection of Phenylhydrazine40mg/kg body weight in rats for two consecutive days. The Hemoglobin and Red Blood Cell count were tested before and after induction of Phenylhydrazine.

Method: The animals used approved by the Institutional Ethics Committee (IEC) with REG.NO. 1269/a/10/CPCSEA. Rats divided into four groups with 3 animals each(n=3). Group-I is Anemic control Phenylhydrazine[40mg/kg], Group-II received low dose of 200 mg/kg *Crotalaria juncea* whole plant extract twice daily, Group-III received high dose of 400 mg/kg *Crotalaria juncea* whole plant extract twice daily, Group-IV with standard drug receiving Ferrous ascorbate 10 mg/kg twice daily. Ferrous ascorbate and *Crotalaria juncea* plant extract where given orally from 3-21 days after 1st injection of Phenylhydrazine. On day 21, blood samples were collected from tailvein of rat and parameters like Hemoglobin and Red Blood Cell count were determined manually using traditional methods like Sahil's Hemoglobinometer (Acid Hematin Method) as well as Automated Hematology Analyser. [Operated Hematology Analyzer- Avecon Healthcare Pvt.Ltd]

FTRI Studies

The FTIR Spectra of the ethanolic whole plant extract of *Crotalaria juncea* was taken with "Bruker FTIR Spectrophotometer" and the spectra was recorded in the region of 3500 $cm^{-1}$to 600 $cm^{-1.}$The spectral data of the whole extract was presented in the Table-6. The absorption band at 3348.95 $cm^{-1}$and 1643 cm^{-1}indicating the presence of hydroxyl group and carboxyl group. It shows the evidence of chemical constituents like Phenols- Ferulic acid, Flavanoids like Quercetin, Triterpenoids like Ursolic acid in the plant extract.The band at 1082.67 and 1043.98 cm^{-1}indicates the presence of C-OH bond, while other peak at 2974 $cm^{-1}$and 2926 cm^{-1}indicates the presence of C-H bonds. The absorption band at 878 cm^{-1}due to the presence of C=CH group is Triterpenoids.

RESULTS AND DISCUSSION

***In vitro* antioxidant activity**

(i) **DPPH method:** Ethanolic whole plant extract of *Crotalaria juncea* was subjected to DPPPH Radical Scavenging Assay and the extract at a concentration of 100 µg/ml and 200 µg/ml showed maximum inhibition of 55.50 and 66.40% and the results were compared with standard drug Gallic acid 2.5 µg/ml produced maximum inhibition of 79%. The results are given in Table 1 and Figure 1.

(ii) **Reducing Power Assay:** The two concentrations of *Crotalaria juncea* plant extract 100 and 200 µg/ml produced the absorbance which is compared with standard drug Gallic acid 2.5 µg/ml. The results are described in Table 2 and Figure 2.

***In-vitro* anti-inflammatory activity**

(i) **Protein denaturation method:** This method is very well accepted to evaluate *in-vitro* anti-inflammatory activity. The medicinal plant extract *Crotalaria juncea* at a concentration of 150 and 300 µg/ml produced maximum

percentage of inhibition observed 34.50 and 52.20 and the results are compared with Standard Reference Drug Diclofenac Sodium which produced decent inhibition of 65.5 at 10 µg/ml concentration. The anti-inflammatory effect of the extract is concentration dependent. The results are mentioned in table 3 and Figure 3.

(ii) **Human RBC membrane stabilizing method:** This is very acceptable method to determine *in-vitro* anti-inflammatory action of *Crotalaria juncea* plant extract. When compared to the conventional anti-inflammatory medicine Diclofenac Sodium 10µg/ml, which generated 65.5%, the extract inhibited hypotonicity-induced membrane lysis to the amount of 38% and 60% at concentrations of 150 and 300 µg/ml. The activity is concentration dependent and the results are described in Table 4 and Figure 4.

Anti-anemic activity

Blood parameters- Hemoglobin and RBC

The Hemoglobin and RBC content in the experimental animals is very normal before injecting Phenylhydrazine to albino rats. There is a notable decline in Hemoglobin and Red Blood Cell count in experimental animals treated with Phenylhydrazine 40mg/kg showing hemoglobin levels 7.75 g/dl and Red blood cells 2.95 cells/mm^3. Reduced hemoglobin levels are caused due to decrease in red blood cell count. *Crotalaria juncea* extract with low dose 200 mg /kg and high dose 400 mg /kg significantly exalted the levels of hemoglobin and red blood cell to an appreciable extent of 4.5 and 5.90 cells/$mm^3$for RBC and 9.5 and 11.8 g/dl for hemoglobin. These parameters are compared with standard Ferrous Ascorbate treated group of animals 10 mg/kg body weight with 6.2 cells/$mm^3$of RBC and 12.85 g/dl of hemoglobin. The details of the obtained results where describe in Table 5and Figure 5.

CONCLUSION

The researchers made a sincere attempt to explore the pharmacological investigations of *Crotalaria juncea* whole plant for *in-vitro* anti-oxidant, anti-inflammatory and *in-vivo* anti-anemic activities. Based on the experimental work carried out significant results were obtained leading to favorable results. With the presence of triterpenoids, flavonoids and phenolic compounds identified from FTIR Spectra the researchers have concluded the biological activities like anti-oxidant and anti-inflammatory activity of *Crotalaria juncea.* Further, studies can be carried out and possible herbal formulation can replace the chemical drugs available in the market with cost effective and less side effects. The detailed analytical work to isolate the important phyto-constituents would be helpful to elucidate the possible mechanism for these pharmacological activities.

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CONFLICT OF INTEREST STATEMENT

The authors K Ravishankar, K Gnaneswari and S Thirumala, at the time of writing the article were employees of Aditya College of Pharmacy, Surampalem, India. The authors confirm that this article content has no conflict of interest.

ETHICAL APPROVAL

The ethical approval for this work was obtained in accordance with the IAEC criteria and the Aditya College of Pharmacy's CPCSEA regulations.

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Table-1: DPPH Radical Scavenging Assay of *Crotalaria juncea* extract.

S.No	Test	Concentration (µg/ml)	Percentage of Inhibition
1	*Crotalaria juncea*	100	55.50 ±0.40
		200	66.40±0.45
2	Gallic acid (Standard)	2.5	79.00±0.45

Values are Mean ± SEM, n=3.

Table-2: Reducing Power Assay of *Crotalaria juncea* extract.

S.No	Test	Concentration (µg/ml)	Reducing Power Absorbance
1	*Crotalaria juncea*	100	0.825±0.04
		200	0.96±0.05
2	Gallic acid (Standard)	2.5	0.75±0.12

Values are Mean ± SEM, n=3.

Table-3: *In-vitro* Anti-inflammatory effect of *Crotalaria juncea* whole plant extract by Protein denaturation method.

S.No	Concentration (µg/ml)	Percentage of Inhibition	
		Crotalaria juncea whole plant extract	Diclofenac Sodium (Standard)
1	10	-	65.50
2	150	34.50	-
3	300	52.20	-

Values are Mean ± SEM, n=3.

Table-4: *In-vitro* Anti-inflammatory effect of *Crotalaria juncea* whole plant extract by Human RBC Membrane Stabilizing method.

S.No	Concentration (µg/ml)	Percentage of Membrane Lysis	
		Crotalaria juncea whole plant extract	Diclofenac Sodium (Standard)
1	10	-	65.50
2	150	38.40	-
3	300	60.00	-

Values are Mean ± SEM, n=3.

Table-5: Effect of Ethanolic *Crotalaria juncea* whole plant extract in Phenylhydrazine induced anemic rats.

S.No	Treatment	RBC (cell/mm³)	Hemoglobin (g/dl)
1	Anemic Control	2.95±0.02	*7.75*±0.15
2	Test Group- Low Dose (200mg/kg)	4.50±0.20	*9.50*±0.12
3	Test Group- High Dose (400mg/kg)	*5.90*±0.25	*11.8*±0.16
4	Ferrous Ascorbate (10mg/kg)	*6.20*±0.35	*12.85*±0.60

Values are expressed as Mean ± SEM, n=3, p<0.001 when compared with standard values.

Table-6: FTIR Spectra of Ethanolic Whole Plant Extract of *Crotalaria juncea.*

V max cm-1
3333
2974.22
2926.00
1643.20
1450.20
1380.44
1273.55
1082.67
1043.98
878.69
703.80

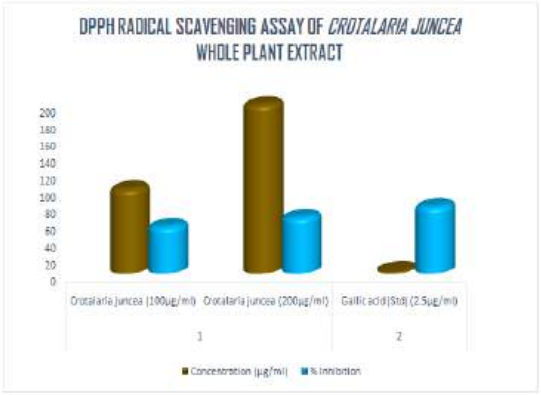


Figure-1: DPPH Radical Scavenging Assay of *Crotalaria juncea* extract.

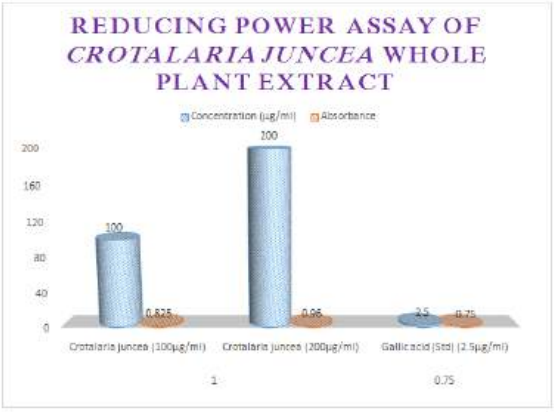


Figure-2: Reducing Power Assay of *Crotalaria juncea* whole plant extract.

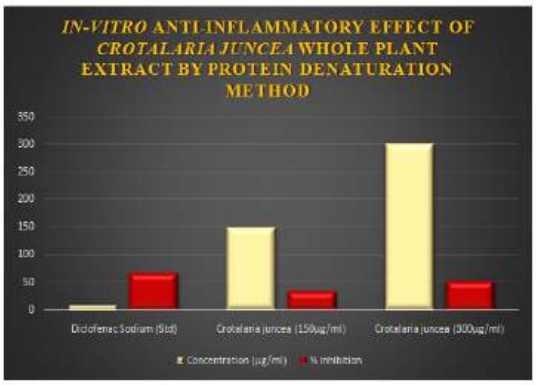


Figure-3: *In-vitro* Anti-inflammatory effect of *Crotalaria juncea* whole plant extract by Protein denaturation method.

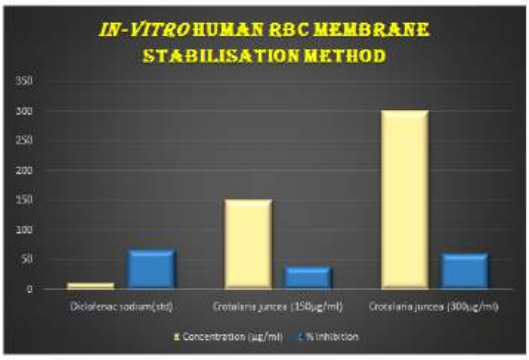


Figure-4: *In-vitro* Anti-inflammatory effect of *Crotalaria juncea* whole plant extract Human RBC Membrane Stabilizing method.

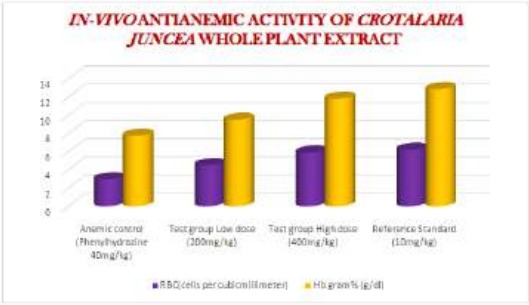


Figure-5: Effect of Ethanolic *Crotalaria juncea* whole plant extract in Phenylhydrazine Induced Anemic rats.

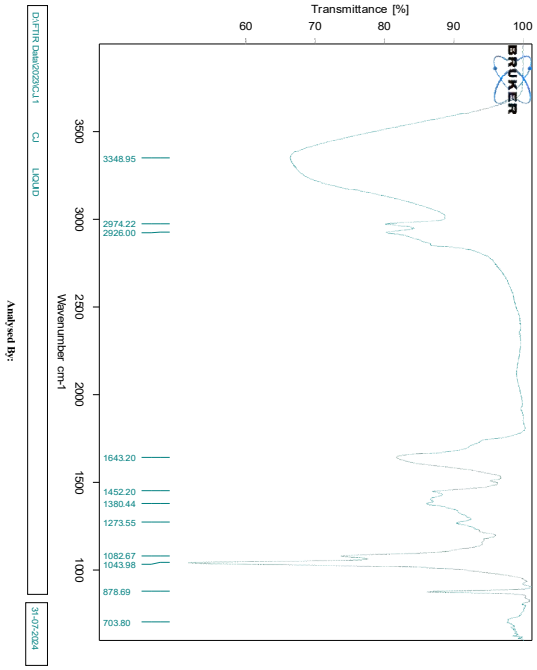


Figure:6 *FTIR Spectra*

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RESEARCH ARTICLE

Antimicrobial, Antioxidant and Cytotoxic Proficiency of Yellow Pigment - An Extracellular Metabolite of *Aspergillus ustus*

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ABSTRACT

The present study set a spot light on extracellular pigment metabolite of *Aspergillus ustus* and assessing its antimicrobial, antioxidant, and cytotoxic efficacy. *A.ustus* yellow pigment exhibited significant antimicrobial activity by inhibiting all test bacterial pathogens. *Salmonella typhi* was most susceptible, with a maximum zone of inhibition of 20.96±0.35 mm, 17.96±0.15 mm, 11.16±0.28 mm and 10.86±0.23 mm at concentrations of 20, 10, 05 and 2.5 mg/mL respectively. At a concentration of 40 mg/mL yellow pigment of *A. ustus* displayed potential to inhibit test fungal pathogens such as *Aspergillus brasiliensis* (15.50±0.20 mm), *Candida albicans* (20.00±0.20 mm), *Claviceps purpurea* (18.46±0.25 mm) and *Fusarium oxysporum* (18.53±0.25 mm). The MIC values ranged from 6.25×10^2 to 2.5×10^3µg/mL. The pigment of *A. ustus* exhibited significant antioxidant efficacy, i.e., $DPPH^+$ (IC_{50} 398.99µg/mL), $ABTS^{\bullet+}$ (IC_{50} 205.6µg/mL), FRAP ranging from 0.088 to 0.733 and total antioxidant potential ranging from 0.068 to 1.24. *A. ustus* pigment affects the viability of HepG2 (IC_{50}174.89µg/mL) and A498 (IC_{50} Value 262.45µg/mL) and is less-toxic to HEK-293 normal cells. The research output recommends that, the yellow pigment of *Aspergillus ustus* can be useful scale-up for pharmaceutical and textile applications in future.

Keywords: Agar-well diffusion, Anticancer, Biological activity, MIC, Myco-pigment, Radical scavenging

INTRODUCTION

Colors are the mesmerizing glory of the world and they have been used for millennia to enhance the appearance of products such as foodstuffs, textiles, cosmetics, arts and creative works. Azodyes are chemically synthesized compounds that are widely used as colorants, but they have a negative impact on human health as well as on the environment. [1] Natural pigments are mainly attained from plants and microorganisms. Pigment production from microorganisms is more stable compared to plant-based pigments because of the availability of microbial cultivation skills. Due to the limitations of plant pigments, pigments of microbial origin gained more prominence. [2] Filamentous fungi are a fascinating source of natural pigments. Melanins, carotenoids, azaphilones, quinones, quinones, phenazines, indigo, violaceinand monascinare some of the pigments that fungi produce in a prolific manner.[3]Fungal pigments have tremendous benefits over other natural pigment sources and their synthetic counterparts, therefore increasing their demand and enabling novel investigation possibilities.[4]For the biosynthesis of fungal pigments mainly four pathways are responsible which comprises polyketide synthetic pathway, shikimate pathway, nitrogen-containing metabolite pathway and terpenoid synthetic pathway.[5]Fungal pigments such as melanin, quinones, flavins, ankaflavin, and azaphilones have therapeutic applications such as antimicrobial, antioxidant, and anticancer properties.[6]Thus, the industries are intent about the filamentous fungi from a broad range of habitats such as marine origin, soil, endophytic fungi from terrestrial and endo-lichenic fungus which can be easily grown in laboratory conditions and permissible for the industrial production.[7, 8]Certain *Aspergillus* species are well-known producers of aspergillin, asperenone, azaphilone pigments.[9] *Aspergillus ustus* is a saprobic fungus generally associated with the top soil. It produces various extracellular metabolites such as autocystins, austalides, sterigmatocystins, versi colourins and nidulol that possess antibacterial and other biological applications.[10]This research study embraces the cultivation of *A. ustus* in submerged fermentation for pigment production, the extraction of extracellular pigment that is yellow and the investigation of its bio-efficacies corresponding to its antimicrobial, antioxidant, and cytotoxic properties against cancer causing as well as normal cell lines.

MATERIAL AND METHODS

Cultivation and extraction of extracellular pigment from *Aspergillus ustus*

A. ustus was cultivated in submerged fermentation using potato dextrose broth (PDB) medium supplemented with sucrose (2%), sodium nitrate (1%), potassium phosphate (0.05%), tyrosine (0.5%) and pH 7. Starter culture (1:10 v/v) was inoculated to mass medium and incubated as stationary cultures for 21days. After incubation, the fully grown fungal biomass was separated from the culture broth; the grown-up culture was filtered through Whatman No. 1 filter paper. 95% methanol was added to the culture filtrate in the ratio of 1:1 and agitated on a rotary shaker for 30 min at 150 rpm and centrifuged at 5000 rpm for 15-20 minutes. The separated pigment phase was retrieved and n lyophilized. The dried pigment was used for further analysis [11].

Antimicrobial activity of yellow pigment of *A. ustus*

Test pathogenic microorganisms

The test bacterial cultures including *Escherichia coli* (MTCC 1559), *Enterococcus faecalis* (MTCC 439), *Klebsiella pneumonia* (MTCC 7028), *Pseudomonas aeruginosa* (MTCC 1934), *Staphylococcus aureus* (MTCC 902), *Salmonella typhi* (MTCC 734) and fungal cultures including *Aspergillus brasiliensis* (MTCC 1344), *Candida albicans* (MTCC 3272), *Claviceps purpurea* (MTCC 479), *Fusarium oxysporum* (ITCC 55) were procured from the Microbial Type Culture Collection (MTCC) center, Chandigarh and Indian Type Culture Collection (ITCC), New Delhi. The tests were performed as per the Clinical and Laboratory Standards Institute (CLSI) guidelines.

Agar cup diffusion assay

The 24-hour-old liquid bacterial cultures were consistently swab inoculated on sterile Mueller Hinton agar plates. Correspondingly, 72-hour-old test pathogenic fungal cultures were swab inoculated on sterile Sabouraud dextrose

agar plates and aseptically, 6mm cups were punched using a sterile gel borer. 1 mg/mL of standard antibiotics such as ciprofloxacin (CPFX), streptomycin (STM), chloramphenicol (CPL) and 5 mg/mL of standard antifungals such as clotrimazole and fluconazole were prepared in sterile de-ionized water and used as positive controls, while 10% DMSO (dimethyl sulfoxide) was served as a negative control. 100 µL of different fractions of pigment, along with positive and negative controls, were incorporated into the labeled cups. The MHA plates were incubated for 24 hours at 37°C and SDA plates were incubated at 28 ± 2°C for 72 hours and after incubation, the zone of inhibition formed around the cups was measured.[12, 13]

Minimum inhibitory concentration (MIC) of yellow pigment of *A. ustus*

The antibacterial activity of the pigment against six test bacteria was confirmed by evaluating the MIC using a modified resazurin 96-well microtitre plate broth dilution assay. A two-fold serial dilution of pigment extract was made in a concentration range of 5000–10µg/mL in a sterile 96-well plate containing Mueller Hinton broth. Similarly, a two-fold serial dilution was also made for standard antibiotics such as ciprofloxacin (CPFX), streptomycin (STM) and chloramphenicol (CPL) in a concentration range of 1000–2µg/mL in separate microtitre plates. Test bacterial inocula were prepared i.e., 1.5×10^8 CFU/mL in accordance with 0.5 McFarland's standard. 10 µl of bacterial suspension was added to each well microtitre plates were incubated aseptically for 18–24 hours at 37°C. After incubation, 10µL of resazurin (0.015%) solution was dispensed to each well, and again, plates were incubated at 37°C for 3–4 hours and observed for the color change from alamar blue to pink. The lowest concentration, which does not display the color change, was considered the MIC value.[14, 15]

Antioxidant activity of yellow pigment of *A. ustus*

DPPH+ radical scavenging assay

The 1,1-Diphenyl-2-picrylhydracyl ($DPPH^+$) radical scavenging activity was accomplished as described by with minor modifications[16]. In this assay, pigment extract was dissolved in methanol at concentrations ranging from 50 to 800µg/mL; similarly, ascorbic acid (the reference standard) was also prepared. To 1 mL of a varied concentration of pigment extract and ascorbic acid, 1 mL of DPPH radical solution (0.004% in methanol) was added. The reaction mixture tubes were then incubated at 37 °C for 30 minutes, followed by assessing the absorbance of the reaction assortment at 517 nm. The strength of the pigment to scavenge the DPPH radicals was determined by using the following equation:

DPPH radical scavenging activity (%) $=\frac{(A0-A1)}{A0}\times 100$

Where, *A0* is absorbance of the control and *A1* is the absorbance of the tested sample.

ABTS•+ radical scavenging assay

To measure the ABTS•+ [2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid)] radical scavenging efficacy of pigment, 0.2 mL of methanol-dissolved pigment extract solution of various concentrations ranging from 50 to 800μg/mL was mixed with 1.8 mL of the ABTS radical solution. Ascorbic acid was used as a standard. The optical density of reaction mixtures was read at 734nm. The percentage of $ABTS^{\bullet+}$ free radicals scavenged were calculated using the following formula.[17, 18]

$ABTS^{\bullet+}$ radical scavenging activity (%) $=\frac{(A0-A1)}{A0}\times 100$

Where, *A0* is absorbance of the control and *A1* is the absorbance of the tested sample.

Ferric reducing antioxidant power (FRAP) assay

The different concentrations (50–800µg/mL) of pigment extracts were added to this 2.5 mL of 0.2 M phosphate buffer (pH 6.6), and 2.5 mL of 1% potassium ferricyanide was added and agitated properly. The reaction mixture tubes were then incubated at 50°C for 20 minutes. After incubation, 2.5 mL of 10% trichloroacetic acid was added to the reaction mixture tubes and centrifuged at 3000 rpm for 10 minutes. Afterwards, 2.5 mL of the supernatant of the reaction mixture was combined with 2.5 mL of double-distilled water and 0.5 mL of 0.1% ferric chloride, and lastly, absorbance was read at a wavelength of 700nm. Ascorbic acid was served as a reference standard [19, 20].

Total antioxidant activity

1 mL of pigment concentration ranged from 50 to 800 µg/mL, was added with 2 mL of phospho-molybdenum reagent (4mM ammonium molybdate, 28 mM sodium phosphate and 0.6M sulphuric acid) and mixed vigorously and incubated at 95°C for one and a half hours. Then the tubes were air-conditioned and the absorbance was read at a wavelength of 695nm against methanol (blank). The total antioxidant potential of the pigment was expressed as the ascorbic acid equivalents.[21]

In-vitro cytotoxic* Activity of yellow pigment of *A. ustus

Collection and maintenance of cell lines

A498-human renal (kidney) adenocarcinoma, HepG2-human hepatocellular (liver) carcinoma and HEK-293-human non-malignant embryonic kidney (normal) cell lines were collected from the National Centre for Cell Science (NCCS), Pune, India. The cells were maintained in Minimum Essential Medium (MEM) with Non-Essential Amino Acids (NEAA) supplemented with 10% FBS (Fetal Bovine Serum) along with a 1% antibiotic-antimycotic solution in the atmosphere of 5% CO_2 and 18–20% O_2 at 37°C in the CO_2 incubator and sub-cultured for every 2 days.

MTT assay

The cytotoxicity of pigment extract was determined by the 3-(4, 5-dimethyl-2-thiazolyl)-2, 5-diphenyl-tetrazolium bromide (MTT) method. Accurately 200 µL of cell suspension was seeded in 96-well plate at the required cell density (2×10^4 cells per well) without the pigment extract and cells were allowed to grow for about 24 hours. After the cell reaches confluence, pigment extract was added in concentrations ranging from 12.5 to 200µg/mL and incubated at 37 °C in a 5% CO_2 atmosphere. Cisplatin was used as a standard. After incubation, the spent medium was removed aseptically and 10µL of the MTT reagent (final concentration of 0.5 mg/ml) was added to each well and covered to avoid exposure to light and it was again incubated for 4 hours. After incubation, 100µL of solubilization solution DMSO (dimethyl sulfoxide) was added into all the wells and gently stirred in a gyratory shaker. Then absorbance was measured at a wavelength of 570nm in an ELISA reader using DMSO as the blank. The percentage of cell viability will be calculated using the following formula.[22]

Cell viability (%) = [Abs. of treated cells/Abs. of untreated cells] x 100

RESULTS AND DISCUSSION

Cultivation and extraction of extracellular pigment of *A. ustus*

Submerged fermentation implies the process of growing microorganisms in broth media for the development and recovery of industrially important commercial products.[23]It accomplishes the voluminous advantages over solid-state fermentation, it is cost effective and produces high yield end products and preferred for the easy recovery of multifaceted extracellular metabolites.[24]The fungus exhibits intensive yellow extracellular pigment synthesis in PDB medium (Figure 1).

Antimicrobial activity of yellow pigment of *A. ustus*

The yellow pigment has the tendency to inhibit all the test bacterial pathogens, as illustrated in (Table 1) and (Figure 2). Among the test bacterial pathogens, *Salmonella typhi* was most susceptible, with a maximum zone of inhibition of 20.96±0.35mm, 17.96±0.15mm, 11.16±0.28mm and 10.86±0.23mm at concentrations of 20, 10, 05 and 2.5 mg/mL respectively. The pigment of *A. ustus* at a concentration of 40 mg/mL displayed potential to in hibit test fungal pathogens such as *Aspergillus brasiliensis* (15.50±0.20 mm), *Candida albicans* (20.00±0.20mm), *Claviceps purpurea* (18.46±0.25 mm) and *Fusarium oxysporum* (18.53±0.25 mm). The antifungal activity of the *A. ustus* pigment was documented in (Table 2) and (Figure 3).In previous studies, the *A. ustus* pigment has inhibitory effects on *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, and *Streptomyces longispororuber,* but not effective against pathogenic fungi. [25] Ramesh et al. reported that, carotenoids, melanin, monascus, riboflavin pigments and other pigments from microbial origin can inhibit various pathogens.[26]

Minimum inhibitory concentration (MIC) of yellow pigment of *A. ustus*

MIC is the least concentration of the drugrequired to inhibit the growth of pathogens. The MIC value of the yellow pigment of *A. ustus* required for inhibiting the test bacterial pathogens ranged from 6.25×10^2 to 2.5×10^3µg/mL. The overview of MIC values of pigment metabolite extract and standard antibiotics to inhibit test bacterial pathogens is accessible in Table 3. In preceding study, described that the pigment of *Penicillium canescens* was effective in inhibiting all the selected bacteria with MIC values ranging from 1.5×10^3 to 2.5×10^3 µg/mL.[27]

Antioxidant activity of yellow pigment of *A. ustus*

In the current study, the pigment extract exhibits concentration dependent $DPPH^+$ radical scavenging potential. The IC_{50} value is virtually equal to the radical scavenging efficiency. The IC_{50} value of *A. ustus* pigment was 398.99µg/mL and ascorbic acid was found to be 112.44µg/mL to scavenge $DPPH^+$ free radicals which are presented graphically in the Fig. 4 a&b. In earlier findings, reported that the free radical scavenging IC_{50} values of the pigment extracts of *P. multicolour*, *T. verruculosus*, *P. canescens*, *F. solani*, and *P. herquie*, was 2.27, 0.36, 0.28, 0.56, and 1.26 mg/mL (ascorbic acid equivalence) respectively. Contemporarily assessed the $ABTS^{\bullet+}$ radical scavenging potential of *A. ustus*pigment and the result is incarnated graphically in Figure 5a & b. The IC_{50} value of pigment extract was 205.6µg/mL and ascorbic acid was found to be 22.8µg/ml to scavenge $ABTS^{\bullet+}$ free radicals.[27]The IC_{50} value of yellow pigment extracted from *Bacillus* sp. to scavenge the $ABTS^{\bullet+}$ radicals was found to be 75.125µg/mL. The ferric reducing power of *A. ustus* pigment ranged from 0.088 to 0.733 and that of ascorbic acid ranged from 0.551 to 1.985 [28]. The comprehensive result of the FRAP assay is graphically exemplified in Figure 6.The antioxidant potential of ascorbic acid is greater than that of the red biopigment of *Monascus purpureus.* [29] The total antioxidant potential of the *A. ustus* pigment ranged from 0.068 to 1.24 and ascorbic acid ranged from 0.251 to 2.985, which are graphically illustrated (Figure 7).The total antioxidant activity of yellow pigment extracted from *Bacillus* sp. was 21.45± 0.33mg of ascorbic acid equivalent [28].

In-vitro* cytotoxic activity of yellow pigment of *A. ustus

The percentage of cell viability was exemplified graphically in Fig. 8. *A. ustus* pigment showed a dose-dependent mode of cytotoxicity towards HepG2 and A498 cancer cells, with a decrease in cell viability as the concentration of yellow pigment increased. The pigment was very less toxic to the human non-malignant embryonic kidney (HEK-293) cell line with an IC_{50} value of 430.95µg/mL when compared to HepG2 and A498 cells. In HepG2 cells, the IC_{50}value of *A. ustus*pigment was observed to be 174.89µg/mL, while in A498 cells, the IC_{50} value of the pigment metabolite extract was 262.45µg/mL. In previous studies, the melanin pigment of *Penicillium citrinum* exhibited the inhibition of A549 (Lung cancer) cells in dose-dependent mode with significant IC_{50} value 65.49µg/mL [30]. Previous study discloses that, the green pigment of *Streptomyces tunisiensis* showed The IC_{50} values of 2.2 mg/mL, 1.1 mg/mL and 1.04 mg/mL against HepG-2, A549 and PAN1 (pancreas cancer cell line) correspondingly, while IC_{50} value towards Vero cells (normal cells) was 2 mg/mL which evidences its non-toxicity towards normal cells.[31]

CONCLUSION

The *in-vitro* biological studies of the yellow pigment of *A. ustus* reveal that it has a potential antimicrobial property and the study discloses the remarkable antioxidant efficacy by scavenging free radicals such as $DPPH^+$, $ABTS^{\bullet+}$ and ferric ions and the total antioxidant activity. The yellow pigment of *A. ustus* also possesses anti-proliferative potential by affecting the viability of HepG2 (Hepatocellular carcinoma) and A498 (Lung cancer) cells and it is considerably very less toxic to normal cells, which is evidenced in this study by least affecting the HEK-293 (Human non-malignant embryonic kidney) normal cells. The yellow pigment of *A. ustus* is non-hazardous in nature and also a promising source for combating the negative impact of synthetic azodyes. Hence, the findings of this systematic study recommend that *A. ustus* can be useful for pharmaceutical and textile applications in the future.

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Table 1. Antibacterial activity of yellow pigment of *Aspergillus ustus*

Test Pathogenic Bacteria	Standard antibiotics (1mg/mL)			yellow pigment			
	Ciprofloxacin	Streptomycin	Chloramphenicol	20 mg/mL	10 mg/mL	05 mg/mL	2.5 mg/mL
	Zone of inhibition in diameter (Mean ± SD mm)						
E. coli	20.96±0.55	17.96±0.35	23.96±0.15	18.93±0.40	16.43±0.20	10.06±0.11	10.06±0.11
E. faecalis	23.00±0.20	16.00±0.20	22.93±0.40	18.50±0.30	14.96±0.25	11.00±0.20	09.93±0.11
K. pneumoniae	22.16±0.28	14.96±0.15	22.43±0.20	17.06±0.11	15.93±0.11	10.03±0.15	08.86±0.32
P. aeruginosa	25.96±0.25	20.16±0.28	23.33±0.28	17.40±0.17	13.96±0.25	11.16±0.28	10.86±0.23
S. aureus	25.06±0.11	16.13±0.23	22.13±0.23	15.00±0.20	12.00±0.00	08.93±0.11	07.83±0.28
S. typhi	25.66±0.28	18.96±0.21	22.93±0.11	20.96±0.35	17.96±0.15	10.00±0.00	08.83±0.28

Table 2.Antimycotic activity of yellow pigment of *Aspergillus ustus*

Test Pathogenic Fungi	Standard antimycotics (5mg/mL)		yellow pigment			
	Clotrimazole	Fluconazole	40 mg/mL	20 mg/mL	10 mg/mL	05 mg/mL
	Zone of inhibition in diameter (Mean ± SD mm)					
A. brasiliensis	27.50±0.30	18.43±0.11	15.50±0.20	00.00±0.00	00.00±0.00	00.00±0.00
C. albicans	28.86±0.32	21.1±0.36	20.00±0.20	13.00±0.20	00.00±0.00	00.00±0.00
C. purpurea	38.36±0.32	17.93±0.30	18.46±0.25	16.96±0.25	00.00±0.00	00.00±0.00
F. oxysporum	31.40±0.17	13.46±0.35	18.53±0.25	00.00±0.00	00.00±0.00	00.00±0.00

Table 3. Minimum inhibitory concentration (MIC) of yellow pigment

Test Pathogenic Bacteria	*Standard antibiotics*			yellow pigment
	Ciprofloxacin	Streptomycin	Chloramphenicol	
	Minimum inhibitory concentration (MIC) in µg/mL			
E. coli	0.3×10^{-2}	0.5×10^{3}	0.6×10^{2}	1.25×10^{3}
E. faecalis	0.1×10^{-2}	0.25×10^{3}	0.6×10^{2}	2.5×10^{3}
K. pneumoniae	0.3×10^{-2}	0.5×10^{3}	0.6×10^{2}	6.25×10^{2}
P. aeruginosa	0.3×10^{-2}	0.5×10^{3}	0.6×10^{2}	2.5×10^{3}
S. aureus	0.3×10^{-2}	0.5×10^{3}	0.3×10^{2}	2.5×10^{3}
S. typhi	0.3×10^{-2}	0.5×10^{3}	0.6×10^{2}	2.5×10^{3}



Figure 1. Cultivation of *A. ustus* in PDB

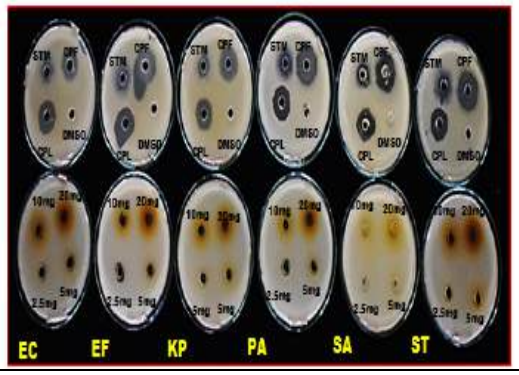


Figure 2. Antibacterial activity of *A. ustus* yellow pigment metabolite against test bacterial pathogens (EC-*Escherichia coli*, EF- *Enterococcus faecalis*, KP- *Klebsiella pneumonia*, PA- *Pseudomonas aeruginosa*, SA-*Staphylococcus aureus*, ST- *Salmonella typhi*)

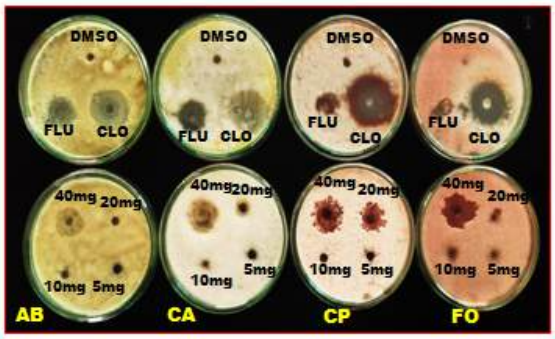


Figure 3. Antimycotic activity of *A. ustus* yellow pigment metabolite against test fungal pathogens (AB- *Aspergillus brasiliensis*, CA- *Candida albicans*, CP-*Claviceps purpurea*, FO-*Fusarium oxysporum*)

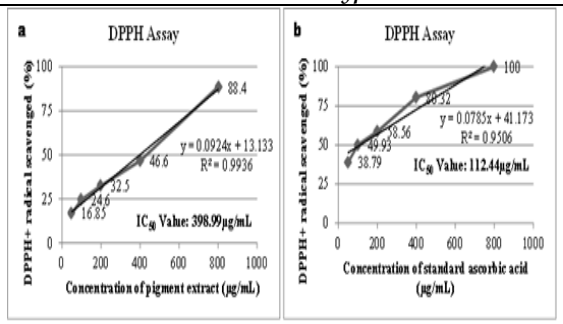


Figure 4. DPPH⁺ radical scavenging activity of (a) *A. ustu* spigment and (b) ascorbic acid

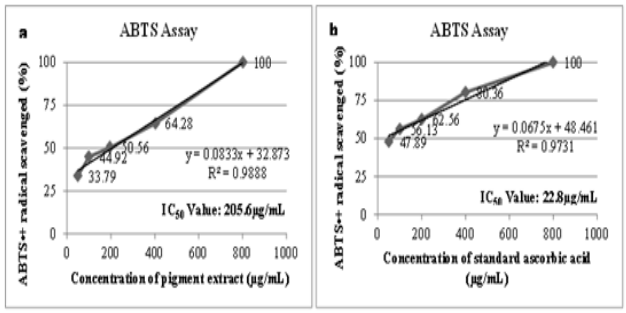


Figure 5. ABTS•+ radical scavenging activity of (a) *A. ustus* pigment and (b) ascorbic acid

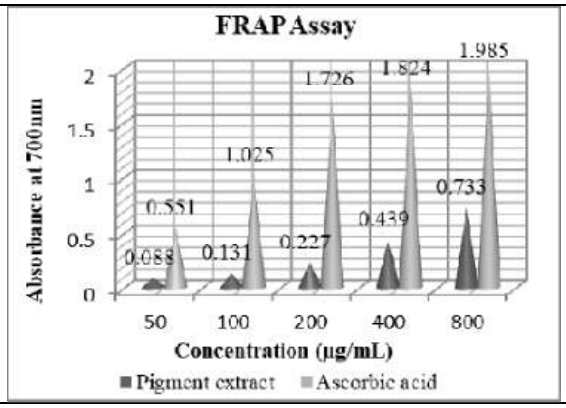


Figure 6. FRAP assay of *A. ustus* pigment and standard ascorbic acid

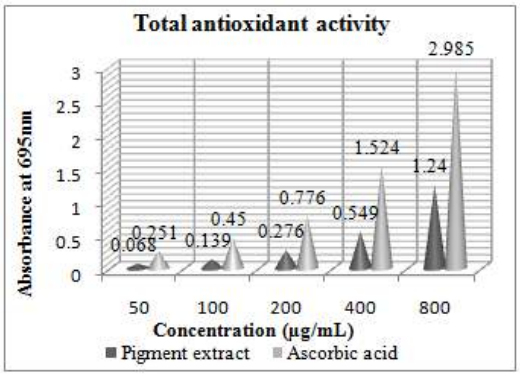


Figure 7. FRAP assay of *A. ustus* pigment and standard ascorbic acid

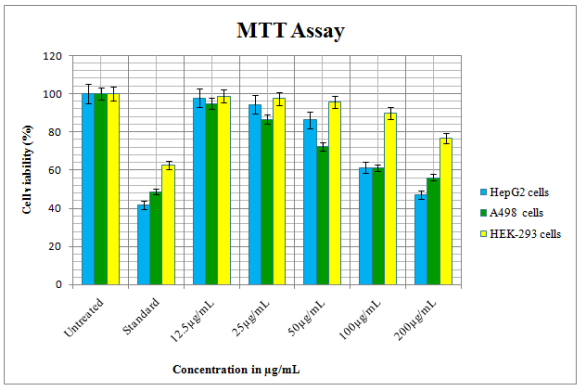


Figure 8. *In -vitro* cytotoxic activity of *A. ustus* pigment metabolite extract and standard cisplatin

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RESEARCH ARTICLE

Effectiveness of Resistance Training on Muscle Strength and Quality of Life among Elderly within Surat District : A Pilot Study

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ABSTRACT

Aging leads to muscle weakness and reduced quality of life (QoL), impacting independence. Resistance training is a potential solution, but its effects in India are underexplored. With India's growing elderly population, strategies to maintain strength and QoL are crucial. This study evaluates the effectiveness of resistance training in elderly individuals in Surat District. Eleven participants underwent a 6-week resistance training program (3 sessions/week) based on NSCA guidelines. Pre- and post-assessments included Manual Muscle Testing (MMT) and QoL evaluation. The Wilcoxon signed-rank test showed significant improvements in MMT ($Z = -6.415$, $p < 0.001$) and QoL scores ($Z = -5.801$, $p < 0.001$), with all participants benefiting. Resistance training significantly enhances muscle strength and QoL in the elderly. Larger studies are needed to confirm long-term benefits.

Keywords: Resistance training, Elderly, Muscle strength, Quality of life, Manual muscle testing.

INTRODUCTION

Aging and Muscle Decline

Aging is a natural process associated with physiological changes, including muscle mass and strength loss, known as sarcopenia. This decline leads to frailty, reduced functional capacity, and lower quality of life (QoL).[1] The World Health Organization (WHO) highlights physical inactivity as a major factor in functional decline among older adults.[2] Resistance training (RT) is an effective intervention to counteract these effects, enhancing muscle strength and functional capacity. Sarcopenia, which begins in the fourth decade and accelerates after 60, increases the risk of falls, fractures, and dependency.[3] It is primarily caused by reduced muscle fiber size and number due to hormonal

changes, inactivity, and poor nutrition. [4] Dynapenia, or muscle weakness, significantly impacts mobility and balance, further compromising independence.[5]

Importance of Resistance Training in the Elderly

RT involves muscle contractions against external resistance, promoting hypertrophy and neuromuscular adaptations. Unlike aerobic exercises, RT specifically improves muscle strength, which is essential for maintaining functional capacity.[6] Studies demonstrate that regular RT enhances muscle mass, strength, balance, and coordination, reducing fall risks and preserving independence.[7,8]A systematic review by Peterson et al. found that RT performed two to three times weekly leads to significant gains in muscle strength and endurance, translating into practical benefits for daily activities.[9]

Mechanisms Behind RT's Effectiveness

RT induces muscle hypertrophy through mechanical tension, muscle damage, and metabolic stress.[10] Mechanical tension from external loads stimulates muscle protein synthesis (MPS), promoting muscle growth. Muscle damage triggers repair mechanisms, further enhancing MPS.[11] Metabolic stress increases growth-promoting hormones such as testosterone and IGF-1, counteracting muscle atrophy. These mechanisms collectively improve muscle function, reducing age-related decline.[12,13]

Resistance Training and Quality of Life

QoL in older adults is influenced by physical, psychological, and social well-being. Functional decline negatively affects daily activities, emphasizing the importance of physical fitness.[14,15]RT improves physical health, self-esteem, and mental well-being, while also fostering social interactions.[16]A meta-analysis by Steib et al.[17,18] that strength training reduces depression and enhances overall life satisfaction. A study by Liu and Latham[19] found that elderly individuals with chronic diseases like arthritis who participated in RT reported decreased pain and improved function.

Resistance Training and Functional Outcomes

Functional capacity, essential for independent living, declines with aging. RT significantly improves walking speed, balance, and endurance, reducing fall risks.[20]Falls are a leading cause of morbidity and mortality, with the WHO identifying them as the second leading cause of accidental injury deaths globally.[21,22]RT strengthens muscles, improves coordination, and enhances balance.[23]A study by Fiatarone et al.[24]demonstrated that a 10-week RT program significantly improved muscle strength, walking speed, and stair-climbing ability, fostering independence and reducing caregiver reliance.

Barriers and Recommendations

Despite its benefits, RT is underutilized due to accessibility issues, injury fears, and misconceptions. [25]Many healthcare professionals do not emphasize RT's role in aging management. To promote participation, awareness campaigns, community programs, and access to trained professionals are essential. Individualized RT programs tailored to older adults' needs enhance safety and effectiveness.[26]

AIMS & OBJECTIVES OF THE STUDY

Aim

The aim of this study is to evaluate the effectiveness of resistance training on muscle strength, assessed using manual muscle testing (MMT), and its impact on the quality of life (QoL) among elderly individuals.

OBJECTIVES

1. To assess the baseline muscle strength of elderly individuals using manual muscle testing.
2. To implement a resistance training program specifically designed for elderly participants.

3. To evaluate changes in muscle strength after completing the resistance training program using manual muscle testing.
4. To assess the baseline quality of life of elderly participants using a validated QoL scale.
5. To measure the impact of resistance training on the quality of life after completing the program.
6. To determine the correlation between muscle strength improvements and enhancements in quality of life among the elderly.
7. To compare the effectiveness of resistance training across different age groups (65-74, 75-80) within the elderly population.
8. To investigate the long-term retention of muscle strength gains and QoL improvements three months after completing the resistance training program.

HYPOTHESIS

Null Hypothesis

- **H_0:** There is no significant effect of moderate to high intensity resistance training on Muscle strength among elderly within Surat district.
- **H_1:** There is no significant effect of moderate to high intensity resistance training on quality of life among elderly within Surat district.

Alternative Hypothesis

- **H_0:** There is a significant effect of moderate to high intensity resistance training on Muscle strength among elderly within Surat district.
- **H_1:** There is a significant effect of moderate to high intensity resistance training on quality of life among elderly within Surat district.

REVIEW OF LITERATURE

1. **Sundell (2011)** examined the effects of resistance training on sarcopenia in elderly individuals, showing that a 12-week program significantly increased muscle strength and improved physical function in adults aged 65 and older. The study highlighted resistance training's role in preventing frailty and maintaining independence.[16]
2. **Peterson et al. (2010)** conducted a meta-analysis on resistance training in older adults, finding that it led to a 30-50% increase in muscle mass and strength, regardless of age or initial fitness level. These findings emphasize resistance training's universal benefits for elderly populations.[17]
3. **Liu & Latham (2009)** studied elderly individuals with osteoarthritis, revealing that moderate-intensity resistance exercises over 10 weeks led to significant muscle strength gains, pain reduction, and improved functional independence.[18]
4. **Steib, Schoene, & Pfeifer (2010)** reviewed resistance training's effects on frail elderly individuals, concluding that it enhances muscle strength, balance, and fall prevention, contributing to safer movement and greater independence.[19]
5. **Fiatarone et al. (1990)** investigated high-intensity resistance training in frail nursing home residents (average age 90). Their study demonstrated that even the oldest individuals could significantly improve muscle strength and functional capacity, challenging misconceptions about aging and exercise.[20]
6. **Blake & Mo (2008)** explored the psychosocial benefits of resistance training, finding it reduced depression and anxiety while increasing social engagement and life satisfaction. Their study emphasized resistance training's role in enhancing mental well-being.[21]
7. **Westcott (2012)** reviewed the overall benefits of resistance training, highlighting its importance in preserving muscle mass, improving metabolic health, and maintaining functional independence in aging populations.[22]
8. **Bean et al. (2010)** conducted a randomized controlled trial on progressive resistance training in older adults with mobility limitations. Their study demonstrated significant improvements in lower body strength, gait

speed, and physical performance, directly enhancing QoL. These findings underscore the accessibility of resistance training for individuals with mobility challenges.[23]

METHODOLOGY

Study Design: Experimental Study
Study Population: Elderly People
Study Sample: Elderly People between the age group of 60-80 years
Sampling Technique: Convenient Sampling
Study Duration: 6 months
Sample Size: 11 participants
Study Setting: Two old age homes within Surat district

Selection Criteria
Inclusion Criteria

- Elderly People aged 60 to 80 years
- Both Male and Female
- Willing to participate and able to do exercise for a predetermined time duration
- Able to walk with or without an assistive device
- Ability to understand instructions and follow commands

Exclusion Criteria

- Participants currently enrolled in any other research study
- Participants advised by doctors not to perform exercises
- Participants diagnosed with significant medical or surgical conditions that may interfere with evaluation and intervention
- Individuals with known musculoskeletal conditions like Rheumatoid arthritis, osteoarthritis, or neurological conditions like Alzheimer's disease, Parkinson's disease that may interfere with intervention
- Individuals with known cognitive-behavioral problems like depression, anxiety, or insomnia
- Individuals with neuro-psychosomatic disorders like schizophrenia or delirium

Procedure
A total of 13 participants were screened for inclusion criteria, out of which 11 met the criteria and were recruited for the study. Their demographic data were recorded using an assessment proforma. Once recruited, participants were required to sign a written consent form after receiving a detailed explanation of the study.
Pre-outcome measures were assessed, including Manual Muscle Testing (MMT) for various muscle groups using the Oxford grading system and Quality of Life (QOL) assessment.

Muscle Groups Assessed

- Neck Extensors, Neck Flexors
- Shoulder Internal Rotators, External Rotators, Flexors, Extensors, Abductors (right & left)
- Elbow Flexors and Extensors (right & left)
- Wrist Flexors and Extensors (right & left)
- Trunk Flexors, Extensors, Lateral Flexors (right & left)
- Knee Flexors and Extensors (right & left)
- Ankle Dorsiflexors & Plantar Flexors (right & left)

Resisted Exercise Program

Experimental Group/ Resisted Exercise Group (Protocol)

- Exercises performed according to the National Strength and Conditioning Association position statement[27]
- **Frequency:** 3 days per week (non-consecutive days)
- **Sets:** 3 sets of 2 multi-joint exercises per major muscle group
- **Repetitions:** 12 reps per set
- **Intensity:** 65%-75% of 1RM (Moderate), progressing to 75%-80% (High) of 1RM as tolerated
- **Rest Periods:** 60 sec between exercises, 3 min between sets, and 48 hrs between sessions

Warm-Up (15 minutes)

- Neck Rolls, Shoulder Rolls, Arm Circles, Wrist Circles
- Hip Circles, Ankle Circles, Side Bends, Toe Touches, Marching in Place

Resistance Exercises (Using Resistance Bands):

1. Seated Rows
2. Shoulder Press
3. Bicep Curls
4. Triceps Extensions
5. Chest Press
6. Squats
7. Glute Bridge

Cool-Down Exercises

- Static Stretching (Calf, Quadriceps, Hamstrings, Shoulder)
- Standing Forward Bend
- Corpse Pose

The intervention lasted for 4 weeks, followed by a 2-week progression phase. Post-test measurements were taken at the end of the 6-week period, assessing MMT and QOL.

STATISTICAL METHODS

A total of 11 subjects aged 60-80 years participated in the study. Manual Muscle Testing (MMT) and Quality of Life (QOL) were assessed pre- and post-intervention following resistance training.

Statistical Tests

- The **Shapiro-Wilk test** was used to check normality. The data did not follow a normal distribution.
- **Descriptive analysis** was performed to determine the mean and standard deviation (SD) for MMT and QOL.
- As the data did not follow normality, the **Wilcoxon Signed-Rank Test** was used for paired sample comparisons (pre- and post-intervention within the group).

Statistical Software

- Data analysis was conducted using **SPSS version 25 (IBM)**.

Informed Consent

- Written consent was obtained from all participants included in the study.

RESULTS

The ranks table reveals that all differences between post-test and pre-test MMT scores were positive, with 11 positive ranks and no negative ranks observed. This consistent pattern indicates that in each case, the post-test MMT scores were higher than the pre-test scores, suggesting an improvement in the overall improvement of the large muscle groups following the intervention or treatment. The significant negative Z statistic (-6.415) provides further support for this finding, indicating a substantial improvement in MMT scores. Additionally, the p-value of .000 indicates strong evidence against the null hypothesis, reinforcing the conclusion that there is a significant difference between post-test and pre-test MMT scores thus accepting the alternative hypothesis. Hence, the Wilcoxon signed-rank test demonstrates a statistically significant enhancement in MMT scores after the treatment. The ranks table reveals that all differences between post-test and pre-test QOL scores were positive, with 11 positive ranks and no negative ranks observed. This consistent pattern suggests that in each case, the post-test QOL scores were higher than the pre-test scores, indicating an improvement after the intervention or treatment. The presence of ties (0 in total) indicates cases where the post-test and pre-test QOL scores were equal. The significant negative Z statistic (-5.801) provides further support for the improvement observed in QOL scores. Additionally, the p-value of .000 indicates strong evidence against the null hypothesis, reinforcing the conclusion that there is a significant difference between post-test and pre-test QOL scores. In summary, the Wilcoxon signed-rank test demonstrates a statistically significant enhancement in QOL scores after the intervention or treatment.

DISCUSSION

The results of this study indicate significant improvements in Manual Muscle Testing (MMT) scores and Quality of Life (QOL) scores among elderly individuals with age-related mobility limitations following the intervention. The Wilcoxon signed-rank tests demonstrated statistically significant differences in pre- and post-intervention scores, with p-values of .000 for both MMT and QOL, providing strong evidence against the null hypothesis. The absence of negative ranks in both tests highlights the consistent positive effect of the treatment across all participants.

Improvement in Muscle Strength

The improvement in MMT scores aligns with research on resistance training and neuromuscular rehabilitation in older adults. Resistance training counteracts sarcopenia and improves functional capacity. Studies by Fielding et al. (2011) demonstrated that structured resistance programs enhance muscle mass and strength, reducing frailty and fall risk. Similarly, the current study found universal improvements in MMT scores, suggesting the intervention effectively targeted age-related muscle decline. Scholtes et al. (2012) reported comparable results in elderly cohorts, where strength training improved lower limb function and balance, critical for maintaining independence. The absence of negative ranks in MMT scores underscores the intervention's broad applicability, even in participants with baseline weakness. These improvements may stem from enhanced neuromuscular recruitment and adaptations in motor unit activation, which remain trainable in older age. Verschuren et al. (2016) noted that combined resistance and balance training improves walking efficiency and reduces disability. While the current study focused on muscle strength, future research should integrate metrics like gait speed or timed-up-and-go tests to capture functional mobility gains.

Quality of Life Improvements

The significant improvement in QOL scores post-intervention reflects the multifaceted benefits of physical rehabilitation in elderly populations. QOL in older adults hinges on physical independence, social engagement, and mental health. Interventions addressing functional decline can mitigate isolation and depression, common in aging populations. Maher et al. (2013) found that physical activity programs improved self-reported QOL, correlating with increased autonomy and participation in daily activities. Similarly, this study's universal QOL improvements suggest that enhanced physical capacity fosters psychosocial well-being. The absence of negative ranks reinforces the intervention's consistency in promoting holistic health.

Comparison to Similar Studies

The findings align with research on multimodal interventions for elderly populations. Sherrington et al. (2019) demonstrated that exercise programs combining strength, balance, and functional training reduce fall risk and improve QOL. Studies on tai chi and low-impact aerobics highlight how structured physical activity enhances both physical and mental health. Pahor et al. (2014) emphasized that sustained physical activity delays disability onset in frail elderly individuals. While the current intervention was short-term, the results support integrating strength training into routine geriatric care to preserve independence.

CONCLUSION

This study demonstrates that targeted strength-based interventions significantly improve muscle strength and QOL in elderly individuals with mobility limitations. The results reinforce the importance of resistance training and physical rehabilitation in mitigating age-related decline. By addressing both physical and psychosocial needs, clinicians can enhance functional independence and overall well-being in older adults.

LIMITATIONS AND FUTURE DIRECTIONS

Limitations include a modest sample size (n=11), potentially affecting generalizability. Future studies should replicate findings in larger, more diverse elderly cohorts, including those with comorbidities like osteoporosis or dementia. The study did not assess functional outcomes such as balance, gait stability, or activities of daily living (ADLs), which are critical for elderly populations. Long-term follow-up is also needed to evaluate sustainability of gains, as age-related decline may necessitate ongoing intervention.

CLINICAL IMPLICATIONS

These findings advocate for integrating strength training into geriatric care protocols. Clinicians should prioritize interventions that preserve muscle mass and functional capacity, reducing fall risk and hospitalization. Additionally, holistic approaches combining physical rehabilitation with social engagement strategies (e.g., group exercises) may amplify QOL benefits. Tailoring programs to individual capacity and emphasizing safety (e.g., supervised sessions) will optimize outcomes for elderly patients.

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Table 1: Comparison PRE-POST – MMT

Ranks					Test Statistics	
		N	Mean Rank	Sum of Ranks	Z	Asymp. Sig. (2-tailed)
MMT_POST_A - MM_PRE_A	Negative Ranks	0[a]	.00	.00	-6.415[b]	.000
	Positive Ranks	11[b]	7.00	431.00		
	Ties	0[c]				
	Total	11				

Table. 2 Comparison for PRE-POST - QOL

Ranks					Test Statistics	
		N	Mean Rank	Sum of Ranks	Z	Asymp. Sig. (2-tailed)
QOL_POST_A - QOL_PRE_A	Negative Ranks	0[a]	.00	.00	-5.801[b]	.000
	Positive Ranks	11[b]	7.50	490.00		

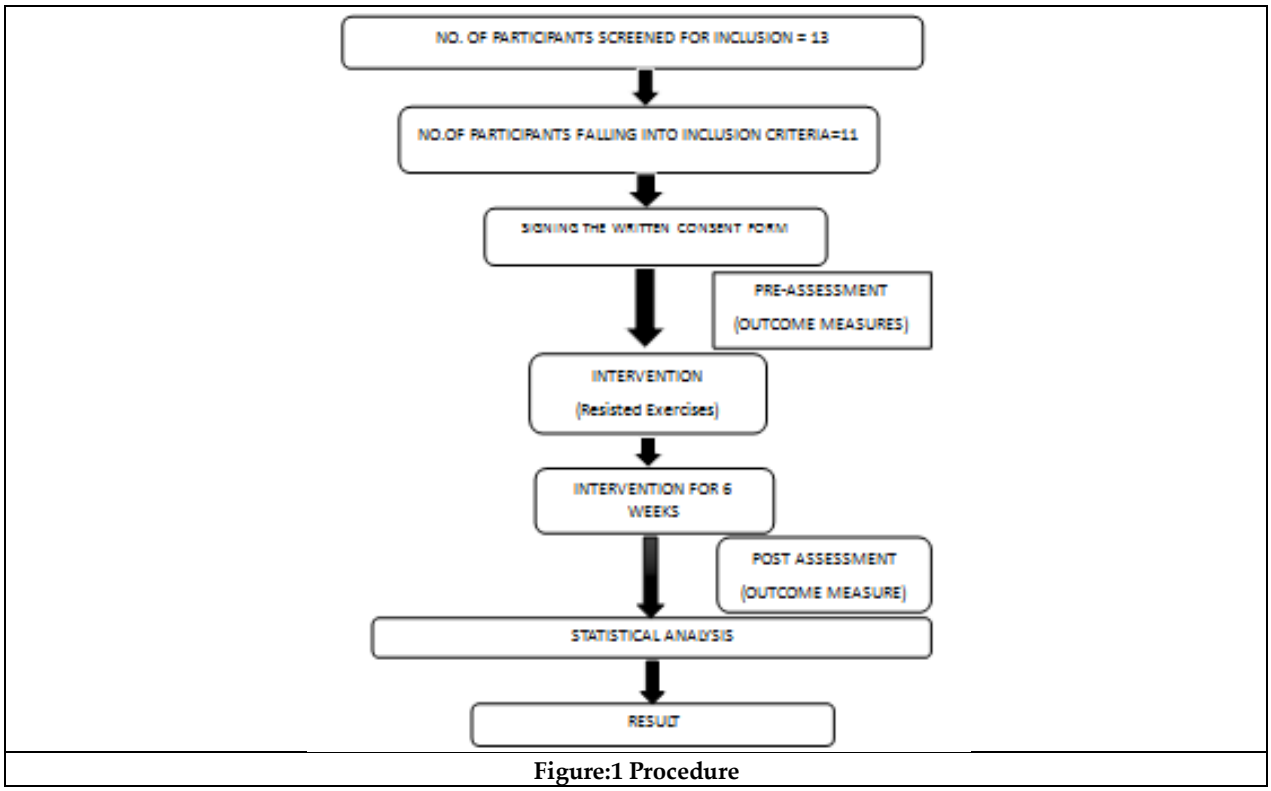


Figure:1 Procedure

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RESEARCH ARTICLE

Malaria through Geography- A Disease Ecology Approach: Bibliometric Analysis from the Scopus and Web of Science Databases (1946-2024*)

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ABSTRACT

A disease can be studied in multiple ways. The medical aspect generally acquires dominance while studying any illness. However, if it is combined or supported with multi-dimensional aspects comprising of factors which create and spread a disease, then the analysis becomes more relevant. In this, geographical setting and geographical factors creating disease epidemiology come to the fore front. The current study is a bibliometric examination on the aspect of natural and human-induced factors as researched in their multiple dimensions for the disease of malaria and its nature in space and time. The bibliometric method of study has gained immense significance in recent times and provides newer perspectives for present and future research. It tends to indicate the focal points of ongoing research, can highlight the gaps and missing points and is useful in scrutinising the interrelationship between the chosen aspects. Results indicate that the Scopus database has more publications on the topic and geographical aspects are observed in selected forms in publication databases of Scopus and Web of Science.

Keywords: epidemiology, malaria, bibliometric analysis, health, literature

INTRODUCTION

Disease epidemiology is the study of all the factors causing the presence or absence of a disease [1]. Malaria is a life threatening [2] tropical and subtropical disease [3] caused by 'parasites which are transmitted through the bites of infected female *Anopheles* mosquitoes [2].Malaria is a leading cause of mortality and morbidity in most of the developing countries. It is defined to be geographically 'very specific' [4] and preventable also [2]. In 2022, there were

about 249 million malaria cases with 6,08,000 deaths in 85 countries [2]. The WHO African region had the maximum share of cases (95%) and maximum deaths were recorded here for children below 5 years of age (80%) [2]. Human and environmental factors operate simultaneously in impacting malaria epidemiology. Important mentions can be given as that of human mobility, rainfall, practices of storing water, and growing urbanisation [5]. It is also observed that the relationship between malaria and climate change is intense and a resultant change in temperature and rainfall can be held responsible for the altered spread of the disease [6]. In health studies, the concept of 'Health–Field' is applied to disease concerns which indicates a combination of - Human Biology, Environment, Lifestyle, and Health Care Systems [7]. In disease ecology studies, the disease ecology triad is emphasized to observe the disease in its totality which indicates that there is an intricate relationship between the disease causing agent, the factors and the prevailing environment, which operate on the disease [8] to create multiple causality. The intensity of malaria is seen to be determined by the ecological factors which support its spread rather than just the vectors which cause it [4]. Such analysis is a part of evolutionary epidemiology and is necessary to understand the basics of a disease which operate at the local level so as to contain it and avoid the losses [9]. Malaria risk mapping with the help of geo informatics is cited as contributory to the systematic study of the disease [10]. Besides, the geographical shifting of disease range and other associated concerns can be well examined through a spatio-temporal approach. This becomes more important in the context of climate change [11]. A geographical approach also seems important as despite numerous efforts, malaria remains a major issue in public health in many nations of the world. Geographic patterning, variations in the disease, and remote sensing techniques provide a unique and helpful method of analysis and disease control. Thus, geography plays an important role in malaria studies [9,12]. It is also noteworthy in this context that identifying the spatial and temporal 'hot spots' of malaria has become a significant approach. It is not only innovative but is an important approach in malaria studies [13]. A geographic database is also essential for a proper surveillance as it is largely missing in the case of this disease [14]. A detailed understanding on factors causing malaria is 'limited' and remains an 'important research topic'[15].

MATERIALS AND METHODOLOGY

Data for the current bibliometric study has been derived from Scopus and Web of Science databases. The analysis is supplemented with results derived from VOS Viewer software. The software is helpful in examining multiple bibliometric aspects. Bibliometric study is considered scientific in nature and provides a quantitative description of data [16].It is a popular and an intense methodology of describing the gradations of research in any field with information on trends in articles, publication sources, collaborations in research, geography of research, citations, publications, and other kinds of analysis which can also provide direction to further research [17]. The years of publication under consideration are till the latest available data for 2024* (*till July,24). Scopus database is seen as a distinct combination of abstracts and citations with scholarly information for numerous disciplines. It is the largest database of peer reviewed work ranging from various kinds of publications [18]. The WoS was previously known as Web of Knowledge and WoS since 2004. It is one of the two large databases providing bibliographic information and covers extensive disciplines across academia. Provided by Thomson Reuters, it has publication records from 1900 to the present. Considered as most trusted global citation data provider in the world with 1.9 billion cited works from 171 million records, the WoS Core Collection gives information on more than 115 years of highest quality research works. The WoS database was searched for the topic in 'All Databases' of the WoS website through Delhi University E-Library System.

RESULTS AND DISCUSSION

Result generated through the Scopus and WoS databases has been analysed here. Scopus generated 6,028 documents for the exact phrase search 'Malaria and Geography and Geographical'. WoS generated 301 publications for the exact phrase search 'Malaria and Geography'. This is an interesting finding as 'Malaria and Geography and Geographical' yielded only 46 publications in WoS. The bibliometric analysis is presented here in two parts:

Scopus database search results on 'Malaria and Geography'

The 6,028 documents were explored for different aspects of the disease and its epidemiology as per the published research works. The output very clearly exhibited that the number of publications were almost stagnant till mid 1990s, after which there was slight fluctuation in the number. A sudden spurt is visible after 1995 and an unprecedented increase can be observed in publications which focus on malaria and geography in some form. This can be seen in Fig.1. Maximum publications were in the form of articles with 1,406 articles which comprised of 66.6% of the total publications. Reviews and books were the next observed categories with around 11.6% of the publications. Conference papers occupied the 5th spot in this category which is indicative of a restricted number of publications in open forums. Another interesting fact is that maximum research on these topics was conducted beyond the geographical domain of the actual occurrence of the disease of malaria. In terms of Scopus publications, University of Oxford, followed by London School of Hygiene and Tropical Medicine did the maximum publications as can be seen in Fig.1. and Table 2. United States and and the United Kingdom had the maximum publications on the topic which is again a very significant observation as the publications again exhibit a non-geographical impact. A mix of developed and developing nations can be seen as the top most contributors to the study of malaria in its geographical dimensions as can be seen in Fig.2. The findings can be further examined for details. It becomes noteworthy to observe the intricacies of these publications with regard to subjects areas, keywords, co-authorships and other dimensions. The Scopus database is indicative that maximum publications on the topic were from the field of Medicine followed by Social Sciences. This indicates the focus of research in which it can be said that the social dimension of the disease is lesser a focus and the medical aspect has gained dominance. Co-authorship information is also a good indicator of research domains. In this regard, maximum co-authorship was observed between authors of the two topmost publishing nations- the USA and UK. This can be seen in Fig.3.United States stands out in terms of number of publications and co-authorship criteria. USA also exhibits a strong independent research focus yet is interconnected with other countries for publications on the topic.

A dense interconnected network of research is visible between the other focal countries notable among which are UK, China, Spain, Indonesia, and Costa Rica. Interestingly, countries for co-authorship are inclusive of the nations of Global North and South. Some of them the tropical ones where malaria occurrence is actually a pertinent concern due to their geographical factors of location and climate. Examples can be given as that of Equatorial Guinea, Chad and Congo. The software generated 231 countries with publications on the search topic. The next analysis is done for observing co-authorship of publications as per institutions. This is shown in Fig.4. A close network of authorship is visible from 2010 onwards with the University of Basel, University of Chinese Academy, London School of Hygiene and Tropical Medicine, Fogarty International Center and, the University of Oxford emerging as specific centers of co-authorship on the topic. This examination is extended to observe the dominant content in the title and abstract filed of the publications. Title fields examination was done with at least two occurrences of words, generated 14,548 words from which 2,770 were the top 60% words from which 1,396 were the largest connected. The results can be seen in Fig. 5. It indicates medical and geographical terminologies, but without a pattern and in close proximity. Geographical data, data science, landsat, geographically, systems approach, social geography, famine, risk area, extinction, uneven development, global burden, and global health can be given as some examples. Abstract field words on the topic are indicated in Fig.6. with the criteria of selection being that of 6 times occurrences of a word. It provided 1,06167 words in which the first 60% were taken as the automatic criteria. It generated 6,556 words and the result is shown in Fig.6. The abstract field in Fig.7. indicates distinct clustering of words. A few can be highlighted as-child, patient, book, parasite, disaster and gene. Majority of the words were from the medical field. Geographical observation generates settlement systems and NDVI at an end of the diagram. Fig.7. is indicative of keywords analysis. These were examined by adopting the criteria of at least a two time occurrence of a word in publications.

WoS database

The WoS database generated 301 publications on the topic 'Malaria and Geography'. The publication categories were again dominated by medical field followed by geography as can be seen in Table1. The further publication statistics can be seen in Fig.8. Publications statistics indicated that tropical medicine had the maximum count of 19.2% in publications followed by Infectious Diseases as the Web of Science Category. With an H-Index of 46, the 301 articles were cited 20,553 times. WoS categories for co-authorship as per institutions indicated the concentration of works around the London School of Hygiene and Tropical Medicine and the University of California. A strong concentration of institutions is visible with outreach observed between newer organisations within and outside the existing clusters. This can be deciphered from Fig.9. As per co-authorship, 94 countries were observed to provide the publications with 84 interconnected. This can be seen in Fig.9. The United States emerges as the major center of co-authorship on the topic since records are available (from 2014). It is also indicated that newer centres of publication are emerging as well. The London School of Hygiene and Tropical Medicine did the maximum publications followed by the University of San Francisco. Here, again USA and UK have maximum publications with close linkage. Publications from other countries are also observed but with co-authorship away from the main centres of publication as can be seen from Fig.10. and Fig.11. Observations on the title field indicated the trend from 2005 onwards in which a clustering can be observed also. Geography and malaria occupy the central position which indicates a geographical focus to studies and that the search generated terms related to the topic. In terms of geographical concerns pertaining to malaria epidemiology, sub- Sharan Africa, Africa, Burkina Faso, China, India and Brazil find a pertinent mention with geographical aspects of study being observed in terms- barrier, access, area, distribution, population and trend among others. Besides, some medical terminologies find a mention as well in the title field. Abstract examination indicated about 9,658 terms and with two occurrences criteria, 2365 terms were generated from which the information could be derived for 1,419 terms. The results are depicted in Fig.12. The abstract field is marked more by medical terminology in terms of occurrences observed.

CONCLUSIONS

The findings indicate that 'Articles' have the maximum number in type of publication category on the topic. Research on observing the interrelationship between geographical factors and malaria seems to be influenced by geographical considerations in some aspects. Medical research seems to dominate and a combination of developed and developing nations can be seen to be conducting it. Besides, Scopus has the maximum number of publications on the topic. This, if pursued further, can be more insightful in studying the social dimensions of the disease in its geographical setting. A holistic approach such as this can be then helpful in leading the studies to more logical conclusions rather than just finding medical solutions to them. It can also be helpful in reducing costs and providing more effective treatments.

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Table 1. Top 9 Publication Categories. Source- Authors, 2024[20]

Web of Science Categories	Record Count	% of 301
Tropical Medicine	58	19.269
Infectious Diseases	52	17.276
Parasitology	51	16.944
Public Environmental Occupational Health	50	16.611
Geography	44	14.618
Medicine General Internal	18	5.98
Multidisciplinary Sciences	17	5.648
Ecology	16	5.316
Economics	16	5.316

Table 2. Top 10 Countries with Publications. Source- Authors, 2024 [20]

Countries/Regions	Record Count	% of 301
USA	166	55.15
England	65	21.595
Switzerland	35	11.628
Kenya	26	8.638
France	25	8.306
Australia	24	7.973
Brazil	23	7.641
Peoples Republic Of China	23	7.641
South Africa	22	7.309
India	21	6.977

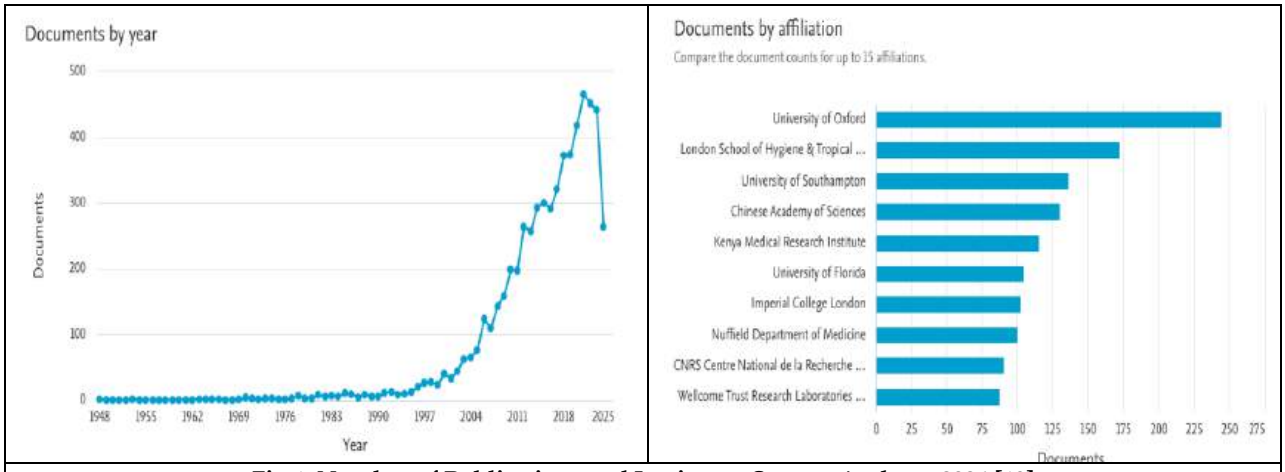


Fig.1. Number of Publications and Institutes. Source- Authors, 2024 [19]

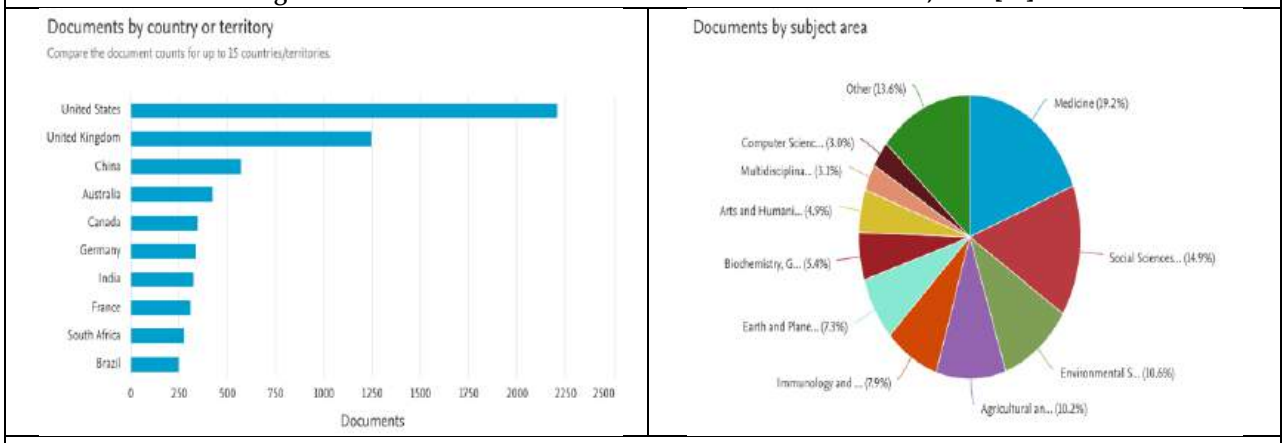


Fig.2. Countries and Subject Areas with Maximum Publications. Source- Authors, 2024 [19]

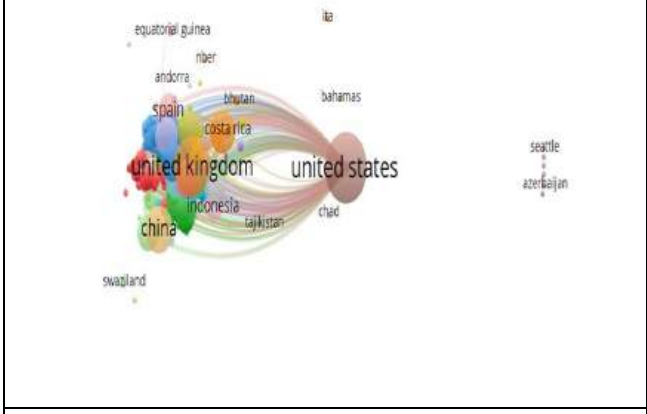


Fig.3. Co-authorship as per Countries (from 2012 onwards). Source- Authors, 2024 [19]

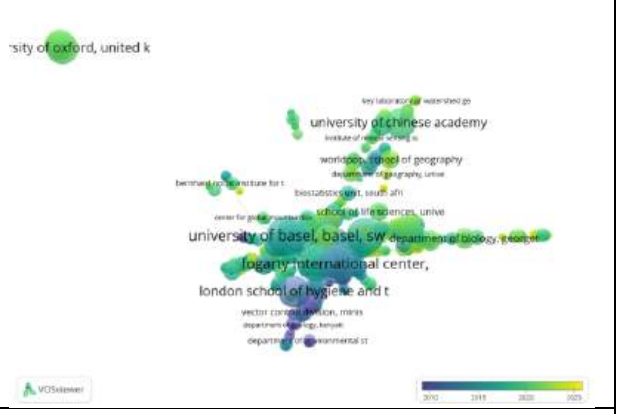


Fig.4. Co-authorship as per Countries (from 2012 onwards). Source- Authors, 2024 [19]

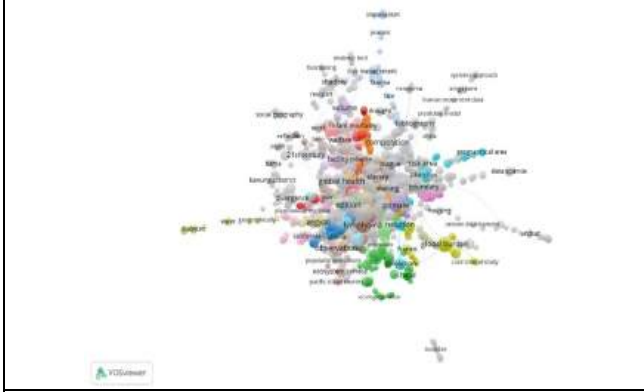


Fig.5. Title Field Words (from 2010 onwards). Source- Authors, 2024 [19]

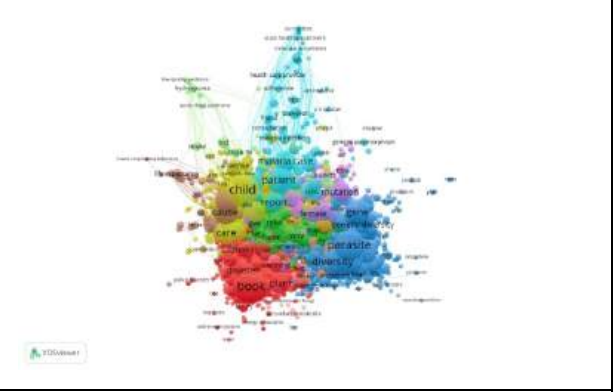


Fig.6. Abstract Field Words on the Topic (from 2012 onwards). Source- Authors, 2024 [19]

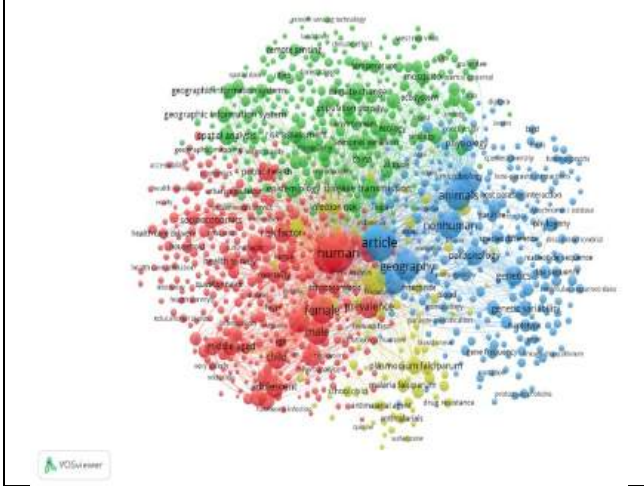


Fig.7. Co-occurrence of Keywords (By total link strength). Source- Authors, 2024 [19]

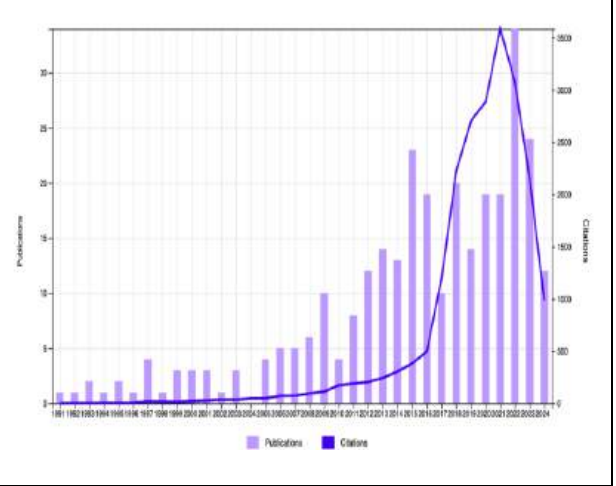


Fig.8. Publication and Citation Record . Source- Authors, 2024 [20]

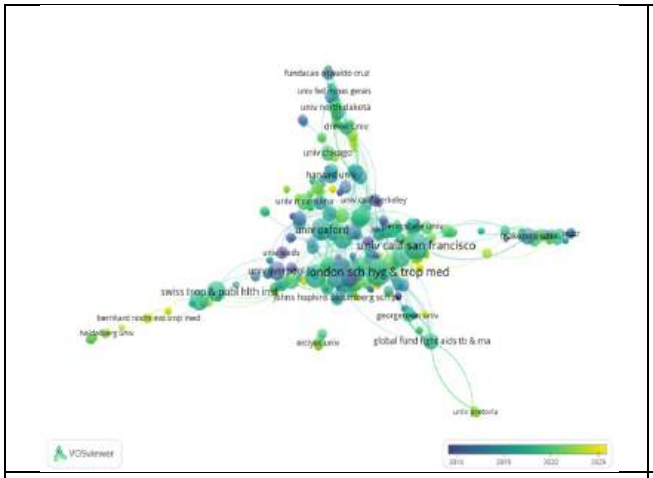


Fig.9. Institutes as per Co- Authorship (from 2010 onwards). Source- Authors, 2024 [20]

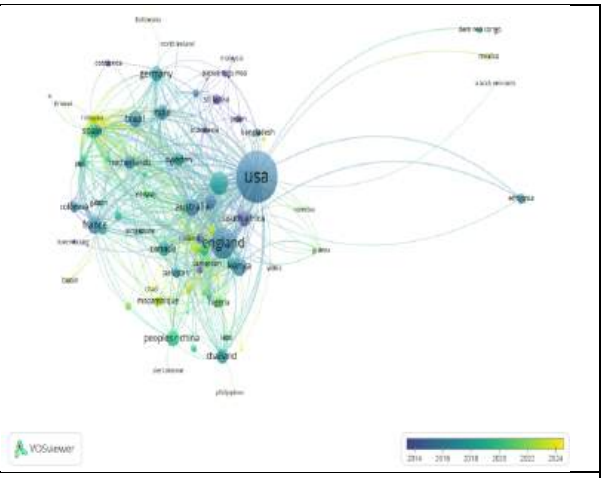


Fig.10. Countries as per Co- Authorship (from 2010 onwards). Source- Authors, 2024 [20]

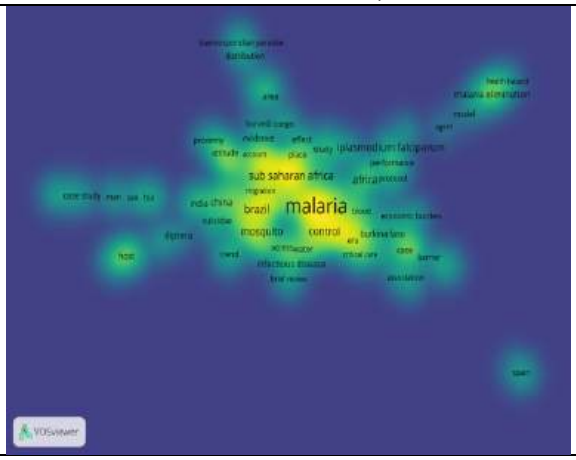


Fig.11. Title Field Words (from 2005 onwards). Source- Authors, 2024 [20]

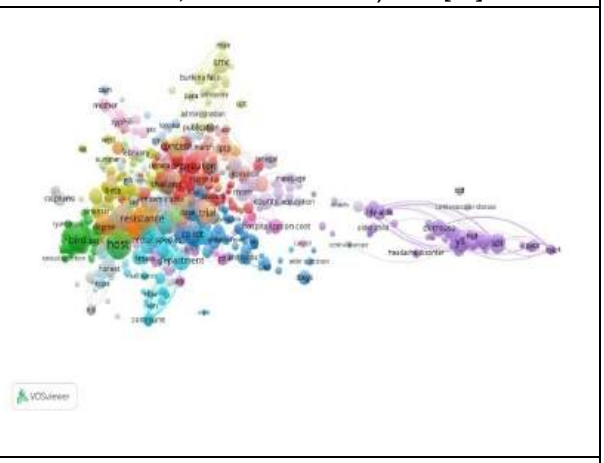


Fig.12. Abstract Field Words (from 2010 onwards). Source- Authors, 2024 [20]

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RESEARCH ARTICLE

Single Case Study: Effective *Ayurvedic* Strategies for Managing Migraine

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ABSTRACT

The WHO estimates that globally 15% of individuals suffer from migraines. These are marked by painful headaches that often come with sensitivity to light, sickness, and throwing up. In *Ayurveda*, this condition links to *Ardhavabhedaka*, a type of *Shirashoola* noted. The key sign of *Ardhavabhedaka* is a strong headache on one side, resulting from an imbalance in the three *Doshas*. *Ayurveda* uses both *Shamana* and *Shodhana* treatments for this condition. This describes the *Ayurvedic* management of a 61-year-old female patient who had been suffering from severe unilateral headaches 4-5 times a week for the last ten years, with complaints of nausea and vomiting. Except for the use of Paracetmol-650, the patient did not have any significant past history or ongoing medications in her lifetime. Patient had complained of exertional dyspnoea and constipation. She was subjected to systematic observation and duly treated with a course of *Ayurvedic* drugs along with the*Virechana* procedure so as to balance the*Doshas.* The patient had a considerable reduction in migraine episodes. No migraine episodes were seen during the follow-up period that lasts for one-month post-treatment. Doubtless due to the efficacy of *Virechana* and pharmacological effects of the *Ayurvedic* medicines, the *Doshas* got back to their equilibrium, thus relieving the symptoms. The approach of treatment, that is *Virechana* with *Shamana Aushadhis* was effective in decreasing the frequency and intensity of migraine attacks in this case.

Keywords: *Ayurveda, Ardhavabhedaka,* migraine, headache, *Virechana, Shamana.*

INTRODUCTION

Migraine [1] is complex neurological disorder which presents with recurrent, severe headaches often associated with symptoms like nausea, vomiting, and photophobia [2] and phonophobia [3], though individual attacks in some forms of migraines might also involve transient visual disturbances. These attacks have great impact on quality of life, and may even result in disability and lowering productivity. Additional options in conventional medicine typically include relief of the symptoms with medication, which can be marginally effective and can carry unwanted side effects. According to *Ayurveda* the cause of Migraine is debilitated of *Dosha Kapha, Pittta* and *Vata*.*Sushruta Samhita* describes a specific condition known as "*Ardhavabhedaka*, "that resembles medical description of migraine, as the most characterized presentation of migraine identified with headache restricted to one side. [4] *Ayurveda* views the condition as primarily rooted in an imbalance of *Pitta Dosha* When *Pitta* is aggravated, it leads to inflammation, manifesting as intense, throbbing headaches typically on one side of the head. In addition to *Pitta* vitiation, *Vata Dosha* intensifies the symptoms. Key *Ayurvedic* factors contributing to migraines include *Pitta* vitiation, *Ama* [5] accumulation, and *Vata-Kapha* imbalance, all of which disrupt bodily equilibrium. *Ardhavabhedaka*in *Ayurveda* mirrors the characteristics of a migraine, with half-headed pain and severe discomfort. The key treatment is to rebalance the *Doshas* and particularly to reduce *Pitta* and leave *Ama*. One of the main therapies include *Virechana*-purgative procedure to eliminate these metabolic byproducts and *Pitta* from the body, thus promoting *Dosha* balance. This case study investigates the treatment of chronic migraines utilizing *Virechana* and internal *Shamana Aushadhis*. For this purpose, Integrated *Ayurveda* treatment helping to reduce symptoms and prevent recurrence appears more effective. This example depicts togetherness of evidence-based medicine and *Ayurveda* to treat migraines.

Case report

A 61-year-old female patient presented to the OPD with chief complaints of *KwachitaVameKwachiteDakshineShirashoola* (intermittent headache affecting either the right or left side of the head), *KwachiteChhardi* (occasional vomiting), *Hrullasa* (nausea), *Vibandha* (constipation), and *GamaneSwasakashtata* (difficulty in breathing during walking). These symptoms had persisted for the past 10 years, significantly affecting her daily life.

History of present illness

Prior to developing cephalalgia about ten years ago, the patient was in excellent health. These episodes happened once or twice a week at first, but they eventually rose to four-five times a week. Along with the headaches, there were sometimes emesis and nausea, which sometimes helped in relieving symptoms. She also mentioned experiencing phonophobia and photophobia when having headaches. The patient has suffered from chronic constipation for the past seven years and has become reliant on *Kayam Churna*, herbal laxative that she taken daily for the previous six years. Her symptoms have not significantly improved despite numerous interventions with allopathic medications. Exertional dyspnoea that the patient had about three years ago complicated her clinical picture even more. She brought these persistent problems to the OPD. Table no.1 showing the chief complains with timeline.

Personal History

Nutritional status: Properly Nourished
Bowel: Constipation, 1 time/2-3 days; Blackish and Hard Stool
Urine: 6-7/Day;1 time/Night(sometimes); Yellowish colour
Appetite: Normal
Sleep: 8 Hours/night; 1 Hour/Day time
Addiction: No any addiction
Built: Normal

Medication and Medical History

There is no history of regular medication use.
Occasionally takes Paracetamol 650 mg during headache episodes.

No history of diabetes mellitus/hypertension or any other major medical or surgical history.

Family History
No relevant family history found.

Systemic Examination
No abnormalities were noted. *Ashtavidha Pariksha*: Showing in Table no. 2.

Diagnosis
The diagnosis was established through clinical evaluation as *Ardhavabhedaka* (Migraine).

Therapeutic Intervention
Virechana[7] and the subsequent internal medication were planned based on the assessment of the *Rogabala* (Severity of Disease) and the *Aturabala*(patient's overall strength and capacity).

Virechana
For the normally built 61 years old woman suffering from *Pitta Dushti, Mridu Virechana* was performed. The treatment initiates with administration of *Trikatu* with*Grita*for Five days as *Deepan-Pachana.* Then next five days of *Snehapana* given with 30 ml of *Go-Ghrita* and increased gradually up to 140 ml. After *Snehapana,* the patient was treated with *Snehana* with *Mahanarayana Taila* for two days along with *Nirgundi Sweda*. After pre-procedure for *Virechana*, the patient was given *TrivrutadiAvaleha*[8] with *DrakshadiKwatha* as *Anupana*. As a result, patient had 14 *Vega.* After itslight diet was advised for the recovery. Throughout the procedure, the vital signs of the patient were monitored for safety and the response to treatment. Oral medication given to the patient mention in Table no.3

Diet
Advised normal diet, with a light schedule as much as possible, excluding oily, spicy, or junk foods.

Exercise
Meditation and P*ranayama-Bhramari* and *Anuloma Viloma* are specifically advised.

RESULT

Shamana Aushadhis(Internal Medicine) were prescribed to patient, following nearly 15 days of undergoing the *Virechana* treatment. She presented for follow-up after one month and revealed a tremendous response to the treatment. She experienced no migraine attacks during this period, with only one mild headache that resolved within an hour. Additionally, her chronic constipation improved, with regular bowel movements without *Kayam Churna,* which she had previously taken daily.She also noted a substantial improvement in her exertional dyspnoea, with a 40-50% reduction in breathing difficulty during walking. She stated a substantial improvement in overall quality of life, including improved mood and enhanced daily functioning. (Fig 1.)

DISCUSSION

A case study that demonstrated chronic migraine resistant to conventional allopathic treatments was presented by a 61-year-old female with a 10-year history of *Ardhavabhedaka* and its associated symptoms that included nausea, vomiting, photophobia, phonophobia, constipation, and exertional dyspnoea. In *Ayurveda*, migraine is understood to be from imbalances in *Tridosha.* Indigestion further accumulates *Ama*and shown the symptoms like constipation and nausea. Hence, the treatment following *Virechana* and *Shamana Aushadhis* for detoxifying the body and restitution of *Dosha* balance, brought considerable clinical benefits as an example of the therapeutic potential of *Ayurveda*. *Virechana* is the most essential in this treatment process because it rectifies *Pitta* and *Vata Doshas,* which are mainly the causes of

the patient's *Ardhavabhedaka* and symptoms with it. Being a purgative therapy, *Virechana* evacuates the excess amounts of *Pitta* and *Ama*, which are stored in the body mainly through the bowel. This detoxification clears the *Raktavaha Srotas*, and reducing all inflammation, by which migraines are often accompanied by intense, throbbing headaches. In this case, *Mridu Virechana* was used as considering the patient's age and constitution. *Virechana* balances *Pitta*which causing the migraine while bringing under control the imbalanced *Vata* to redress neurological symptoms such as photophobia and phonophobia. Chronic constipation alleviated with regular bowel movements without a laxative as *Trikatu* had properties of *Vatanulomana* and *Agni-Deepana*. *Snehapana* relieves chronic constipation by lubricating the gastrointestinal tract, softening stools, and pacifying aggravated *Vata* in the large intestine. Additionally, detoxification of the respiratory system and balancing of *Kapha* and *Vata Doshas* by *Virechana* have helped the patient relieve exertional dyspnoea better. This way the detoxifying and *Dosha*-balancing effect of *Virechana* had appreciably reduced all symptoms.

Probable mode of action

The patient's symptoms linked to *Tridosha* imbalance, were managed by pacifying *Pitta, Vata* and balancing *Kapha*. The combination of *AvipattikaraChurna* and *Kamadudha Rasa* would have reduced the *Pitta* which decreases the *Ushnata. Sudarshana Churna*pacifying *Pitta dosha*, promotes *Ama pachana*, and have analgesic and anti-inflammatory and bronchodilator action, derived from ingredients like *Guduchi* and *Haritaki.* Thereby reduce inflammation and also alleviate the dyspnoea.*Shirshuladi Vajra Rasa* contains *Yashada Bhasma,*which is known for its neuroprotective properties and helps in stabilizing nerve functioning. Also, adequate calcium is vital for nerve function, as it stabilizes neuronal membranes and modulates excitability. In migraine sufferers, heightened neuronal excitability can trigger attacks, highlighting the importance of proper calcium levels for prevention. *Shankha Bhasma*, a natural calcium source, aids in this process while also pacifying *Pitta Dosha,* effectively alleviating nausea and vomiting associated with migraines. *Hrullasa* and *Chhardi* clearly indicated the *Pitta* vitiation happening in the digestive system. Upward movement of *Ama* and *Pitta* irritates the *UdakavahaSrotas*, which causes vomiting. The use of *Deepana-Pachana* with *Trikatu* and *AjamodadiChurna*to enhance *Agni* and eliminate *Ama* from the body strengthened the treatment. It helped digest food well and increase the metabolic rate. *Vibandha* was associated to a *Pakvashaya* imbalance of *Vata*, resulting in dryness, constipation, and hard stool. Dependence on laxatives for a long period of time indicated her digestive system is weak. *Erandabhrushta Haritaki* providing a mild laxative effect, balancing *Vata*, adding bulk and lubrication to stools. The exertional dyspnoea in the patient was due to an imbalance of *Vata* and *Kapha*. The excess *Kapha* in the respiratory system caused obstruction in the *PranavahaSrotas* whereas aggravated *Vata* led to irregular breathing patterns. *PathyadiKwatha* were added with *Godanti Bhasma* to balance both *Kapha* and *Vata*. These drugs helped achieve easier breathing by removing the impediments present in the respiratory pathways, while *PathyadiKwatha* exhibited the property of calming the nervous system that relieved headache and shortness of breath on exertion. Apart from this, the patient demonstrated an excellent improvement in general well-being and morale. Such generalist treatment that even factored balancing the system as well as psychological health proved to be a vital determinant towards improving the quality of life of the patient. Among these, dietary and lifestyle changes with abstinence from spicy, oily, and junk food; meditation and Pranayama (like *Bhramari* and *Anuloma Viloma*) diminished mental stress and led to relaxation, whereas nasal drop of *Anu Taila Nasya* helped nourish the brain and hence reduce tension and hike the working of the nervous system, which led to mood stability along with overall emotional well-being.

CONCLUSION

This case regains *Dosha* balance through *Virechana* therapy, specific herbal interventions, and lifestyle changes, and the patient experiences fewer headaches, resolution of chronic constipation, and an overall sense of better well-being. This, in short, reaffirms the necessity of customized *Ayurveda* treatment in such complex cases to gain holistic well-being. Further research will amplify the emerging evidence in favour of integrating *Ayurveda* in mainstream health care.

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Table . 1 Chief Complains with Timeline

Sr.No.	Chief Complain	Since time
1.	*Shirashoola* with *sabdahishnuta* and *prakashahishnuta*	10 years
2.	*Hrullasa*	10 years
3.	*Chhardi*	10 years
4.	*Vibandha*	07 years
5.	*Gamaneswasakashtata*	03 years

Table:2 *AshtavidhaPariksha:*[6]

Nadi(Pulse)	84/min; *VatajaPittaja*
Mala (Stool)	1 time/2-3 days, Blackish,Hard

Mutra (Urine)	6-7times/day; 1time/night; Yellowish
Jivha(Tounge)	Whitish; *Saama*
Sparsha (Skin/Touch)	*Anushna;Pittavarnya*
Shabdha (Voice)	*Samanya*
Druk (Vision)	*Samanya*
Akriti(Built)	*Samanya*

Table 3: Oral Medication

Sr.No.	Medicine	Dosage	*Anupana*	Timing
1.	*AvipattikaraChurna*[9] *AjamodadiChurna*[10] *Sudarshana Churna*[11] *Shankha Bhasma*[12]	1 teaspoon Twice Daily (BD)	Lukewarm water	After food
2.	*ShirashooladiVajra Rasa*[13]	2 tablets, twice daily (BD)	Lukewarm water	After food
3.	*KamadudhaRasa*[14]	2 tablets, twice daily (BD)	Lukewarm water	Before food
4.	*PathyadiKwatha*[15] With *Godanti Bhasma*[16](250 mg)	40 ml, twice daily (BD)	Lukewarm water	On an empty stomach (Morning & Evening)
5.	*ErandabhrushtaHaritakai*[17]	3 tablets at bedtime	Lukewarm water	At bedtime
6.	*Anu Taila*[18]	1 drop in each nostril, twice daily	N/A	Twice daily

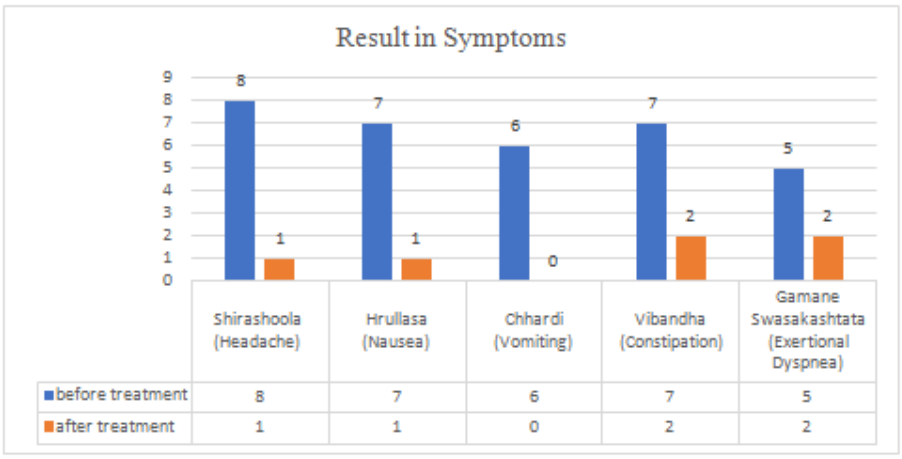


Fig: 1

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RESEARCH ARTICLE

Biodegradation of Disposable Face Masks using Microbial Consortium from Different Soil Samples: A Pilot - Scale Study via Winogradsky Column Method

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ABSTRACT

Extensive usage and increasing accumulation of disposable face masks (made of polypropylene, other plastics and fibers) during and post-pandemic (Covid-19) has massively contributed to pollution in our environment. It is hence imperative to find an eco-friendly way for secured disposal and degradation of these used up plastic masks. The intention of this research was to determine the efficiency of soil microbes to degrade disposable masks by using Winogradsky's column method. Composite soil samples enriched with microbial consortium were collected from different locations such as the garden and dump yard region. Plastic containers (500 ml capacity soft drink bottles) were used to set up Winogradsky's column with soil samples covering 20% of the column while the balance 80% was filled with the minimal media (Bushnell Haas Broth) devoid of any hydrocarbon content. Multiple setups using garden soil (G, G_1, G_2, G_3, G_C) and dump yard soil (D, D_1, D_2, D_3, D_C) were prepared with suitable controls. The disposable masks were cut into small strips, weighed and placed onto the soil at the bottom of each bottle before covering with minimal media. The setup was allowed to incubate for over 100 days. After incubation, the strips were weighed and the percentage of weight loss was calculated. Since there was reduction in weight, the efficient microbes involved in degradation of disposable masks were isolated and identified by VITEK 2, providing insights into the specific bacterial species that can degrade the synthetic material used in masks. This research contributes to developing sustainable solutions for managing pandemic-related plastic waste through microbial degradation.

Keywords: Disposable mask, Winogradsky's column, Composite soil sample, Dump yard soil microflora.

INTRODUCTION

A novel coronavirus appeared in Wuhan, China, in December 2019 and became a global health crisis of unprecedented scale and impact. This outbreak, which came to be known as COVID-19, spurred a global increase in the use of personal protective equipment (PPE), especially disposable face masks. Such an exponential spread led the World Health Organization to term it a Public Health Emergency of International Concern on January 30, 2020. Finally, the WHO declared the COVID-19 outbreak a pandemic on March 11, 2020. Similar to the last decade's pandemic, H1N1 swine flu, the new viral strain, the COVID-19 pandemic, seemed even more of a significant public health threat. In response to this crisis, all countries implemented broad containment measures that included lockdowns, strict travel restrictions, physical distancing measures and isolation for those who exhibited symptoms. A universal mask-wearing mandate was also instituted globally to reduce the risk of direct viral transmission. The introduction of these methods proved to be helpful as a great bound decreased the transmission rate. Though these masks played a significant role in reducing the spread of the virus, their extensive use has resulted in an emerging environmental challenge of great concern (Oliveira et al., 2023). The global health crisis has led to a substantial increase in the consumption of plastic material, particularly with increased usage of personal protective equipment and hygiene products such as face masks, gloves and sanitizer bottles (de Sousa, 2021). Disposable face masks are complex multi-layer structures composed of synthetic polymers, namely polypropylene, polyurethane, polyacrylonitrile, polystyrene, polycarbonate, polyethylene and polyester. Their typical construction consists of three layers: an inner layer of soft fiber, a melt-blown filtering middle layer, and an outer non-woven water-resistant layer. These materials have been proven to have a high environmental persistence with estimated degradation times of approximately 450 years, thus giving rise to significant ecological risks, particularly through their fragmentation into micro- and nano-plastics that can infiltrate various ecosystems.

Among the various environmental issues associated with the continued uncontrolled use of plastics, waste management and pollution stand out as critical concerns (Moshood et al., 2022), necessitating the development of effective solutions to address plastic contamination (Altug and Erdogan, 2022). Recent research points to several microorganisms capable of degrading polyolefins and other synthetic polymers commonly found in face masks. The biodegradation process depends on the catalytic properties of microbial enzymes, which are used by microorganisms to transform organic compounds into simpler molecules, either carbon dioxide and water in aerobic conditions, or carbon dioxide, water and methane in anaerobic environments (Abda et al., 2022). Notable examples include *Rhodococcus ruber* C208, *Bacillus cereus* BF20 and *Pseudomonas* sp. AKS2, has demonstrated the ability to break down polyethylene, polypropylene, polystyrene, polyvinyl chloride, polyurethane and polyethylene terephthalate. Some microbial enzymes, for instance, laccase and manganese peroxidase, have been discovered with potential for degrading plastic wastes (Ru et al., 2020). The improper disposal of face masks represents a multivaried problem environmentally, which affects both terrestrial and aquatic ecosystems. While their role in public health protection is undisputed, particularly in healthcare settings and during disease outbreaks, face masks have environmental concerns that demand their sustainable disposal or degradation to address. This study investigates the potential of indigenous topsoil microflora in plastic mask degradation using a modified Winogradsky column approach. Sergei Winogradsky first developed this column in the late 19th century, which is essentially a dynamic microcosm for simulating the natural environmental condition and studying the interactions of microbial activity and their metabolic processes. This method will allow for the cultivation and observation of diverse microbial communities across different nutrient gradients, making it suitable for exploring bacterial degradation capabilities. Microbial communities from garden and dump-yard soil samples will be compared to identify and characterize efficient bacterial degraders capable of breaking down disposable face masks. This research contributes to the development of sustainable solutions for the overall management of plastic waste while advancing knowledge of synthetic polymer degradation mechanisms through microbes.

MATERIALS AND METHODS

Collection of soil sample

Topsoil samples were collected from two distinct locations namely, a garden environment with plastic contamination (Vadakkupattu, Chennai) (Figure 1) and a municipal dump yard filled with plastics (Pallikaranai, Chennai) (Figure 2) during the year January 2022.These sites were selected to compare microbial communities adapted to different levels of plastic exposure. The topsoil was specifically chosen due to its rich microbial diversity and its role as the primary contact layer for discarded face masks in the environment.

Preparation of plastic masks

Commercial disposable plastic face masks were purchased and processed for the degradation study. The dimensions of the masks were measured first and then the elastic straps and nose clips were removed to make flat and uniform surfaces. Two size categories were prepared: larger strips measuring 10 cm × 2.5 cm and smaller strips of 5 cm × 2 cm (Figure 3). All the mask pieces were weighed before experimentation to establish baseline measurements for degradation analysis.

Preparation of the column

The plastic bottles were cleaned and modified by cutting near the neck region. The topsoil collected from the garden was introduced into bottles labelled G, G_1, G_2, G_3, and G_C, filling 20% of the container volume. Face masks were strategically positioned with 50% soil embedment and 50% surface exposure. Longer mask segments were placed in G_1, G_2, and G_3, while shorter segments were inserted in G. Bushnell Haas broth was added to fill the remaining 80% volume. The containers were hermetically sealed with tape to prevent air infiltration and contamination. Similarly, dump yard topsoil was used to fill 20% of bottles labelled D, D_1, D_2, D_3, and D_C. Short mask segments were placed in D, while longer segments were inserted in D_1, D_2, D_3. The columns were then filled with broth to 80% capacity. Columns D and G underwent 150-day incubation, while the remaining columns were incubated for 100 days (Figure 4). Post-incubation, the setup was opened for further observation and studies (Figure 5 and 6).

Removal of mask from the column

After incubation period, the columns were unsealed aseptically. The mask strips were extracted from columns using sterile forceps and cleansed with sterile Bushnell Haas broth. After thorough drying (Figure 7), the strips were weighed. The degradation rate was measured by obtaining the percent weight loss using the following formula (Kangand Lian, 2015):

Weight loss % = $\left(\frac{w_i - w_f}{w_i}\right) \times 100$

where, w_i= Initial weight of the mask

w_f= Final weight of the mask

Isolation and identification of the bacterial degraders in the soil

Isolation of bacteria was done by inoculating 1g of soil samples from each column into 10 ml saline tubes to make master dilutions.Then they were diluted serially to 10^{-9} concentration and plated on nutrient media by spread plate technique. The bacterial colonies were counted after 24-hour incubation at room temperature. This procedure was replicated for all soil samples (G, G_1, G_2, G_3, D, D_1, D_2, D_3). The isolated colonies, potentially representing efficient plastic mask degraders from the soil microflora, were subcultured on nutrient agar plates to obtain pure cultures. After 24-hour room temperature incubation, the isolates were subjected to identification tests. Final confirmation of genus and species was conducted using VITEK 2 analysis.

RESULTS

Biodegradation Analysis Through Weight Loss Assessment

The experimental analysis revealed significant variations in the degradation patterns between different soil types and sample sizes. Maximum degradation efficiency was noted in the dump-yard soil sample (D) with 11.95% weight loss, while the second-highest was observed in the garden soil sample (G) with 11.28% after an incubation period of 150 days. A notable inverse correlation was observed between sample size and degradation rates, where larger samples exhibited substantially lower degradation percentages, ranging from 0.17% to 0.75%. The weight loss ratios for all experimental samples are summarized in Table 1.

Bacterial Species Identification and Distribution

Microbiological analysis of soil samples led to the isolation and identification of ten distinct bacterial species (Table 2). The bacterial consortium consisted of *Pasteurella pneumotropica*, multiple strains of *Staphylococcus lentus, Pseudomonas oryzihabitans, Aerococcus viridans, Pasteurella testudinis, Escherichia coli, Pantoea* spp., and *Sphingomonas paucimobilis.* This diverse microbial population indicates potential plastic-degrading organisms capable of thriving under their respective soil environments. The presence of multiple strains of *Staphylococcus lentus* suggests its significant role in the degradation process within these specific soil conditions.

DISCUSSION

The metabolic activities of soil microorganisms can be the reason for microbial degradation of plastic masks in topsoil. In the experimental setup, microbes were confined in columns with Bushnell Haas broth, a specialized medium lacking carbon sources typically used for hydrocarbon degradation studies. Thus, the enclosed plastic mask was the primary carbon source for the surviving microflora. Umamaheshwari *et al*., (2013) demonstrated that microbes can degrade PET and PS foam buried in soil, cow dung, and sewage by cleaving polymer bonds, with FTIR spectroscopy confirming decomposition through the detection of stretching between constituent bonds like C=C, CH, OH, C-O, and C=O. Significant percent weight loss averages were observed for the dump yard topsoil microflora as compared to garden topsoil microflora, which indicates that the microbes found in the dump yard topsoil may be naturally more plastic degrading due to long-term exposure and adaptation to plastic-rich environments. This observation is found in accordance with Kamble et al., (2015), whereby they reported that garbage soil degraded faster than garden soil. Significant differences in weight loss percentages were noted between samples G and D versus G_1, G_2, G_3, D_1, D_2, and D_3, which are due to the difference in incubation periods (150 days versus 100 days) and differences in total surface area. The data showed that as sample sizes increased, degradation rates decreased significantly. Larger samples showed minimal degradation, with rates falling between 0.17% and 0.75%. This inverse relationship between surface area and degradation rate, along with the direct correlation between incubation time and degradation efficiency, can be expressed as:

$$\frac{1}{\textbf{total surface area}} \propto \textbf{Rate of microbial degradation} \propto \textbf{time for incubation}$$

The study identified various bacterial isolates obtained by serial dilution and spread plate technique from soil sample Include *Pasteurella pneumotropica, Staphylococcus lentus, Pseudomonas oryzihabitans, Aerococcus viridans, Pasteurella testudinis, Escherichia coli, Pantoea* spp., and *Sphingomonas paucimobilis*, as verified by VITEK 2. While previous research has identified *Pseudomonas* sp., *Bacillus* sp., *Staphylococcus* sp., *Moraxella* sp., *Serratia* sp., and *Micrococcus* sp. as effective plastic degraders, this study revealed additional potential degraders including *Pasteurella* sp., *Aerococcus viridians, E.coli, Pantoea* sp., and *Sphingomonas* sp., in addition to common soil fungi like *Aspergillus* sp. Different microorganisms employ various mechanisms and enzymes to degrade plastics. Kathiresan (2003) reported that *Pseudomonas* could degrade 20.54% of polythene within a month but only 3.97% of hard plastic, thus showing that degradation rates are polymer-specific. Face masks, with their complex fiber composition and multiple layers, exhibit longer degradation times compared to thin-layered polythene. A six-month microcosm experiment by Knicker and Velasco-Molina (2022) at 25ºC indicated that mask components have different mean residence times (MRT) in soil,

with the center mask showing a 7-year MRT and other components ranging from 19 to 28 years. While confirming biodegradability, the extended persistence of masks in soil raises concerns about micro(nano)plastic release and potential threats to soil organisms (Kwak and An et al., 2021). Despite the relaxed mask mandates around the world, these products are still a staple in healthcare and are likely to re-emerge during future epidemics. A range of mitigation strategies have been suggested, including enhanced pandemic-related plastic waste management (Tripathi et al., 2020) and development of biodegradable alternatives (Silva et al., 2020; Silva et al., 2021; Nghiem et al., 2021).

CONCLUSION

The unprecedented increased use of single-use face masks as a result of the global pandemic has further catalyzed an increased need to develop efficient solutions for biodegradation. Advances in plastic waste management, biodegradation, and bioremediation are still progressing worldwide, including the degradation of plastic masks in natural environments occurring through multiple phases. These mechanisms vary with conditions such as microbial species, enzyme activity, and mechanisms of biodegradation as well as types of polymers and time. This study focuses on the assessment of plastic mask degradation utilizing indigenous topsoil microflora from different environments. The results depicted a higher degradation rate in dump yard topsoil microflora than in garden soil topsoil microflora due to differences in microbial communities adapted to different soil conditions. The identification of specific bacterial isolates revealed varying degradation capabilities among different species, suggesting potential for targeted biodegradation approaches. Future research directions should focus on the characterization of the enzymatic mechanisms of plastic degradation in isolated bacterial strains with special emphasis on the identification of specific enzymes within *Pasteurella, Staphylococcus* and *Pseudomonas* species. Improved culture conditions must be developed for enhanced degradation efficiency, molecular genetic studies to explain the pathways and gene transfer or modification. Scaling up the experimental design to simulate diverse environmental conditions, such as temperature, moisture and soil composition variations, will be important. Furthermore, studies on synergistic effects of co-culturing bacterial strains, detailed ecotoxicological assessments and practical bioremediation strategies will be crucial for translating laboratory findings into real-world waste management solutions. Such initiatives are vital not only for mitigating micro and nano plastic pollution but also for preserving natural resources for future generations. Furthermore, these efforts contribute to protecting human health, wildlife, and aquatic ecosystems by preventing microplastic infiltration into food chains and maintaining ecological equilibrium. The abundance and composition of contaminants released by face masks (microplastics, fibers, and chemical compounds) in pre- and post-pandemic scenarios must be given more attention. This demands the development of advanced methodological approaches to overcome current technical limitations in quantifying and characterizing minute microplastics, fibers, adsorbents and leachates. Such advancements would increase the environmental relevance of experimental conditions and provide more accurate assessments of ecological impacts.

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Table 1: Table representing weight loss ratio (%) of mask strips in garden soil (G series) and dump yard soil (D series) after incubation

S.no	Sample code	Initial weight	Final weight	Weight loss	Weight loss ratio (%)
1	G	0.0904	0.0802	0.0102	11.283
2	G_1	0.1742	0.1734	0.0008	0.459
3	G_2	0.1742	0.1739	0.0003	0.172
4	G_3	0.1742	0.1731	0.0011	0.631
5	D	0.0904	0.0796	0.0108	11.946
6	D_1	0.1742	0.1739	0.0003	0.172
7	D_2	0.1742	0.1733	0.0009	0.516
8	D_3	0.1742	0.1729	0.0013	0.746

Table 2: Identification of bacterial isolates from garden and dump yard soil samples using VITEK 2 analysis

ISOLATE NO.	ISOLATES IDENTIFIED
1	*Pasteurella pneumotropica*
2	*Staphylococcus lentus*
3	*Pseudomonas oryzihabitans*
4	*Staphylococcus lentus*
5	*Staphylococcus lentus*
6	*Aerococcus viridans*
7	*Pasteurella testudinis*
8	*Escherichia coli*
9	*Pantoea* spp.
10	*Sphingomonas paucimobilis*



Figure 1:Garden soil sampling site - Vadakkupattu, Chennai



Figure 2:Dumpyard soil was sampling site - Pallikaranai, Chennai



Figure 3:Disposable face mask strips



Figure 4: Winogradsky's column setup for plastic mask degradation



Figure 5: Garden soil column after incubation period



Figure 6:Dump yard soil column after incubation period



Figure 7:Washed and dried mask strips post-experiment

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RESEARCH ARTICLE

Determination of Bioactive Compounds by GC-MS in Methanol Extracts of *Evolvulus nummularius* Species and Comparative Analysis with *Evolvulus alsinoides* Species

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ABSTRACT

The members of genus Evolvulus are widely used in Traditional, Folk and Ayurvedic systems of Medicine; of which two species are mostly found in India namely *Evolvulus nummularius and Evolvulus alsinoides* The aerial parts of these plants are picked and widely used by the tribal people. The present study aims to identify the bioactive compounds present in the extracts through GC/MS analysis. The majority of herbal treatments and the products derived from them were traditionally made from crude plant extracts, which are made up of a complex mixture of various phytochemical substances. These chemical substances/components characteristics vary greatly between species. An intriguing technique GC-MS method used for determining the concentration of certain active ingredients in herbs used in the food, pharmaceutical, cosmetic, and drug industries. In this work, we used gas chromatography and mass spectrometry (GC-MS) to identify the bioactive components in the whole plant methanolic extract of both *Evolvulus* species and compared with its.

Keywords: *Evolvulus nummularius and Evolvulus alsinoides, saponins, phytosterol, flavonoids*

INTRODUCTION

As more individuals attempt to use herbal therapies instead of allopathic ones due to their lower cost and lack of adverse effects, the use of medicinal plants is growing in popularity.[1]. In recent times, there has been a notable surge in scientific study and popularity of complementary and alternative medicine, particularly in relation to medicinal plants [2]. An extensive list of plants that have been used for a long time in traditional Chinese and Indian medicine have been screened and indexed, leading to the development of innovative medicines that may be used to

treat a variety of human ailments, such as blood pressure, cancer, rheumatism, kapha, and pitha. The use of traditional medical systems, like Ayurveda, which were handed down through the generations by "Gurukula," depended on the intimate knowledge that the Guru imparted to his disciples over an extended period of time as he treated each patient on an individual basis. [3]. Early western medical practices were influenced by the botanical cures of antiquity. As per Ghimire et al., the capacity to preserve medicinal plants and their extended usage is essential for preserving human health and life [5]. Medicinal plants are the main source of life-saving drugs for the majority of people on Earth. Plants include secondary metabolites such as phenolic and flavonoid compounds, which often act as antioxidants with the ability to chelate metals and redox, according to Karimi and Jaafar. This makes plants an excellent source of antioxidants [6]. According to Galatid and Brien, Since they can reduce the quantity of free radicals in the body and slow down their rate of generation and lipid peroxidation, which can cause a number of diseases and ageing, antioxidants are chemical compounds that are extremely valuable to humans [7]. Many drugs that are discovered in plants contain secondary metabolites as their active ingredient [8].

Through *in vitro* regeneration, high-quality plant-based medication could be created [9].The continued use of products derived from plants to treat medical conditions has led to the establishment of several pharmacological laboratories [10]. Life-saving drugs are primarily derived from medicinal plants for the majority of individuals *Evolvulus nummularious* L. syn. *Convolvulus nummularius* L. is a perennial herb belonging to the Convolvulaceae family that thrives in the wastelands of northeastern India (Figure 1). Tiny funnel-shaped blooms are produced by it. Vermifuge and febrifuge properties are present in the herb[11].Since large quantities of *Evolvulus nummularius* L. are a highly helpful medicinal resource, in vitro cultivation is necessary for the current investigations. The herb is applied topically to wound healing, hysteria, convulsions, and mild sedatives. It contains several phytoconstituents, including alkaloids, saponins, phytosterol, flavonoids, tannins and phenolic compounds, carbohydrates, etc. [12].Studies on the pharmacological properties of *E. nummularius* L. have revealed that it has anti-helminthic properties and is good for burns, fever, cuts, wounds, and scorpion lacerations. The extraction method is simple, rapid, and inexpensive because it uses less solvent. Analysis of the extracted materials using the GC-MS approach is an interesting method for finding the concentration of certain active compounds in herbs used in food, cosmetic, medicinal, environmental, and forensic applications[13].It combines two analytical techniques to provide a single method for assessing mixtures of chemical compounds. Once the components of the mixture are separated by gas chromatography, each component is examined separately by mass spectroscopy. Chemical investigations reveal that cardenolides, pregnane glycosides, and volatile components are its main elements [14, 15].Significant in biological systems, long chain unsaturated fatty acids, which comprise most volatile components, are essential energy sources and structural building blocks of many beneficial compounds[16].Recent studies have looked more closely at fatty acids, and the results show that they have potent sedative and hypnotic effects [17].

Accordingly, the current study's goal was to evaluate the chemical constituents of *E.nummularius* L . methanolic whole plant extract. The Convolvulaceae family member *Evolvulus alsinoides* (Linn) is also known as Shankhpushpi / Vishnukranthi. Open, grassy areas are usually home to *E. alsinoides* L. Subtropical countries like Africa, India, and the Philippines are home to it. Known as miniature morning glory, *Evolvulus alsinoides* features tiny leaves and pale blue blooms. The fruits resemble thin capsules. This plant may be found in both deep soil and open grassland areas. India is home to two different species of *Evolvulus alsinoides*. Slender dwarf morning glory, or *Evolvulus alsinoides* L. var. angustifolius Torr., is one kind, while another type is *Evolvulus alsinoides* L. var. *debilis* (Kunth) van Ooststr. The parts of plants that are used medicinally are whole plants and leaves [22]. *Evolvulus alsinoides* Linn (Vishnukranthi) is used as a nootropic or brain-tonic in certain ancient medical systems, including Ayurveda and Unani. The plant is used to cure fever, cough, cold, azoospermia, adenitis, depression, and some ethnic races in India, Africa, and the Philippines [23]. Ayurveda states that Vishnukranthi is an essential part of Medhya Rasyana (nervine tonic) herbs, which help with neural regeneration and synaptic plasticity. Traditional applications include anticonvulsant, anthelmintic, sedative, memory improvement, antiepileptic, and anti-anxiety effects. Many other ailments, including as epilepsy, uterine hemorrhage, mental debility, and insanity, are also treated with the herb. In addition, it has antifungal, antibacterial, antiulcer, and anti-asthmatic qualities and is used as a brain and memory tonic [24]. Herbal remedies for brain tonic, vermifuge, antistress, antidepressant, anxiolytic, analgesic, neuroleptic, and anti-inflammatory

purposes include vishnukranti. Preclinical in vivo and in vitro investigations have demonstrated anti-amnesic, antistress (adaptogenic), antimicrobial, and gastroprotective effects [25].A brain tonic called vishnukranti is used to enhance mental performance. A common component of many Medhya formulations is vishukranti. Herbal medicines are employed as a traditional and alternative therapy; the study's particular goal is to repair declining cognitive capacities. Medicinal plants include secondary metabolites that have a variety of therapeutic properties. The medicinal plant's aid in inhibiting enzymes or delaying vital metabolic processes is what causes the biochemical effects. Herbal bioactives also hold potential for being rewarded for their acceptance, safety, and effectiveness. It has been determined that medicinal plants provide a reliable source of lead chemicals for the development of new medications [26]. In order to extract the accessible chemicals from the plant extract, Gas Chromatography-Mass Spectrometry (GC-MS) seeks to isolate different substances within a specific sample. Numerous secondary metabolites with strong antioxidant properties have been found in prior studies. Properties: vermifuge, antidepressant, anxiolytic, analgesic, neuroleptic, anti-inflammatory, antifungal, antiulcer, and antiasthmatic; anti-amnesic, antistress (adaptogenic), antibacterial, and gastroprotective; epilepsy; uterine hemorrhage; neurological debility; insanity [27]. Hence, our goal was to extract the phytochemicals from the methanolic extract of *Evolvulus alsinoides* Linn using GC-MS analysis. We are interested in the isolation and phytochemical assessment from this extract utilizing the GC-MS analytical approach.

MATERIALS AND METHODS

Collection of plant material

In the beginning, *Evolvulus nummularious* L. aerial parts were gathered from playgrounds, grasslands, and waste areas in the Durg region of Chhattisgarh, India. The area of District Durg is 22,38.36 square kilometers, and its coordinates are 20°54′ and 21°32′ north and 81°10′ and 81°36′ east. District Durg is situated at an elevation of 317 meters above sea level. In a space with enough ventilation, the plant leaves were then softly covered and let to dry. Once that was done, the dried leaves were ground into a powder and stored in an airtight, dry glass jar. the *Evolvulus alsinoides* plant was obtained in July 2022 from Sri Venkateswara University in the Chittoor District of Andhra Pradesh, India. The entire plant was recognized and verified by plant taxonomist Dr. K. Madhava Chetty (IAAT:337) of the Department of Botany, Tirupathi- Andhra pradesh, India [28].

Instrumentation

methanol is used to extract *Evolvulus nummularious* L. from plants. The whole plant extract was subjected to GC-MS analysis using Thermo MS DSQ II and Thermo GC-Trace Ultra Version: 5.0 equipment. DB 35 - MS Capillary Standard, a non-polar column with dimensions of 30 mm × 0.25 mm ID x 0.25 µm film, is one component of the device.

RESULT AND DISCUSSION

Gas chromatography-mass spectroscopy (GC – MS) analysis Aerial plant extract is analyzed using GC-MS. A low flow rate of 1.0 milliliters per minute is used for the carrier gas, helium. With the injector operating at 250 °C, the oven's temperature was adjusted as follows: The temperature was gradually increased from 60 °C for 15 minutes to 280°C for 3 minutes. The components were determined by comparing the NIST and Willey libraries' retention indices. The results were gathered, and the components were identified by comparing them to those in the computer library (Willey and NIST) that was attached to the GC-MS apparatus. The National Institute of Standards and Technology (NIST) Library describes the molecular weight, chemical formula, peak retention time, and other properties of the bioactive compounds found in the methanolic leaf extract of *Evolvulus nummularius* L. The GC-MS chromatogram showed several peaks (Figure 3). The methanolic leaf extract of *Evolvulus nummularius* L. yielded a total of sixteen organic components; Table 1 lists these components along with their retention periods and structures. Below is an identification of these phytoconstituents: Butanoic acid, 2-methyl-; 1,2-Cyclopentanedione; -hydroxy-2-methylbutyric acid; Maltol; 2-Methoxy-4-vinylphenol; Caryophyllene; Benzene propanoic acid, 3,5-bis(1,1-dimethyle;

d-Mannitol, 1,1'-O-1,16-hexadecanediylbis-; D-Friedoolean-14-en-3-one; Lup-20(29)-en-3-one; D-Friedoolean-14-en-3-ol; Lupeol; 13-Docosenamide, (Z)-; 2,6,10,15,19,23-Pentamethyl-2,6,18,22-tetraco; Vitamin E; 2,6,10,15,19,23-Pentamethyl-2,6,18,22-tetraco. Herbal remedies are used to create new pharmaceuticals. A vital part in preserving both individual and communal health, medicinal plants are the unofficial source of many contemporary drugs. In order to fight a variety of illnesses and disorders, they have supplied various components. Studying and extracting plant material has a big impact on developing, modernizing, and controlling the quality of herbal formulations. There are two additional advantages to researching therapeutic plants: determining plant toxicity and assisting in protecting humans and animals from naturally occurring toxins. Thus, the current work was carried out to identify the bioactive compounds contained in the methanolic extract of *Evolvulus nummularious* L. using gas chromatography and mass spectroscopy. It is a species with moderate distribution that is extensively found in India and may have inadvertently made its way to the tropical parts of the Old World. Small, spherical leaves grow on creeping stalks, and bracteoles are found at or at the base of the flower stalk. In the Species Plantarum 1:157(1793), Linnaeus named it convolvulus numularius. [18]. *E. nummularius's* anthelmintic activity against adult Pheretima posthuman earthworms from India was evaluated by Dash *et al.* in both aqueous and hydroalcoholic extracts [19]. In the methanolic extract of *Evolvulus nummularious* L., different bioactive phytochemical substances were identified with varying area and area%, according to GC-MS experiment (Figure 2), which also shows the concentration (peak area percentage), retention time (RT), molecular formula, and molecular weight (MW) of the active principles. 16 components with variable area and area% were discovered among the 146 components detected by GC-MS analysis. *Evolvulus nummularious* L.'s methanolic plant extract's identified component mass spectra were displayed in Figure 3. The whole plant, *Evolvulus nummularious* L., contains the aforementioned compounds, which are responsible for a variety of industrial and medicinal purposes, including anthelminthic, wound healing, weak sedative, anticonvulsant, anti-microbial, and treatment for hysteria and scorpion stings.. [20, 21].GCMS equipment was used to analyze the extract of *Evolvulus alsinoides.* A 30 Mt diameter, 0.25 mm ID, and 0.25 m film thickness TR 5MS capillary standard non-polar column was utilized in the GC-MS system. From the beginning, the mobile phase's flow rate was fixed at 1.0 mL/min. Temperature was increased in the gas chromatography section from 40°C to 250°C at a rate of 5°C/min using a 1 microliter injection volume. The results of the samples soaked in chloroform were analyzed across a mass spectrum of 50650 m/z12 using the Wiley Spectral library search tool. [10] figure 4: Gas chromatography-mass spectrum(GC-MS) analysis chromatogram of isolated compounds from *E.alsinoides* showing 5 distinctive peaks time and relative abundance plotted along x axis and y axis respectively

CONCLUSION

In recent decades, pharmacological research has been intensely focused on the basis of traditional medicinal herbs. The realization of the significance of medicinal plants as viable sources of cutting-edge therapeutic molecules and lead compounds for drug development has made this feasible. For a very long time, *Evolvulus nummularious* L. has been utilized in herbal therapy. As a result, 146 compounds were found in *Evolvulus nummularious* L. after bioactive components were identified using GC-MS analysis. *Evolvulus nummularious* L. may be a new potential source of therapeutic goods due to the presence of these phytochemicals and bioactive compounds, according to the study's findings. Ten compounds in all were found using the GC-MS technique; of these, five compounds demonstrated importance (having two peaks), and five of the compounds had more hits than the other nine; the resulting chromatogram was then displayed. We looked examined the pharmacodynamic aspects of the compounds with more hits. The availability of several compounds in the methanolic extract of *E. alpinoides* is shown in Table 1. These chemicals may have implications for the pharmacodynamics, pharmacokinetic potency, and overall physicochemical aspects of the extract. The chromatogram displays ten distinct chemicals. Still, based on the area and peak seen in the chromatogram, only five chemicals are primarily seen as productive. The pharmacological effects of the methanolic extract of *E.alsinoides* may be attributed to them. The results above demonstrate that *Evolvulus nummularius* (L.) has a higher number of phytochemicals in its methanolic extract than *Evolvulus alsinoides*, indicating a greater concentration of bioactive compounds and a possible source of therapeutic goods.The results above compared that

*Evolvulus nummularius (*L.) has a higher number of phytochemicals in its methanolic extract than *Evolvulus alsinoides*, indicating a greater concentration of bioactive compounds and a possible source of therapeutic goods.

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Table 1: GC-MS analysis identified

S.No	RT (min.)	Name of compounds	Molecular formula	Molecular weight	Area	Area%
1	6.938	Butanoic acid, 2-methyl-	$C_5H_{10}O_2$	102	894500	0.03
2	7.936	1,2-Cyclopentanedione	$C_5H_6O_2$	98	11621659	0.36
3	12.804	3-Hydroxy-2-methylbutyric acid	$C_7H_{14}O_3$	146	13721798	0.42
4	13.635	Maltol	$C_6H_6O_3$	126	120956336	3.71
5	19.098	2-Methoxy-4-vinylphenol	$C_9H_{10}O_2$	150	52118285	1.60
6	22.058	Caryophyllene	$C_{15}H_{24}$	204	76752534	2.36
7	33.960	Benzene propanoic acid, 3,5-bis(1,1-dimethylethyl)-4-hydroxy-	$C_{18}H_{28}O_3$	292	23638078	0.73
8	34.791	d-Mannitol, 1,1'-O-1,16-hexadecanediylbis-	$C_{28}H_{58}O_{12}$	586	521927590	6.02
9	43.106	D-Friedoolean-14-en-3-one	$C_{30}H_{48}O$	424	33147509	7.16
10	43.697	Lup-20(29)-en-3-one	$C_{30}H_{48}O$	424	232563139	7.14
11	44.212	D-Friedoolean-14-en-3-ol	$C_{30}H_{50}O$	426	188116208	5.78
12	44.803	Lupeol	$C_{30}H_{50}O$	426	270923700	8.32
13	45.197	13-Docosenamide, (Z)-	$C_{22}H_{43}NO$	337	55604205	1.71
14	47.820	2,6,10,15,19,23-Pentamethyl-2,6,18,22-tetracosatetraen-10,15-diol	$C_{30}H_{54}O_2$	446	50024116	1.54
15	50.340	Vitamin E	$C_{29}H_{50}O_2$	430	162331695	4.98
16	51.899	2,6,10,15,19,23-Pentamethyl-2,6,18,22-tetracosatetraen-10,15-diol	$C_{30}H_{54}O_2$	446	109911565	3.37

Table 2: GC-MS analysis identified

Retention Time	Compound Name
6.73	Tetraacetyl-d-xylonic nitrate
9.834	Bicyclo[5.2.0]nonane 2-methylene 4,8,8-trimethyl-4-vinyl
10.909	Benzoic acid, 4-ethoxy-ethyl ester
11.917	Omega-3 fatty acid (EPA)
12.591	Triethyl citrate
12.912	3-O-methyl-d-glucose
17.244	Palmitic acid (C16:0)
17.802	Palmitic acid ethyl ester
19.831 & 19.921	Eicosatrienoic acid (Z,Z,Z)



Figure: 1 Plant of *Evolvulus nummularius L.*



Figure 2. Plant Of *Evolvulus alsinoides L.*

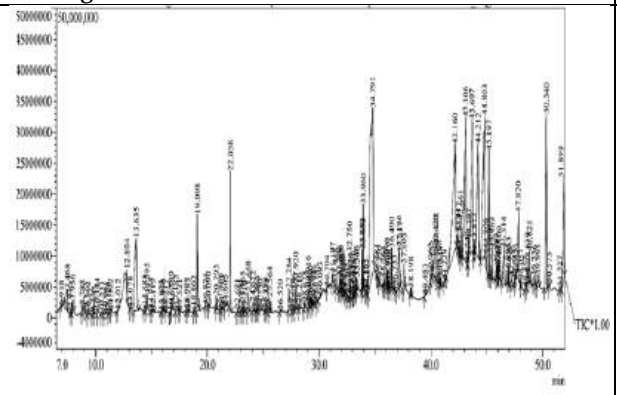


Figure 3: GC-MS chromatogram of aerial portion of *Evolvulus nummularious* L.

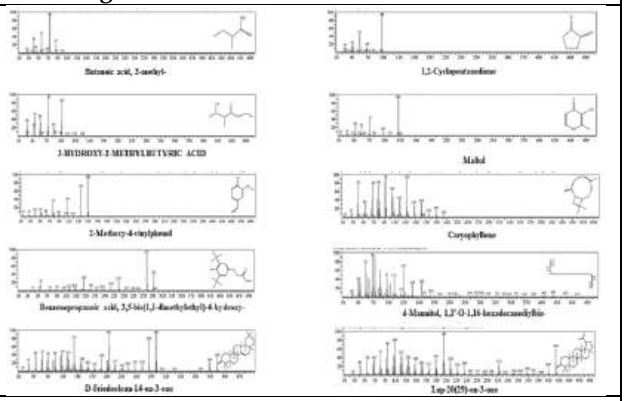


Figure 4. *Evolvulus nummularious* L. mass spectra of components isolated from ethanolic extract.

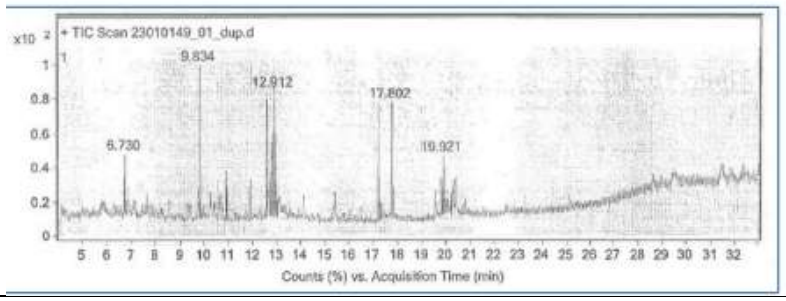


Figure 5: Gas chromatography-mass spectrum(GC-MS) analysis chromatogram of isolated compounds from E.alsinoides showing 5 distinctive peaks time and relative abundance plotted along x axis and y axis respectively

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RESEARCH ARTICLE

A Behavioural Analysis of Investment Pattern in Mutual Funds: Gen Z VS Gen Y

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ABSTRACT

This study analyzes how Generation Z (Gen Z) and Generation Y (Gen Y, also known as Millennials) have different perceptions of mutual fund investments. Understanding the differences in investment patterns of the two generational cohorts is essential to financial institutions because technology and economic factors influence investing preferences. This study explores some key questions including risk tolerance, investment preferences, attitudes towards mutual funds, and the relationship between digital platforms and investment decisions. After multivariate analysis of survey data from a diverse sample of Gen Z and Gen Y people, the study found significant differences in how these groups approach long-term financial planning and asset creation. The results suggest that Gen Z, for example, values digital access, sustainability and short-term profits in the same way that Gen Y values stability, long-term rewards and tax efficiency. These insights can assist financial companies in refining their products and strategies to meet the needs of younger investors. The contradicting findings indicate that targeted financial education and focused marketing are helpful in raising the participation of both generations in mutual fund investing.

Keywords: Generation Z, Gen Y, Millennials, Mutual Fund Investing, Risk Tolerance, Investment Preferences, Financial Behaviour, Digital Platforms, Sustainability, Financial Education, Wealth Management.

INTRODUCTION

Mutual fund investment is known to be one of the most important options that a person has in terms of obtaining wealth and maintaining the risk. Investor preference and behaviours are rather dynamic and varies along the financial market continuum. Generational differences are particularly pronounced, with different cohorts approaching their investments with their own unique attitudes, values and experiences. Factors such as the rise of digital financial platforms, increased focus on sustainability, and changing economic conditions are reshaping the investment preferences of various demographics, including with respect to mutual funds. Younger generations like Gen Z (people born between 1997 and 2012) and Gen Y, or Millennials, (people born between 1981 and 1996) make up large swaths of the current investing demographic. These groups are often considered tech-savvy the Gen Z's were born into a digital-first world while the Gen Y's were the first ones where the internet and online financial tools were widely available. Though similar in many respects, differences in investment preferences, risk tolerance, and/or financial literacy may help determine how these two groups choose to invest in Mutual Funds. This study aims to explore these inequities across generations in relation to mutual fund investing. The goal is to gain a deeper understanding of Generation Z and Gen Y's perspectives on mutual funds, along with their investment preferences and the factors that influence their decisions such as risk, long- versus short-term returns, and tax benefits. Through an analysis of these generational contrasts, the current study offers valuable insights into the evolving landscape of mutual fund investments, and recommends financial institutions on adapting their offerings to the specific needs of both generations. Based on survey data and an analysis of consumer behaviour, the study explores key drivers of mutual fund investment decisions while also offering potential opportunities for the financial sector to engage with young investors more effectively. This helps to shed more light on the role of generation in potentially more financially sound decision making.

REVIEW OF THE LITERATURE

When looking at the behavioural analysis of mutual fund investment behaviours, there are significant generational differences, particularly with Gen Z and Gen Y according to research studies financial literacy is essential to make investment decisions. Lusardi et al. (2010) who point out that millennials have often lower financial literacy, despite naturally being tech-savvy, which leads to their difference in employing mutual funds. According to Malmendier and Nagel (2011), when they analyze data up to 10/2023, they find that younger generations, those who are less affected (or do not remember) previous financial crises, like take more risk on their investments, while older generations, like Generation Y, are more risk-adverse. Also Baker and Nofsinger (2010) highlighted the age-risk taking behaviour curve where Gen Z is more drawn to mutual funds due to their accessibility and potential for long-term growth Gen Y however is more likely to seek out tax-favoured investments, yet with riskier undertones. We see this in Elliott (2020) who found that Gen Y like to invest in high-risk investments and tax breaks, compared to Statman (2017) who found that Millennials become envious of trends in the market and they make impulsive decisions, whereas Gen Z like to get their information from digital tools and financial advisors. The literature suggests that financial knowledge, risk tolerance and the digital ecosystem impact the investment behaviours of Gen Z and Gen Y to diverse degrees.

RESEARCH METHODOLOGY

The research methodology of this study is based on quantitative analyses of parameters like age, annual income, tax benefits, and risk perception of Gen Z and Gen Y mutual fund investments. Data were collected through surveys with 300 respondents, who were selected across a range of age groups, income levels, and occupations. The survey asked questions about views on mutual funds as a safe investment, the impact of tax breaks, the priority of short versus long-term gains and the impact of past performance on investment decisions. Statistical analyses (ANOVA, Chi-Square tests and Pearson correlation) were then performed to identify the correlations and differences for the

variables. The results are analysed at 95% confidence to ascertain the effect of the demographic features on mutual fund investment behaviour and decision-making.

DATA ANALYSIS

ANOVA

The perception of mutual funds as a safe investment option across the age groups of respondents.

Null Hypothesis (H_0)

There is no significant difference in the perception of mutual funds as a safe investment option across the age groups of respondents.

Alternative Hypothesis (H_1)

There is a significant difference in the perception of mutual funds as a safe investment option across the age groups of respondents.

Descriptives								
The Age group of the Respondents.								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Agree	173	2.78	1.462	.111	2.56	3.00	1	5
Strongly Agree	127	3.09	1.477	.131	2.84	3.35	1	5
Total	300	2.91	1.474	.085	2.75	3.08	1	5

ANOVA					
The Age group of the Respondents.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.227	1	7.227	3.352	.068
Within Groups	642.519	298	2.156		
Total	649.747	299			

Interpretation

The ANOVA results indicate an F-value of 3.352 with a significance level (p-value) of 0.068, which is slightly above the conventional threshold of 0.05. This suggests that there is a statistically significant difference in the perception of mutual funds as a safe investment option across the age groups at a 95% confidence level. However, with a p-value close to the threshold, it is reasonable to explore whether other factors or a larger sample might reveal subtle differences. Positively, this near significance implies that perceptions across age groups are relatively aligned, which could simplify creating uniform marketing strategies for mutual funds targeting a diverse age demographic.

The annual income of respondents who prioritize short-term gains over long-term growth between the Agree and Strongly Agree groups.

Null Hypothesis (H_0)

There is no significant difference in the annual income of respondents who prioritize short-term gains over long-term growth between the "Agree" and "Strongly Agree" groups.

Alternative Hypothesis (H_1)

There is a significant difference in the annual income of respondents who prioritize short-term gains over long-term growth between the "Agree" and "Strongly Agree" groups.

Descriptives								
Annual Income of the Respondents.								
	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Agree	158	2.47	1.110	.088	2.30	2.65	1	4
Strongly Agree	142	2.42	1.138	.096	2.23	2.61	1	4
Total	300	2.45	1.122	.065	2.32	2.58	1	4

ANOVA					
Annual Income of the Respondents.					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.203	1	.203	.161	.688
Within Groups	376.047	298	1.262		
Total	376.250	299			

Interpretation

Based on the ANOVA results, the p-value (Sig.) is 0.688, which is greater than the standard significance level of 0.05. This means we fail to reject the null hypothesis, indicating that there is a statistically significant difference in the annual income between the two groups. A positive interpretation of this finding could suggest that prioritizing short-term gains over long-term growth does not appear to significantly differentiate individuals' annual income levels. This could imply that other factors, rather than this specific investment attitude, play a more dominant role in determining income variations.

CORRELATION

The tax benefits play a crucial role in mutual fund investment decisions and the confidence in knowledge and understanding of mutual fund investments.

Null Hypothesis (H_0)

There is no significant relationship between the belief that tax benefits play a crucial role in mutual fund investment decisions and the confidence in knowledge and understanding of mutual fund investments ($\varrho = 0$).

Alternative Hypothesis (H_1)

There is a significant relationship between the belief that tax benefits play a crucial role in mutual fund investment decisions and the confidence in knowledge and understanding of mutual fund investments ($\varrho \neq 0$).

Descriptive Statistics			
	Mean	Std. Deviation	N
Tax benefits play a crucial role in my decision to invest in mutual funds.	4.47	.500	300
I am confident in my knowledge and understanding of mutual fund investments.	4.54	.499	300

Correlations			
		Tax benefits play a crucial role in my decision to invest in mutual funds.	I am confident in my knowledge and understanding of mutual fund investments.
Tax benefits play a crucial role in my decision to invest in mutual funds.	Pearson Correlation	1	.019
	Sig. (2-tailed)		.746

	N	300	300
I am confident in my knowledge and understanding of mutual fund investments.	Pearson Correlation	.019	1
	Sig. (2-tailed)	.746	
	N	300	300

Interpretation

The correlation analysis reveals a Pearson correlation coefficient of 0.019, with a p-value of 0.746. Since the p-value is greater than the significance level (typically 0.05), we fail to reject the null hypothesis, indicating a statistically significant relationship between the two variables. However, the mean scores (4.47 and 4.54, respectively) and low standard deviations suggest that respondents generally agree that tax benefits are important and feel confident in their mutual fund knowledge. This implies that while these factors might be directly correlated, both independently contribute positively to mutual fund investment behaviour.

Believing mutual funds are a safe investment option and the perception that the risk associated with mutual funds significantly impacts investment decisions.

Null Hypothesis (H_0)

There is no significant correlation between believing mutual funds are a safe investment option and the perception that the risk associated with mutual funds significantly impacts investment decisions ($\varrho = 0$).

Alternative Hypothesis (H_1)

There is a significant correlation between believing mutual funds are a safe investment option and the perception that the risk associated with mutual funds significantly impacts investment decisions ($\varrho \neq 0$).

Descriptive Statistics			
	Mean	**Std. Deviation**	**N**
I believe mutual funds are a safe investment option.	4.42	.495	300
The risk associated with mutual funds significantly impacts my decision to invest.	4.49	.501	300

Correlations			
		I believe mutual funds are a safe investment option.	The risk associated with mutual funds significantly impacts my decision to invest.
I believe mutual funds are a safe investment option.	Pearson Correlation	1	-.011
	Sig. (2-tailed)		.851
	N	300	300
The risk associated with mutual funds significantly impacts my decision to invest.	Pearson Correlation	-.011	1
	Sig. (2-tailed)	.851	
	N	300	300

Interpretation

The Pearson correlation coefficient (-0.011) indicates a negligible and negative relationship between the two variables. The p-value (0.851) is much greater than the conventional significance level (e.g., 0.05), suggesting that the observed correlation is statistically significant. Therefore, we fail to reject the null hypothesis and conclude that there is a meaningful relationship between these beliefs. Positively, this result implies that individual's perception of mutual fund safety may remain consistent regardless of their concerns about associated risks, highlighting a potential trust in mutual funds as a stable investment option.

The prioritization of short-term gains over long-term growth while investing and the consideration of the past performance of mutual funds a key factor before investing.

Null Hypothesis (H_0)

There is no significant correlation between the prioritization of short-term gains over long-term growth while investing and the consideration of the past performance of mutual funds as a key factor before investing.

Alternative Hypothesis (H_1)

There is a significant correlation between the prioritization of short-term gains over long-term growth while investing and the consideration of past performance of mutual funds as a key factor before investing.

Descriptive Statistics			
	Mean	**Std. Deviation**	**N**
I prioritize short-term gains over long-term growth while investing.	4.47	.500	300
I consider the past performance of mutual funds as a key factor before investing.	4.51	.501	300

Correlations			
		I prioritize short-term gains over long-term growth while investing.	I consider the past performance of mutual funds as a key factor before investing.
I prioritize short-term gains over long-term growth while investing.	Pearson Correlation	1	-.039
	Sig. (2-tailed)		.505
	N	300	300
I consider the past performance of mutual funds as a key factor before investing.	Pearson Correlation	-.039	1
	Sig. (2-tailed)	.505	
	N	300	300

Interpretation

The Pearson correlation coefficient of -0.039 indicates a very weak negative relationship between the two variables, which is not statistically significant (p-value = 0.505, greater than 0.05). Therefore, we fail to reject the null hypothesis, suggesting that there is a significant correlation between prioritizing short-term gains over long-term growth and considering past performance when investing in mutual funds. However, if the correlation had been positive, it would have implied that as one-factor increases, the other would also tend to increase, showing a direct relationship between the two behaviours.

CHI-SQUARE TEST

The age group of the respondents and their preference for investing in mutual funds over other investment options like stocks or fixed deposits.

Case Processing Summary						
	Cases					
	Valid		**Missing**		**Total**	
	N	**Percent**	**N**	**Percent**	**N**	**Percent**
The age group of the Respondents and I prefer investing in mutual funds over other investment options like stocks or fixed deposits.	300	100.0%	0	0.0%	300	100.0%

Null Hypothesis (H_0)

There is no significant association between the age group of the respondents and their preference for investing in mutual funds over other investment options like stocks or fixed deposits. In other words, the preference for mutual funds is independent of the age group.

Alternative Hypothesis (H_1)

There is a significant association between the age group of the respondents and their preference for investing in mutual funds over other investment options. The preference for mutual funds is dependent on the age group.

The age group of the Respondents and I prefer investing in mutual funds over other investment options like stocks or fixed deposits. Crosstabulation					
			I prefer investing in mutual funds over other investment options like stocks or fixed deposits.		**Total**
			Agree	**Strongly Agree**	
The age group of the Respondents.	18-24	Count	42	35	77
		Expected Count	37.0	40.0	77.0
	25-34	Count	24	25	49
		Expected Count	23.5	25.5	49.0
	35-44	Count	29	27	56
		Expected Count	26.9	29.1	56.0
	45-54	Count	20	39	59
		Expected Count	28.3	30.7	59.0
	55 and above	Count	29	30	59
		Expected Count	28.3	30.7	59.0
Total		Count	144	156	300
		Expected Count	144.0	156.0	300.0

Chi-Square Tests			
	Value	**df**	**Asymptotic Significance (2-sided)**
Pearson Chi-Square	6.394[a]	4	.172
Likelihood Ratio	6.495	4	.165
N of Valid Cases	300		
a. 0 cells (0.0%) have an expected count of less than 5. The minimum expected count is 23.52.			

Interpretation

The Pearson Chi-Square test results show a value of 6.394 with a p-value of 0.172, which is greater than the typical significance level of 0.05. This means that we fail to reject the null hypothesis. There is a statistically significant relationship between age group and the preference for mutual funds. Essentially, the preference for mutual funds across different age groups does differ in a meaningful way, indicating that individuals from all age groups have a similar inclination toward investing in mutual funds over other options like stocks or fixed deposits.

The occupation of the respondents and their likelihood to seek advice from financial experts before investing in mutual funds.

Case Processing Summary						
	Cases					
	Valid		**Missing**		**Total**	
	N	**Percent**	**N**	**Percent**	**N**	**Percent**

Occupation of the Respondents and I frequently seek advice from financial experts before investing in mutual funds.	300	100.0%	0	0.0%	300	100.0%

Null Hypothesis (H_0)

There is no significant relationship between the occupation of the respondents and their likelihood to seek advice from financial experts before investing in mutual funds. In other words, the occupation does not affect the frequency with which individuals seek financial advice.

Alternative Hypothesis (H_1)

There is a significant relationship between the occupation of the respondents and their likelihood to seek advice from financial experts before investing in mutual funds. In other words, the occupation does affect the frequency with which individuals seek financial advice.

Occupation of the Respondents and I frequently seek advice from financial experts before investing in mutual funds. Crosstabulation

			I frequently seek advice from financial experts before investing in mutual funds.		Total
			Agree	Strongly Agree	
Occupation of the Respondents.	Employed	Count	26	38	64
		Expected Count	31.8	32.2	64.0
	Other	Count	36	28	64
		Expected Count	31.8	32.2	64.0
	Retired	Count	26	29	55
		Expected Count	27.3	27.7	55.0
	Self-employed	Count	29	29	58
		Expected Count	28.8	29.2	58.0
	Student	Count	32	27	59
		Expected Count	29.3	29.7	59.0
Total		Count	149	151	300
		Expected Count	149.0	151.0	300.0

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.824[a]	4	.430
Likelihood Ratio	3.841	4	.428
N of Valid Cases	300		

a. 0 cells (0.0%) have an expected count of less than 5. The minimum expected count is 27.32.

Interpretation

The results of the Chi-square test show a Pearson Chi-Square value of 3.824 with an asymptotic significance of 0.430, which is greater than the 0.05 significance level. This means that we fail to reject the null hypothesis, indicating that there is a significant association between the occupation of the respondents and their tendency to seek financial advice before investing in mutual funds. Therefore, the occupation of individuals does appear to influence their likelihood of seeking expert financial guidance for investments in mutual funds.

The annual income of the respondents and their agreement with the statement that tax benefits play a crucial role in their decision to invest in mutual funds.

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
The annual Income of the Respondents and the Tax benefits play a crucial role in my decision to invest in mutual funds.	300	100.0%	0	0.0%	300	100.0%

Null Hypothesis (H_0)

There is no significant relationship between the annual income of the respondents and their agreement with the statement that tax benefits play a crucial role in their decision to invest in mutual funds. In other words, the distribution of responses is independent of the annual income categories.

Alternative Hypothesis (H_1)

There is a significant relationship between the annual income of the respondents and their agreement with the statement that tax benefits play a crucial role in their decision to invest in mutual funds. This implies that the distribution of responses is dependent on income categories.

The annual Income of the Respondents and the Tax benefits play a crucial role in my decision to invest in mutual funds. Crosstabulation					
			Tax benefits play a crucial role in my decision to invest in mutual funds.		Total
			Agree	Strongly Agree	
Annual Income of the Respondents.	Above Rs. 100,000	Count	37	36	73
		Expected Count	38.9	34.1	73.0
	Below Rs. 20,000	Count	40	38	78
		Expected Count	41.6	36.4	78.0
	Rs. 20,000 – Rs. 50,000	Count	44	38	82
		Expected Count	43.7	38.3	82.0
	Rs. 50,000 – Rs. 100,000	Count	39	28	67
		Expected Count	35.7	31.3	67.0
Total		Count	160	140	300
		Expected Count	160.0	140.0	300.0

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.981[a]	3	.806
Likelihood Ratio	.984	3	.805
N of Valid Cases	300		
a. 0 cells (0.0%) have an expected count of less than 5. The minimum expected count is 31.27.			

Interpretation

Based on the Chi-Square test results, with a Pearson Chi-Square value of 0.981 and an asymptotic significance of 0.806, we fail to reject the null hypothesis. This suggests that there is a significant relationship between the annual income of the respondents and the importance they place on tax benefits when deciding to invest in mutual funds. The responses are independent of income categories, indicating that tax benefits are equally important for people across different income groups.

FINDINGS

The data also provides many positive findings that could be used to direct mutual fund marketing strategies. Firstly, belief about mutual funds being a risk worthy safe investment avenue is uniform across the age group. Moreover, even though incentivizing shorter-term returns over sustainable, longer-term growth does not seem to necessarily reflect the amount invested on an annual basis, it suggests that income by itself is not necessarily a key driver of investment decisions. The correlation study reveals that respondents respect tax benefits and are confident in their mutual fund knowledge, which demonstrates the need to teach investors about tax advantages. Lastly, the research indicates that individuals' degree of belief in mutual funds does not change with the risk, emphasizing mutual funds as a secure choice. Lastly, the affirmative nature of mutual funds across various demographic subsets implies that, overall, it is more probable that people would be able to obtain financial assistance, even if just for the sake of attempting to reach a wider audience.

SUGGESTIONS

The analysis of data shows that there is a scope of enhancing mutual fund marketing strategies by understanding that aspects like tax benefits, perceived security, and previous returns have a bearing on investment decisions across different age buckets, income brackets, and professional profiles. While certain qualifying criteria — annual income, as seen in the table above, as well as the relevance of tax benefits — show independence of other decisions, positive perceptions about mutual funds should help formulate targeted but nevertheless well-aimed marketing toward each demographic. In addition, as respondents report they trust those funds they claim to know, educational programs may enhance that confidence, and as a result make it easier to attract new investors. A wider approach of building trust and establishing mutual funds' position as a safe and worthwhile investment option is likely to resonate with several audiences.

CONCLUSION

The study presented in this paper demonstrates vital differences between two generations, Gen Z and Gen Y in general and mutual fund investment practices specifically. While mutual funds are viewed by both generations as a relatively safe option (moderate risk), their risk tolerance and expected returns are different for short-term and long term. Whereas Gen Z values long-term growth and relies heavily on digital resources and financial advice, Gen Y are more likely to seek higher risk investments and tax deductions. It indicated that even those in the young age groups have a constant overall confidence in mutual fund investments even though there are age differences. The report also highlights the impact of things like tax incentives, financial literacy and perceived safety on investment decisions. While tax breaks tend to be seen as beneficial across age and income brackets, respondents by annual income disagree—there is no real difference when it comes to prioritizing short-term over long-term profit. Furthermore, individuals' risk assessments of mutual funds were not determined by individuals' confidence in their investment knowledge, suggesting mutual funds are widely perceived as a sound investment decision. From a marketing perspective, the results suggest that financial institutions can profit from promoting mutual funds as a sound and safe investment vehicle, harnessing good attitudes among general demographics. The study further emphasizes the role of educational programs in increasing investor confidence, especially in communicating tax benefits and demystifying mutual fund investing. In conclusion, these findings present marketers at mutual funds with actionable insights on designing personalised marketing campaigns that cater to the specific needs and preferences of distinct

generations, as well as establishing credibility and promoting informed investment activities across the entire spectrums of demography.

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RESEARCH ARTICLE

Study on Strength Properties of High Strength Concrete using Metakaolin and Glass Powder as Partial Substitute

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ABSTRACT

Reinforced concrete stands as one of the most widely utilized materials in construction globally. However, it is particularly susceptible to deterioration, especially in coastal areas. Consequently, researchers worldwide are focusing their efforts on the development of alternative materials to address this issue. This has led to the incorporation of additive materials aimed at enhancing the quality of concrete. High Strength Concrete has garnered considerable interest from various industrial sectors, particularly in the realm of ready-mix concrete. This study presents a comprehensive experimental investigation into the strength and durability characteristics of high strength concrete that incorporates mineral admixtures. The research examines different proportions of mineral admixtures, specifically Glass Powder (GP at 10%, 20%, 30%, and 40%) and Metakaolin (MK at 5%, 10%, and 15%), which are partially substituted for Ordinary Portland Cement (OPC) in the concrete mix. Concrete, High Strength Concrete, Metakaolin, Glass Powder. Additionally, short-term durability tests, including Sorptivity and Water Absorption, were performed on cylindrical and cubic specimens. Beams measuring 1.2 m x 0.1 m x 0.15 m were also cast for both controlled and optimal mixes to evaluate the flexural behavior of the mineral admixture-enhanced concrete. The experimental findings indicate that substituting cement with 10% Glass Powder and 10% Metakaolin significantly enhances the strength, durability, and flexural properties of the concrete compared to the control mix.

Keywords: Cube specimens were cast in various combinations to assess the compressive strength of the concrete after a curing period of 28 days.

INTRODUCTION

Construction is seen as critical to a nation's development, especially in countries that are developing quickly. In order to build infrastructure, concrete is mostly used as primary source [1]. Every year, 40 billion tons of virgin fine and coarse aggregates are utilized in concrete worldwide, depleting the nation's natural resources [2]. Because of its greater versatility, ease of molding, and affordability, concrete is the most adaptable material. High strength concrete attracts researchers in the perspective mechanical and durability charecteristics. Mahsa Kamali et al,[3] examines the mechanical strength and durability behaviour of cementitious materials modified with two types of glass powders and class F fly ash at various levels of cement replacement. The findings from this study indicated that cementitious materials modified with glass powders showed an improvement in compressive and flexural strengths compared to the control concrete at late ages of curing. Addition of glass powders decreased alkali-silica reaction expansions of the modified cementitious materials when mixed with reactive sands and enhanced resistance to chloride permeability and electrical resistivity of cementitious materials. Elahi et al. [4], experimental investigation was carried out to evaluate the mechanical and durability properties of high performance concretes containing supplementary cementitious materials in both binary and ternary systems. Portland cement was replaced with fly ash up to 40%, silica fume up to 15% and GGBS up to a level of 70%. The results confirmed that silica fume performs better than other supplementary cementitious materials for the strength development and bulk resistivity. Eva Vejmelkova et al.[5] studied the parameters of high performance concrete (HPC) with metakaolin including basic physical characteristics, mechanical and fracture-mechanical properties, durability characteristics, thermal properties and chloride binding characteristics are measured. The experimental results show that the replacement of Portland cement by 10% of metakaolin leads to improvements. Widodo Kushartomo et al. [6], investigated the influence of glass powder in the mechanical behaviour of RPC. The mechanical behaviour is examined by the tests of 11 compressive strength, flexural strength and split tensile strength. The results indicated that the use of glass powder in this study was good enough to replace quartz powder in RPC. Dinakar et al.[7], studied the effect of incorporating metakaolin (MK) on the mechanical and durability properties of high strength concrete for a constant water/binder ratio of 0.3.MK with cement replacement of 5,10 and 15% were added and designed for target strength and slump of 90 MPa and 100 ± 25 mm. From the results, it was observed that 10 % replacement level was the optimum level in terms of Compressive strength. Sumrerng Rukzon [8], presents the use of ternary blend of Portland cement with two pozzolans in producing high-strength concrete. PortlandCement Type I (CT) was partially replaced with ground Bagasse Ash (BA), ground rice husk-bark ash (RB) 12 and Fly Ash (FA) at the dosage levels of 20% and 40% by weight of binder. Test results reveal that the resistance to chloride penetration of concrete improves substantially with partial replacement of CT with a blend of equal weight portion of FA and RB; or FA and BA and the improvement increases with an increase in the replacement level. Hassan EL-Chabib et al. [9] investigated the performance of high-strength flowable concrete (HSFC) made with binary, ternary, or quaternary binder and with up to 70% of Portland cement replaced by supplementary cementitious materials (SCMs). Results showed that HSFC made with high volume of SCMs and exposed to hot climate condition increases the compressive strength and reduces concrete permeability and free shrinkage compared to the control mixture in the same group and cured under similar curing conditions. G.Vijayakumar et al. [10], studied finely powdered waste glasses are used as a partial replacement of cement in concrete and compared it with conventional concrete. Consequently extensive research is on going into the use of cement replacements, using many waste materials and industrial by products.From the results obtained , it is found that glass powder can be used as cement replacement material upto particle size less than 75µm to prevent alkali silica reaction.

RESEARCH SIGNIFICANCE

From the reviewed paper, it is clearly noted that only limited studies are reported for high strength concrete using combined mineral admixtures. In this connection , this research work aims to evaluate the behaviour of high strength

concrete using metakaolin and glass powder as combined alternative for cement. The strength and durability charecters are evaluated and discussed.

MATERIAL PROPERTIES

The following materials were used in this investigation.

- Ordinary Portland cement of 53 grade
- Fine aggregate - Natural River Sand
- Coarse aggregate – Crushed granite
- Glass powder
- Metakaolin
- Potable water
- Superplasticizer – Fosroc SP 43

EXPERIMENTAL INVESTIGATION

Specimen Preparation

Concrete cube specimens of size 150 mm x 150 mm x 150 mm were cast to study the effect of Glass powder and Metakaolin on compressive strength of concrete at different ages. Cylindrical specimens of size 100 mm diameter and 50 mm height were cast to study durability characteristics such as Sorptivity (as per ASTM C1585) and water absorption porosity (as per ASTM C642). Chemical admixture is added in all the mixes as it gives better results and good workability. For testing compressive strength of control and ternary blend concrete, a total number of 24specimens were cast (age = 28 days) with different proportions of glass powder and metakaolin. Similarly 10 cylindrical specimens each for sorptivity and water absorption tests were cast. Beams of size 1200 mm x 100 mm x 150 mm were cast to find the load deflection behavior of HSC.Concrete were placed in the well lubricated mould and compacted and the specimens were left at room temperature for 24hrs and after that specimens were placed in curing tank till their testing ages.

TESTING OF SPECIMENS

Compressive strength test

The compressive strength test is the most common test conducted because most of the desirable characteristic properties of concrete and the structural design purpose are qualitatively related to compressive strength. All the specimens were cast in steel moulds and well compacted. Then they were cured and tested at different ages of concrete for 28 days to understand the effect of age of concrete.

Flexure Test

For finding flexural behaviour, tests were carried on 100 mm x 150 mm x 1200 mm beam prototypes at the age of 28 days using 1000kN capacity flexural strength testing machine. The test setup includes two point loading using a single point loading system by which the loads are transferred equally to the two points using a spreader beam and two rollers. Dial gauges are placed in the bottom of the beam at the mid-point to find the deflection. Demecs are placed on the surface of the beam to find the surface strain which are placed at a distance of 100mm from one another. The strains at these points are found using a mechanical strain gauge. The crack patterns are noted on both sides of the beams at particular intervals. The gauge length between the loading points are 333.33 mm and 100 mm are left on both sides of the beam at the supports. All the specimens were capped for uniform loading 15 prior testing. The control of load over the test was 10 kN/min. Automatic data acquisition system was used to record the load, strain and axial displacement which in turn connected to the computer.

RESULTS AND DISCUSSION

Compressive Strength

The compressive strength of concrete cubes were found at the age of 28 days. The cubes of size 150 mm x 150 mm x 150 mm were cast and tested at the age of 28 days in compressive testing machine. When age increases, the strength of the concrete gets increased irrespective of all mix combinations. Increase in the age of concrete increase in strength. At the age of 28 days, the control concrete yield 61.8Mpa.From the test results higher compressive strength for concrete was observed for mix GP (10%) with MK (10%) at age of 28 days. The compressive strength development is due to the pozzolanic reaction and filler effects of GP and MK. On the pozzolanic reaction, the GP and MK react with calcium hydroxide and produce more C-S-H gel. This gel is the source of strength of hardened concrete as it is the binder which binds the aggregate together. MK combines with the calcium hydroxide to produce additional cementing compounds, the material responsible for holding concrete together. Hence, less calcium hydroxide and more cementing compounds means stronger concrete. It has been observed during test on controlled specimens that the cracks are developed around coarse aggregates. However, in concrete with SF and MK, the interfacial zone becomes stronger, more homogeneous and dense. Hence, the cracks usually traverse the aggregates.

Flexure Test

Initial Crack Load

The first crack load for beams are cast with optimum mix of glass powder and metakaolin and these optimum value of GP and MK in a ternary combination shows the initial crack load. Replacement of mineral admixture gives high strength so it resist load maximum upto 37kN,38kN,40kN and after that loads it starts a first crack and continues till it attain a peak load.

Peak load

The ultimate load or Peak load for beams of control mix is 65kN , for optimum 1(GP 10% & MK 10%) and optimum 2 (GP 10% & MK 5%) are 64kN and 63.2kN.Itwas observed that the beams cast with Glass powder and Metakaolin showed similar load carrying capacities compared to control beam.

CONCLUSION

From the experimental results presented in this study, the following conclusions has can be drawn, From the literature, this scenario has been observed only in concrete produced with low water/cement ratio in conjunction with use of super plasticizer. The effect of metakaolin is to reduce the workability of HSC with greater reducing effects at high replacement levels. The influence of glass powder and metakaolin on the workability of HSC is slightly higher when compared to the normal strength concrete, which is to improve the workability. For each mineral admixtures (i.e) glass powder and metakaolin, the maximum long-term strength was obtained at replacements levels of GP 10% with MK 10% respectively. Terinary combination of Glasspowder and Metakaolin replaced with cement obtained maximum strength as per given grade of concrete control mix of cube obtained 100% of the grade of concrete M60. Finally concluded that by replacing mineral admixtures glass powder 10% and metakaolin 10% gives high strength of 61.6 N/mm2. Maximum compressive strength value is 12% more than the control concrete. The beam control mixes and optimal mixes (10%GP+10%MK) showed the initial crack and ultimate load. Hence glass powder and metakaolin as a mineral admixtures can be used to get the high strength concrete.

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Fig:1 Compressive strength test

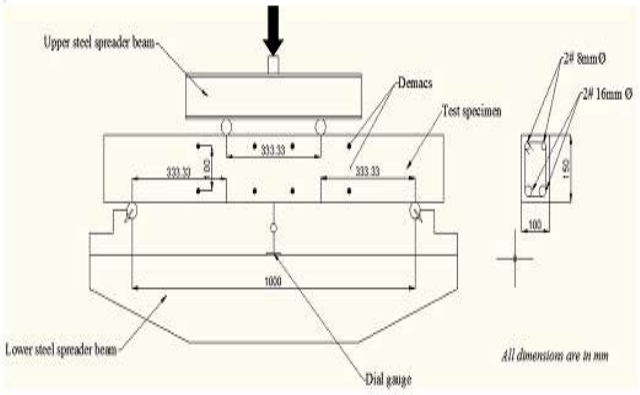


Fig: 2 Flexure Test

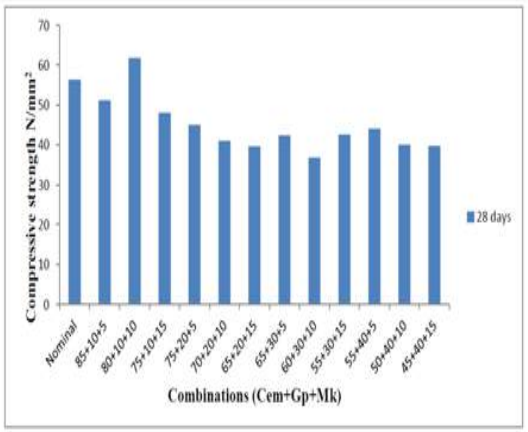


Fig:3 Compressive Strength

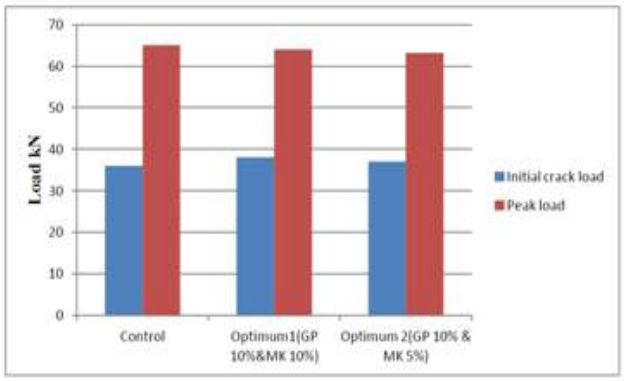


Fig: 4 Peak load

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RESEARCH ARTICLE

Investigation of Antibacterial Activity in *Funaria* sp. Collected from Gautala Wildlife Sanctuary Jalgaon Region

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ABSTRACT

Funaria samples were collected from the Jalgaon area of Gautala Wildlife Sanctuary. Antibacterial effectiveness against both Gram-positive and Gram-negative bacteria was investigated in this study. The agar well diffusion method was used to measure the antibacterial activity. Statistical analysis was performed by combining Tukey's Honestly Significant Difference (HSD) test with one-way ANOVA. A significance level (α) of 0.05 is commonly employed .The difference between the means of the treatments was measured using the Q statistic. The means of the antibacterial activity for each species differed significantly according to the results of the one-way ANOVA test. This analysis's Tukey's HSD results offer crucial information on species-specific variations in antibacterial activity. Cefotaxime and aqueous extracts were consistently found to differ greatly.

Keywords: sanctuary, antibacterial, ANOVA, Tukey's Honestly Significant Difference, agar well etc

INTRODUCTION

The second largest group of plants after angiosperms is bryophytes, the first land plant. They spanned the evolutionary divide between vascular plants and algae, including the plant families Bryophyta (mosses), Marchantiophyta (liverworts), and Anthocerotophyta (hornworts). Indian, European, North American, and Chinese traditional medicines have used bryophytes for the treatment of burns, bronchitis, tonsillitis, tympanitis, skin

conditions, and cardiovascular issues (Khanam et al., 2011). Because of their phytochemical makeup, bryophytes have a wide range of biological activities, such as antibacterial, antioxidant, antitoxic, NO generation inhibitory and muscle-relaxing properties. Asakawa (2007) Native Americans, Chinese, and North Americans have long used a variety of bryophytes as herbal remedies. Some species of the Hypnaceae family, such as Mnium sp., Bryum sp., and Philonotis sp., have been used to relieve bum pain. Burned moss ash, combined with fat and honey, has been used as an ointment for cuts, wounds, and bums in the Himalayas (Pant et al. 1986). Mosses that cover the forest with moisture and temperature, prevent soil erosion, and offer seed beds include Funariahygrometrica, Atriam sp., and Pogonatum sp. The pigments of isolated bryophytes showed antibiotic qualities against gram-positive bacteria (Aureobacteriumliquefaciens, Arthrobacterglobiformis, Bacillus brevis, B. cirulans, and B. subtilis), according to a 2003 study by Wakuli et al.A review of the literature indicates that there is little proof of the antibacterial properties of bryophytes found in the Gautala wildlife sanctuary. The antibacterial efficacy of Funaria sp. extract against both Gram-positive and Gram-negative bacteria was the focus of this study.

MATERIAL AND METHOD

Sample collection and Preparation of plant powder

The Gautala Wildlife Reserve in the Jalgaon area is where the Funaria sample was collected. After gathering the plant pieces, they were cleaned with running tap water and autoclaved to remove any remaining dirt. An electronic grinder was used to crush fresh plant leaves after drying for ten days at room temperature. For later use, the dirt-free plant powder was stored in an airtight container at 4 °C (Mehra and De, 2017). The materials were dried and powdered into a fine powder.

Preparation of extracts

A finely ground sample (30 g) was extracted using ethanol and methanol in a Soxhlet extractor, and care was taken to not exceed the boiling point of the solvent. The extracts were filtered through Whatman filter paper No.1 and concentrated under reduced atmospheric pressure. The dry extracts were stored at -20°C. The extracts were dissolved in 5% dimethyl sulfoxide (DMSO) for further experiments.

Antimicrobial activity

Six different species of bacteria were used in this study to explore the effectiveness of the extract in inhibiting growth. The bacteria chosen for this study were both gram-positive and gram-negative bacteria. The six bacterial species used in this study were *Escherichia coli, Pseudomonas auriginosa, Lactobacillus sporogense, Bacillus cereus, Salmonella abony* and *Staphylococcus aurius.* The experiment method adopted for this inquiry was the agar well Diffusion Assay method, it was chosen since it was the easiest and the simplest approach to use.

Agar well Diffusion Assay method

The Agar well diffusion method outlined by Magaldi et al. (2004) was used. A sterile inoculation loop was used to disseminate 100µl of various bacterial cultures in sterile distilled water (SDW) onto the surface of an agar plate using a micropipette. Each culture plate had a hole created using a sterile cork borer. An extract of the various solvents (75µl) was then added. The culture plates were then incubated at 37 °C, and the results were observed after 24 h, depending on the bacterial growth. The clear zone around each well was measured in millimeters, indicating the activity of the extract against the bacterial strain. Each test was performed in triplicate and the mean was calculated.

Statistical analysis

One-way ANOVA was performed in conjunction with Tukey's Honestly Significant Difference (HSD). Typically, a significance level (α) of 0.05 is used. The Q statistic measures the difference between the means of treatments.

Formulate Hypotheses

- Null Hypothesis: There is no significant difference in antibacterial activity among the methanol extract, ethanol extract, aqueous extract, and antibiotic for each bacterial species.
- Alternative Hypothesis: There significant difference in antibacterial activity among methanol, ethanol, and aqueous extracts and antibiotics for at least one bacterial species.

Observation Table

RESULT AND DISCUSSION

ANOVA analysis of the study findings showed that the antibacterial activity of the tested therapies varied significantly ($F = 3.423$, $P = 0.0427$). The Aqueous Extract and Cefotaxime (control) were repeatedly found to vary significantly by post-hoc tests such as Tukey HSD, Scheffé, and Bonferroni-Holm. The Scheffé test produced a statistic of 3.4837 with a P-value of 0.0212, whereas the Tukey HSD test produced a Q-statistic of 4.9267 with a P-value of 0.0115. Similarly, with a P-value of 0.0141 and T-statistic of 3.4837, the Bonferroni-Holm test validated the significance. These findings suggest that compared to cefotaxime, the aqueous extract had noticeably less antibacterial activity. The findings of this study correspond with earlier research on the antibacterial activity of plant extracts and medications, such as cefotaxime. Third-generation cephalosporins, such as cefotaxime, are well-known for their broad-spectrum antibacterial activity. The results of this investigation, which showed that cefotaxime had the highest inhibition zones, were in line with those of Khan et al. (2020), who showed notable inhibition zones against pathogens, including Escherichia coli and Pseudomonas aeruginosa. Its strong antibacterial activity can be explained by its mode of action, which targets the formation of bacterial cell walls. In contrast, the aqueous extract exhibited a statistically significant difference ($P < 0.05$) in antibacterial activity when compared to cefotaxime. This conclusion is in line with the findings of Patil et al. (2018), who found that aqueous extracts had poor efficiency against bacteria, such as Salmonella and Staphylococcus aureus, because they were unable to extract non-polar bioactive chemicals. Additionally, there were no discernible differences between the methanol and ethanol extracts, which is consistent with Sharma and Verma's (2017) findings that both solvents are equally effective at extracting flavonoids, phenolics, and other bioactive substances. However, prior research has shown that organic solvent-based extracts generally have higher antibacterial activities than aqueous extracts. The findings of Singh et al. (2019), who emphasized that antibiotics, such as cefotaxime, routinely outperform crude or aqueous plant extracts, are supported by the substantial difference between the aqueous extract and cefotaxime (Scheffé $P = 0.0212$). To increase the effectiveness of plant-based formulations, Singh et al. underlined the necessity of further refinement techniques, such as fractionation or synergistic extract combination. Plant-based extracts have potential as substitutes for antimicrobials, despite having comparatively less activity than antibiotics. According to Kumar et al. (2021), medicinal plant extracts in methanol and ethanol showed encouraging antibacterial activity against bacteria, such as Bacillus cereus and Escherichia coli. These findings implied that improving the extraction process and targeting bioactive fractions could boost the effectiveness of plant-based antimicrobials. Overall, although cefotaxime was still the most successful treatment in this study, further research and development are necessary to fully explore and improve the potential of plant-based extracts for antimicrobial applications.

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Table 1:Antibacterial activity among methanol, ethanol, queous extracts and antibiotics.

Sr.No.	Bacteria Strain	Average Zone of Inhibition in mm (Dilution factor 1:1)			
		Methanol extract	Ethanol extract	Aqueous extract	Cefotaxim (100 µg/ml)
1.	*Pseudomonas aeruginosa*	16	26	19	27
2.	*Escherichia coli*	17	23	16	28
3.	*Lactobacillus sporogenes*	23	24	15	31
4.	*Bacillus cereus*	23	28	18	29
5.	*Salmonella abony*	20	2.8	16	23
6.	*Staphylococcus aureus*	23	22	16	24

Table 2:Anova: Single Factor.

1) Anova: Single Factor						
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	300.646	3	100.2153	3.423006	0.042736	3.238872
Within Groups	468.432	16	29.277			
Total	769.078	19				

Table 3: Tukey HSD results.

Treatments pair	Tukey HSD Q statistic	Tukey HSD p-value	Tukey HSD inferfence
Aqueous Extract Vs Cefotaxime.	4.9267	0.0115452	* p<0.05

Table 4: Scheffé multiple comparisons.

Treatments pair	Scheffé-statistic	Scheffép-value	Scheffé inferfence
Aqueous Extract Vs Cefotaxime.	3.4837	0.0212190	$p < 0.05$

Table 5: Bonferroni and Holm results

Treatments pair	Bonferroni and Holm T-statistic	Bonferroni p-value	Bonferroni inferfence	Holm p-value	Holm inferfence
Aqueous Extract Vs Cefotaxime.	3.4837	0.0140511	* p<0.05	0.0140511	* p<0.05

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RESEARCH ARTICLE

Environmental and Health Implications of Tannery Effluents: Exploring Microbial Bioremediation

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ABSTRACT

Tannery industries play a significant role in polluting an environment when its effluents are released into the water bodies like river, pond and lake etc. Many hazardous toxic metals, including arsenic, cobalt, uranium, nickel, copper, cadmium, lead, mercury and chromium are found in the tannery effluents. One of the extremely poisonous and cancerous toxic heavy metals is Chromium. The high level of toxicity seen in tannery leather wastes is commonly attributed to the containment of harmful substances such as heavy metals, organic contaminants, and dyes. These effluents have been found linked to significant dangers to human well-being, including cancer, and contamination of the environment. The emission of chromium compounds, aromatic amines, and other genotoxic substances, which can cause damage to nucleic acids such as DNA, mutations, and an increasing the risk for cancer in populations exposed to them, is primarily responsible for the carcinogenic potential of tanning leather waste. Different options are required since traditional methods of treatment are not always sufficient to fully mitigate the hazardous effects of these effluents. One environmentally acceptable and long-lasting way to deal with tannery effluent pollution involves microbial detoxifying via bioremediation. Many microorganisms, especially fungi and bacteria have shown the capacity of detoxification as well as break down complicated contaminants, changing dangerous substances into less harmful or harmless forms. These microorganisms have biochemical pathways that can decolorise colours, degrade cancerous chemicals, and lessen the harmful effects of chromium. Investigating bioremediation's potential

not only shows potential for lessening the adverse impacts of tannery wastes to human wellbeing and environment, however, additionally advances the improvement of eco friendly as well as reasonably priced treatment facilities for wastewater. The summary highlights the possibility of bioremediation processes as a critical tactic in reducing the carcinogenic risks caused by tannery effluents and examines the microbiological processes involved with their decontamination.

Keywords: Tannery effluents, Carcinogenesis, Heavy metals, Bioremediation, Environmental challenges.

INTRODUCTION

Among the important challenges facing the globe today is environmental pollution, which is growing daily because of industrialisation and urbanisation. One of India's largest industries is the tanning sector (Srinath *et al.,* 2002). India has over 2,000 tanneries, with many small-scale units spread across states like West Bengal, Tamil Nadu, Maharashtra, and Uttar Pradesh. Vellore district alone hosts 548 tanneries, mainly in areas like Vaniyambadi, Ambur, and Ranipet. Effluents from tanning processes significantly contribute to environmental pollution and groundwater contamination (amala *et al.,* 2023). The tannery business is a significant environmental polluter and has a great potential to affect land and water due to the unintentional disposal of unprocessed effluent. A large amount of trash, both liquid and solid, is released into the environment by numerous companies. The textile and tannery industries are among the many that contribute significantly to the large-scale discharge of waste as effluent (Sarker *et al.,* 2013).The way that industry currently operates modifies the normal distribution of harmful substances and releasing new chemicals into the environment, which is made of by people and other living things. When metals that are heavy or micronutrients accumulate in soil at phytotoxic quantity, it can have detrimental effects on plants and even endanger human health (Mahatma Gandhi *et al.,* 2010). The features of tannery effluent differ significantly amongst tanneries based on factors including tannery size, kind of final product produced, quantity of water consumed, and chemicals used to perform the specific process (Alfredo *et al* 2007).Leather is a stable and putrescible commodity that is composed of animal hides as well as skin that is chemically tanned (Hayelom Dargo *et al.*,2014).One of the world's oldest industries is tanning. On recent times, tanning operations were set up to Satisfy the requirements of the people needs for instruments for music and leather shoes (Durai*et al.,* 2013). Poisonous both solid and liquid waste are contained in the tannery effluent until being released untreated. A lot of water and several chemical compounds that dissolve is utilised in the tanning process of leather (Shakir *et al.,* 2012).Significant quantities of trace metals, chromium, sulphides and carcinogenic organic matters may be found in the tannery waste (Landgrave *et al.,* 1995).Numerous pathogens and odorous liquids consisting of both acidic and alkaline liquors can be present in the tannery waste (Cooman *et al.,* 2003).

Contamination of the environment is considered as one of the greatest consequences that is affecting the today's world, that is getting harsher every day as an outcome of industrial activity (Tadesse *et al.,* 2017; Yadav*et al.,* 2020). Both treated and unprocessed effluents from different industries contain metal chelates and harmful metals (Ammann *et al.,* 2003). Among chemical pollutants, heavy metals can concentrate with the food chain and produce their toxic effects at points far removed from the beginning of the pollution point since they aren't biodegradable (Tilzer*et al.,* 1993).Considering one of the primary causes of pollution, the active release of tannery effluents into the water bodies have become an increasingly serious environmental concern (Bosinc *et al.,* 2000). To make leather appropriate for making many kinds of leather products, such as bag, shoe, wallet, and upholstery furniture, organ metallic salt of Dissimilar toxic metals, such as Cr, nickel, Pb are widely employed as colouring reagents as well as the mordants while on leather dyeing purposes and in other post-tanning and finishing processes (Mahdi *et al.,* 2021; Sivaram *et al.,*2019).In addition to being undesirable, fish that have been exposed to chemicals in surface and subsurface water are known to have several ailments that are transmitted by water, including dermatitis, nausea, bleeding, ulcers on skin and mucous membranes, nasal septal perforations, and extreme inflammation of the respiratory tract (Karim *et al.,* 1994). These metals eventually end up in the soil and water, where they may then move

to various plant tissues (stems, roots, leaves etc.) where some of them perform as essential micronutrients for growth of plants, as well as ultimately enter the human food chain if those plants are eaten (Ahmed *et al.,* 2017; Chen*et al.,* 2014). For the reason of evaluating the environment's safety and biodiversity, pollution from heavy metals surveillance is important.

Industrial Tannery Effluents

The leather manufacturing procedure generates various contaminants in the tannery effluents, which is a major challenge for the industry in terms of effluent disposal. One of the world's oldest industries is tanning. In earlier times, tanning operations were set up to meet the local need for musical instruments and leather footwear. Vegetable tanning and tanning with chrome are both commonly approved techniques for tanning raw hide or skin (Durai and Rajasimman *et al.,* 2011).Ten percent to hundreds of milligrams of chromium per litter can be found in the effluents of these sectors (Dermou *et al.,* 2005).The fabrics and tannery industries are among the many industries that contribute significantly to the massive amounts disposal of waste as effluent (Sarker *et al.,* 2013). One of the largest consumers of water and polluting entities, the textile industry contributes significantly to the production of effluent (Nemerow *et al.,* 1978). Since the tanning process involves turning raw hide or skin into leather, this sector of the economy has the potential for generating a lot of pollution (Ghoreishi *et al.,* 2003).Toxic heavy metal pollution from industrial effluent has a negative consequence on the wellbeing of individuals, animals, and other living things (Garg*et al.,* 2012). discharge of waste from tanneries into the environment, containing substantial quantities of organics and tannins, contaminates the soil and water and poses significant hazards to human well-being and aquatic organisms (Gibb*et al.,* 2000). Being one of the main sources of pollution, an intentional release of tannery effluents into sources of water is now an increasingly serious problem for the environment (Bosinc *et al.,* 2000).The tannery effluents that have contaminated the air, land, and water are associated with number of illnesses. Due to this fact that manufacturing leather frequently produces substantial quantities of toxic waste, the concentration of tanneries has an ability to cause an adverse impact on the environment and public health (Pastapure *et al.,* 2023).Because of the development of the tannery industry, pollutants released from leather tanning have become one of the primary industrial pollutant sources. (Rajamani *et al.,* 2018).Even though they function a significant role in the economic growth and employment in many nations, tannery has been recognised as a feasible contributor of pollution from toxic metals to the environment (Mondal *et al.,* 2020).Improvement of the finished top leather's waterproof qualities produced from cow hides from Bangladesh (Euro *et al.,* 2019). Basic chromium sulphate (BCS), an important chromium (Cr) salt, is used in significant amounts all through the tannery processing to give tanned leathers with excellent hydrothermal stability and other special characteristics (Ozkan *et al.,* 2019). Among the primary sectors that has grown globally, particularly in Turkey, Brazil, Bangladesh, China, India, and Pakistan, is tanning leather (Moktadir *et al.,* 2018).As the tannery industry developed, tannery effluents have grown into the primary sources of industrial pollutants (Rajamani *et al.,* 2018). Both water and solid waste are released into the environment by these kinds of companies in huge amounts. These businesses produce trash that contains both inorganic and organic materials that are extremely hazardous, carcinogenic, and mutagenic (Sarker *et al.,* 2013).In terms of exporting and producing leather, India is ranked third. In overall, Tamil Nadu, West Bengal, Uttar Pradesh, Andhra Pradesh, Karnataka, Punjab, Maharastra and Rajasthan belong to the countries with over 3000 tanneries installed (Chaudhary *et al.,* 2017).

Toxic heavy metals in tannery effluents

Heavy toxic metals such as Lead, Cd, Chromium and copper are frequently employed as colouring reagents as well as the mordants (Mahdi *et al.,* 2021;Sivaram *et al.,* 2019).When these heavy toxic metals get into contact with people or animals via water contamination, they may trigger bone disorders. These metals include Cr, Fe^{2+}, Zn^{2+}, Cu^{2+}, Ca^{+}, and Na+ (Tamburlini *et al.,* 2002).It was found that as the tannery effluent percentage increased, so did the chromium level (Camargo *et al.,* 2003).Trivalent and hexavalent chromium are the two different forms of Chromium salt that result from the following reaction, which is why tannery companies employ it extensively when making animal products (Samrithi *et al.,* 2012).Basic chromium sulphate (BCS), an important chromium (Cr) salt, is utilised in significant amounts during the tanning process to give tanned leathers improved hydrothermal stability and other special qualities (Ozkan *et al.,* 2019).The chemical element chromium (Cr) is hard and shiny (Panda *et al.,* 2012).One of the most hazardous substances frequently discovered in tannery waste is chromium (Sultan *et al.,* 2005). Although

chromium (Cr) can exist in any number of oxidation states, the Cr^{3+} and Cr^{6+} species are the most stable and have distinct chemical properties and biological consequences (Cervantes *et al.,* 2001).One of the most hazardous heavy metals releases into the environment through various kinds of industrial effluents is chromium, which is generated by the tanning of leather, electroplating, paints, pigments, and steel (Dermou *et al.,* 2005). Tannery wastewaters release significant quantities of various toxic heavy metals such as Cr, Cadmium, Cu, Nickel, lead, Ba, Arsenic and iron (H.I. Adel-Shafy *et al.,* 1995).In addition to causing pollution in the environment, certain toxic metals are considered as dangerous substances because they interfere with normal cellular functions, which can have anadverse effect on human wellbeing and plant materials (S. Sinha *et al.,* 2007; Xaba, *et al.,* 2018).According to Fu *et al.,* (1994), most of these effluents contain complicated mixes made up of inorganic compounds. These compounds include metals like Cr, Fe^{2+}, Zn^{2+}, Cu^{2+}, Ca^{+}, Na^{+}, and others, as well as anions like SO_4^{2-}, NO_3^{-}, and PO_4^{3-} that can be found in the effluents or trapped in the suspended matter (Bosinc *et al*.,2000).Phenomena like suspended solids (SS), chromium, sulphide, chemical oxygen demand, biochemical oxygen demand, etc. can be used to describe the pollution of tannery effluent (Buljan *et al.,* 2011).Furthermore, the tanning process has a major impact on the wastewater's pH, total suspended solids (TSS), chemical oxygen demand (COD), total dissolved solids (TDS), biological oxygen demand (BOD), concentrations of T Cr, Cr^{3+}, Cr^{6+}, Cl, sulphate, sulphide, and inorganic components. According to a report by the United Nations Industrial Development Organisation (UNIDO 2000), over 175 different chemicals are employed in every phase of the tannery, such as enzymes, Ca $(OH)_2$), (Cl),H_2SO_4), (T Cr), (CH_2O_2), (NH_4Cl), $((NH_4)_2SO_4)$, non-identical metallic salts, and organic compounds (Mannucci *et al*.,2010; Ali *et al.,* 2015). An element that exists naturally in gases, plants, volcanic dusts, rocks, animals and soil is chromium. It is found in +2 to +6 oxidation states, among others. The Cr^{6+} and Cr^{3+} forms are the most stable (Garg*et al.,* 2012). Some investigations revealed that toxic metals such as Cadmium, Arsenic have carcinogens or harmful impacts on people and the environment. Traditionally, chemical reduction, precipitation, exchange of ions, and absorption on coal, kaolinite, alum, fly ash and activated carbon are used for detoxification and eliminate Cr 6+ from the environment (Ohtake *et al.,* 1994).A number of physical and chemical processes are involved in the processing of leather from animal hides and skins, including tanning, pickling, de-liming, skin degreasing, liming or unhairing, bating, and raw hides dyeing and skins using various chemicals, such as enzymes, lime, Cl, H_2So4 ,HCOOH, ammonium salts, various metallic salts, and organic chemicals, among others (Ali *et al.,* 2015).Among the heavy elements found in tannery effluents include lead, arsenic, cadmium, cobalt, copper, selenium, mercury, and azo dyes. Hexavalent chromium (Cr (VI)) is believed as harmful metal that has the potential to disperse in universal solvent and permeate into the living cells and get associated with the proteins and nucleic acids (Samrithi *et al.,* 2012).

Effects of tannery effluents on soil and plant production

The term "environmental quality" describes the traits and qualities of the environment that have an impact on people and other animals. Based on the requirements of any number of species or people, it assesses the state of an environment. Tannery effluents are the most polluting of all industrial pollutants (Haque *et al.,* 2019). The Buriganga River is contaminated by sewage, oil, polymers, dead animals, residential trash, clinical waste, and mill and industrial waste. Environmentally friendly both liquid and solid tannery wastes are treated and dumped unprocessed onto the Buriganga River along with other connected rivers (Zahid *et al.,* 2006).In Bangladesh, the leather industry has long been concerned about the release of unprocessed waste from tanneries into water bodies. (Asaduzzaman *et al.,* 2016). Tanning processes damage the soil with dangerous heavy metals, and heavy metals build up in crops throughout cultivation. The substantial amount of hazardous metal-containing solid waste from the tannery industry is converted into protein concentration and supplied to hens (Islam *et al.,* 2014). High salinity was discovered when discharging effluents containing high quantities of sulphate, ammonia, chloride, sodium, chloride, total dissolved solids and nitrate. Due to an inadequate tanning procedure, pollutants exceeded the threshold level, making the incoming river water hazardous and unfit for animal and human consumption as well as the survival of fishes and other aquatic species. In addition, the use of polluted river water on agricultural purposes reduced soil fertility and created soil toxicity. Tannery effluents contained toxic metals and inorganic compounds, including Arsenic As, Mn, Zn,Pb,Cr, Cd and zinc (Zn). Among other uses, agriculture, poultry husbandry, and fishing operations were the principal ones that made use of tanning wastewaters. These procedures result in the buildup of toxic tannery effluents in human health, which leads to a range of ailments. Dhaka City Corporation

(DCC) has made reducing tannery wastewater a high priority. Many dangerous substances are released on to the soils as a result of tannery effluents not being treated. Plants that accumulate too much chromium may have decreased growth of plants, chlorophyll content, photosynthesis, enzyme activity, and even destruction of their mitochondria and chloroplasts. (Guilizzoni 1991). Salt stress inhibits the synthesis of enzymes necessary for seed germination or slows down metabolic processes (Ashraf *et al.,* 2002). The health of people and animals was negatively impacted by the carcinogenicity of Chromium, Lead and Cadmium in a number of ways. Therefore, authorities must move swiftly to stop the pollution of heavy metals (Rahaman *et al.,* 2016). Therefore, consuming these veggies grown in the research location must have negative effects on public health. Because of their fast growth and the way that metals and metalloids are transferred to their leafy parts, vegetables are more prone to toxic metals and metalloid contamination (Chang *et al.,* 2014). In all the nation's developed regions, soil contamination has grown to be a significant issue. It is widely acknowledged that soil serves as the primary repository for both inorganic and organic pollutants are discharged into the environment by industrial wastewater. Soil serves as a growing medium for many plants and animals, enabling them to grow and develop throughout time. When toxic metals or micronutrients are present in soil at phytotoxic amounts, it can have detrimental effects on plants and even endanger the health of humans. Excessive metal accumulation impacts the development of plants and their metabolism and causes an increase in reactive oxygen species generation. (Mahatma 2010). The other elements of habitats exposed to heavy metals and industrial effluents include vegetables. Growing in contaminated areas, they have the potential to absorb and accumulate harmful metal concentrations from tannery industries, such as Cr (VI) (Weigert1991).

Industries such as textile, tanning leather, electroplating, pigment and paint production, mining and fertilizer utilize a lot of chromium (Unal *et al.,* 2010; Ganguli and Tripathi, 2002). These businesses release Cr^{3+} and Cr^{6+} into the soil, surface waters, and vegetables along with waste effluent. profiles of soil most animals and plants depend on the soil as their development medium for ongoing development and expansion. Many times, the discharge of effluents from industries, particularly from tannery outflow, leads in the presence of pollutants of both organic and inorganic forms that negatively impact the ability of life to persist in the soil matrix. The main causes of contamination by heavy metals in the nearby agricultural soil that has been used for irrigation are the leather factories in Jajmau, Kanpur. If sludge is employed for Agricultural purposes, it can lead to the deposition of toxic heavy metals such as Cd, Zinc, Cr, Nickel, lead and Manganese in soil surfaces. It can also release these metals into underground water or soil solutions that are available for plant absorption because of the ability of the soil to store heavy toxic metals is reduced. When toxic metals or micronutrients are present in soil at phytotoxic amounts, it can have detrimental effects on plants and even endanger public health (Murugesan *et al.,* 2008). The soil's high chromium concentration is a result of agricultural lands being irrigated with effluent full of tannery effluents, which has a high chrome sulfate concentration (Mohd, 2008). Irrigation with a lot of wastewater Water has an impact on the development and yield of plants (Barman and Lal, 1994), and the food chain biomagnifies the buildup of hazardous heavy metals at various trophic levels. Tannery wastewater has phytotoxic effects and high heavy metal accumulation that stresses plants (salinity stress, for example, affects several metabolic processes and reduces the plant's ability to grow vegetatively and later for reproduction). It also negatively impacts respiration, photosynthesis, shortens the time it takes for germs to sprout, and inhibits mitotic activity (Camplin, 2001).

Effectsof Tannery Effluents on Poultry Feed Production and Livestock Production Sector

According to (Kanagaraj *et al.,* 2006 and Bari *et al.,* 2015), the most common solid wastes generated in tanning leather sectors were chrome shaving, fleshing, buffing waste and keratin, skin trimmings. The extent of Pb and cadmium (Cd) in chicken meals already have beyond Egyptian and WHO safe standards, reflecting the state of the local population's health. Analysis based on each research claims that the presence of heavy toxic metals in feedings affects bird, posing an illness to human beings who ingest chicken meats which is contaminated (Islam *et al.,* 2014). A balanced diet was created by combining several feed stocks with locally produced protein concentrates obtained from solid waste from tanneries. Two things were considered. The first was the level of heavy metals, which had decreased because of dilution in the finished diet. Where these protein concentrations were used to create chicken diets, though, didn't really matter. Conversely, these proteins were mixed with the feed staffs. The feed personnel may also contain metals that are toxic (Hossain *et al.,* 2007). (Tinni *et al.,* 2014) carried out an investigation on animal

husbandry in the location called Hazaribagh tanning leather place and found that the high levels of chemical deposition made it impossible for those who worked in production of live stocks to safeguard their animals on exposure from hazardous chemical. The illness claimed many animals' lives. It was discovered that the animal farm in that research zone was unnecessarily diminishing because of the discharge of harmful tannery effluents. In public spaces, solid garbage was disposed of and disposed of. Unplanned discharge of liquid waste occurs without treatment. Livestock also ate these toxic wastes, which caused them to contract several illnesses. The heavy metals in tannery effluent had an impact on the neurological system, liver, and kidneys. According to Verma *et al.,* 2018), chromosomal abnormality, embryotoxicity, and steroid genic dysfunction are the main causes of prolonged duration toxic metal exposure to the reproductive organs.

Effects of tannery effluents on fisheries production

Numerous research show that untreated tannery wastewaters damage aquatic resources and lower fish production when they are released into water bodies. Fish consumed parts of the tannery wastewater. Fish production was decreased by the unmanaged and unprocessed tannery effluent flow into open water bodies (Tinni *et al.,* 2014). Cr, Zn, Pb, Ni, Mn and Cd and were discovered to be contaminated in fish feed supplies in Hyderabad. All sample types had average chromium (Cr) concentrations that were much higher than the capital's maximum permittable level for tannery waste. If consumed by fish or fowl, tanniny feces can damage the liver, kidneys, and induce cancer (Akter *et al.,* 2020). Many studies have found that waste from tanneries undergo insufficient treatment before being released into bodies of water, which harms fish productivity and aquatic resources. One such study (Tinni *et al.,* 2014) found that effluents released from tanneries negatively impact on fishing economically. Fish production was lowered by the uncontrolled and unprocessed tannery wastewater being released into open reservoirs of water. The Buriganga River's physiochemistry was changed by these wastes (Tinni *et al.,* 2014). Waterquality is lowered by the existence of organic debris, sulphides and other hazardous substances in tannery effluents. The general aquatic environment and fish health are impacted by this pollution. Fish are extremely sensitive to hexavalent chromium (Cr (VI)). Survival and development rates are impacted by the physiological and biochemical alterations it brings about. Other aquatic animals and fishes cannot live in the water due to oxygen depletion caused by the elevated levels of organic matter from tannery wastewater (Dhanam *et al.,* 2013). Fish species may experience extreme stress from tanning effluents, which could result in significant mortality rates. Chronic exposure to toxic chemicals can diminish reproductive success and induce abnormalities in fish larvae. It can also affect metabolic processes. Fish metabolism is hampered by sub-lethal effluent concentrations, which affects development and reproduction. Fish tissues bioaccumulate heavy metals including lead and chromium, which can have harmful impacts further up in the food chains (Padmini *et al.,* 2008).

Effects of tannery effluents on human health

Being susceptible to Cr (VI) can cause various kinds of respiratory diseases, including allergies, oedema, itching, and irritation. Amongst the negative effects associated with Cr (VI) exposure include lung cancer, renal disease, and epidermal problems (Farag*et al.,* 2010). Carcinogenicity is determined by genetically induced changes in a cell's DNA as well as environmental variables. These involve lifestyle factors (diet, exercise, alcohol and tobacco use, etc.), naturally occurring exposures (radon gas, infectious agents, ultraviolet light.), and medical treatments (medications and radiations, such as hormone drugs, chemotherapy, immune system suppressors.). The nearby ecosystem and human well-being are put at risk by the toxic metals and harmful chemicals present in wastewater (Shakir*et al.,* 2012). Chromium is an important element but while over exposing, generates allergic dermatitis; ulceration in the mucous membranes, skin and nasal septum; increases opportunities of respiratory-tract cancer and genotoxic and cytotoxic implications and renal tubular necrosis (Flavio *et al.*,).Variety of bacteria resistant to chromium that were collected from dichromate-contaminated soils (Lu*et al.,* 1995). Workers in tanneries who are exposed to extend levels of radiation for prolonged duration of time—five months to fourteen years—pose a real risk of acquiring disorders linked to genetic adverse effects. The toxic effluents of Cr, H2S, Pb, Zn, Cd, and formaldehyde released by tannery are unknown to them. These pollutants can cause short-term illnesses like headaches, dizziness, allergic reaction irritation of the skin, eyes or lungs, poisoning of the kidney, liver or nervous system, or collapse due to oxygen deprivation; they could cause long-term illnesses like dermatitis, ulcers, bronchitis, genetic defects, and occupational

asthma (Rajendran 2010). Although numerous chemicals are exposed during the production process, some of which are being shown to be carcinogenic to individuals, the International Agency for Research on Cancer (IARC) claims that processing and tanning of leather cannot be classified as carcinogenic to humans. IARC monographs on assessment of individual carcinogenic risk (WHO 1987).Certain researchers have hypothesised that exposures to tanning industry products could lead to a range of distinct cancers, such as those of the pancreatic cancer, bladder cancer, lung cancer, kidney cancer, oral cavity, nose, and soft tissue sarcomas, in addition to skin conditions, dermatitis, ulcers, perforations of the nasal septum, and respiratory ailments. Previous study has indicated that workers in tanning industries might have been exposed to a variety of acknowledged or suspected occupational carcinogens, such as arsenic, Cr6+ salts, and organic solvents (Butyl acetate, toluene, benzene, ethanol, formaldehyde, acetone, acetoacetate) (Bonassi *et al.,* 1990) (Seniori Costantini *et al.*,1990; Montanaro *et al.,* 1997).These organisations produce trash that contains inorganic as well as organic substances that are highly dangerous, carcinogenic, and mutagenic (Sarker. B *et al.,* 2013).

Skin cancer

Workers who are directly exposed to leather colours and fats run a chance of developing skin cancer. In addition, melanoma and nonmelanoma skin cancer have been detected in some filling and decorating procedures. Recent research (Veyalkin *et al.,* 2006) found that women working in dyeing, stuffing, and decorating crafts showed a high mortality rate for melanoma and skin malignancies.

Pancreatic cancer

Chromium chemicals are responsible for of the high death rate from pancreatic cancer in women. Chromium III promotes the growth of pancreatic cancer, while azo dyes and/or formaldehyde can lead to DNA mutations (Ghadirian *et al.,* 1991; Di Menza *et al.,* 1992) (Vineis *et al.,* 1985).

Bladder cancer

Dyes based on benzene and aromatic amines were believed to be possibly carcinogenic. Tanners who had been exposed to benzidine-based dyes reported significant increases in premature death from bladder cancer, which improved with exposure time (Vineis *et al.,* 1985).

Bioremediation of tannery effluents using microbes

Tannery effluent treatment is a multi-step procedure that cleans wastewater prior it is released onto land, into a natural body of water, or to be recycled (Buljan *et al.,* 2011).The elimination of hazardous compounds from discharge has been extensively explored using Microorganisms involved fungus, bacteria, and algae. Cr^{6+} can be reduced to Cr^{3+} by most bacteria. (*Pseudomonas sp.*,) (Arellano *et al.,* 2004).Many chromium-reducing bacteria that have been identified and collected come from industrial effluents and soil wastewater that has been contaminated with chromium (McLean *et al.,* 2000).A strain from deep-sea sediment named *Lactobacillus paracase* was able to reduce chromium (VI) and remove azo colouring (Huang et al.,2015).Three processes—bioaccumulation, biosorption, and enzymatic reduction—allow microorganisms to interact with hazardous metals and facilitate their elimination or restoration (Srinath *et al.,* 2002). The detrimental effects and mobility of chromium pollutants in water and soil are reduced when chromium with hexavalent state is reduced to chromium with trivalent state(Kapoor *et al.,*2002).The capacity of bacteria to absorb chromium is 34.5 milligram per gram dry weight for *Bacillus circulans* and 32.0 milligram per gram dry weight for *Bacillus megaterium* (Srinath *et al.,* 1999).By forming a trivalent chromium precipitate, facultative anaerobic bacteria including *Aeromonas dechromatica*, *Pseudomonas chromatophila*, and *Pseudomonas dechromaticans* remove Cr (VI) from solution. An ability to reduce Cr6+ is extensive and has been documented in a variety of organisms, including *Pseudomonas ambigua*, *Pseudomonas fluorescens, Pseudomonas aeruginosa, Bacillus subtilis, Micrococcus roseus, Achromobacter eurydice, Bacillus cereus* and *Escherichia coli* (Sudha Nayar *et al.,* 1985) (Sumit Yadav *et al.,* 2005).Using flasks as batch reactors, S. Shakoori*et al.,* (2000) identified Gram-positive bacteria, resistant to dichromate, from tannery effluents (Shakoori *et al.,* 2000).The biological technique of treating wastewater is a crucial and simple process that uses biological materials, such as fungi and bacteria, to carry out the treatment process. Compared to physical-chemical treatments, biological treatment approaches are more economical.

Many microbes can degrade these contaminants in order to gain nutrients and energy for development (Metcalf *et al.,* 2003).Utilising anaerobic bacteria that thrives without the presence of oxygen, an anaerobic process typically much longer to remediate (Midha *et al.,* 2008).It has been observed that so many species, including *Escherichia coli, Bacillus sp*., *Pseudomonas sp.* and *Flavobacterium sp*., were effective at breaking down complex metals and other xenobiotics found in wastewater. The main constituents of tannery waste are protein and chromium. Many animals may get poisoned by metals. Thankfully, Microorganisms can beable to modify the mobility and reaction of Heavy metals. Microbes that influence the mobility and reactivity of metals and stop further metal contamination (Calormiris *et al*.,1984). The reduction of Cr6+ toCr3+, which is harmless, non soluble in H2O form of chromium, could be catalysed by Microorganisms selected from both Cr6+ deposited and non-contaminate soils and sedimentations. This shows the value of using a selection approach for nativeCr6+ reducing bacteria in a bioremediation process (Kapoor *et al.,* 1997).

CONCLUSION

The link between an industrial tannery effluent and the toxic heavy metals present in the effluents causing the serious environmental pollutions like land, soil and air and water pollutions due to discharge of unprocessed waste effluents into land, soil, air and water bodies like rivers, lakes and ponds respectively. This tannery effluents associated toxic heavy metals also causing the adverse effects on human beings such as skin irritation, DNA mutation, and certain types of cancer. To overcome all these problems, there are so many ways to degrade the toxic heavy metals from high harmful to less harmful. Among all the ways one of the efficient methods is Microbial bioremediation. By this method the toxic heavy metals particularly chromium is highly reduced. Bacteria and Fungi have the capacity to detoxify the dangerous heavy toxic metals. This biological method of detoxification is very easy and cost effective while comparing with the physical and chemical method of detoxification. This article briefly believes that the Microorganisms play a vital function in the protection of public health and an environment in all possible ways.

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RESEARCH ARTICLE

The Study on Real-Time Business Intelligence

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ABSTRACT

This study explores real-time business intelligence (RTBI) at a rubber tyres manufacturing company, focusing on its impact on decision-making and operational efficiency. With data-driven insights playing a crucial role in modern business, the research highlights how RTBI tools enhance productivity, reduce response times, and improve strategic planning. The study delves into the technological infrastructure, data integration processes, and analytical frameworks used, illustrating how RTBI provides real-time monitoring, predictive analytics, and performance optimization. Key findings indicate that effective RTBI implementation leads to improved supply chain management, customer satisfaction, and competitive advantage. Furthermore, the study discusses the challenges of adopting RTBI, such as data security, integration complexities, and employee adaptability, while providing recommendations for successful implementation. By leveraging RTBI, the company, can achieve its competitive advantage.

Keywords: Real-Time Business Intelligence (RTBI), Operational Efficiency, Data Analytics, Cost Reduction, Decision-Making

INTRODUCTION

Real-time business intelligence is an approach to data analytics that enables business users to get up-to-the-minute data by directly accessing operational systems or feeding business transactions into a real-time data warehouse and business intelligence (BI) system. The technologies that can be used to enable real-time BI includes data virtualization, data federation, enterprise information integration (EII), enterprise application integration (EAI)and service-oriented architectures (SOA). Complex event processing tools can be used to analyses data streams in real

time and either trigger automated actions or alert workers to patterns and trends. Real-time BI can help to support instant decision-making, which is necessary, for example, if a company sells clothing online. The company's website and representatives at the company's call Centre need to have the same up-to-the-minute data by directly accessing operational systems or feeding business transactions into a real-time data warehouse and business intelligence (BI) system, real-time business intelligence is a method of data analytics that gives business users access to the most recent information. In real time BI can assist in facilitating prompt decision-making, which is required, for instance, if Clothing is sold online by a corporation. The business's website and employees at the business call center must have the same current information. Real-time business intelligence is a method of data analytics that gives business users access to the most recent information. Real-time BI can be enabled by a number of technologies, such as data virtualization, data Enterprise Application Integration (EAI), Enterprise Information Integration (EII), and federations well as SOA (service-oriented architectures). Advanced technologies for event processing can be utilized to Real-time data stream analysis by either initiating automatic processes or notify employees of tendencies and patterns. In real time BI can assist in facilitating prompt decision-making.

REAL-TIME BUSINESS INTELLIGENCE

Software for real-time business intelligence transforms unstructured data into insights that a company may use to quickly obtain the information it needs. Businesses to employ real-time business intelligence technologies for identifying new business prospects and make better decisions. Additionally, intelligence is utilized to find business possibilities, identify cost-cutting initiatives, and respond swiftly when providing data and offer insightful analysis. Platforms for business intelligence can assist companies in achieving the following goals:

- Give people access to the greatest decision support system available.
- Enhance company plans and provide fast, concise information.
- Provide information for analysis and reporting.
- Find hidden behavioral patterns and new market opportunities.
- Boost operational effectiveness and business performance

REVIEW OF LITERATURE

In **2024, Dr. Maria Rodriguez** the function of technological innovation in real-time business intelligence (RTBI) is examined in this study. The authors investigate how RTBI is affected by cutting-edge technologies like blockchain, artificial intelligence (AI), and the Internet of Things (IoT). The research further highlights the opportunities and difficulties involved in putting these RTBI technology. RTBI is becoming a crucial part of corporate decision-making. But the necessity for real-time insights and the growing complexity of company data have presented RTBI with fresh difficulties. New technologies like blockchain, IoT, and AI provide fresh prospects for RTBI. **Ramirez-Aristzabal & Oliveira Moraes (2024)** A bibliometric study of BI research trends from 2014 to 2024 showed a move away from retrospective analytics and towards real-time decision making. After analyzing 2,442 research publications, they found that automation, AI integration, and real-time data processing are important new themes. They also draw attention to research voids, like the absence of cross-disciplinary cooperation between businesses The need for additional research on the acceptance of BI in the behavioral and cognitive sciences emerging markets. The results indicate that ethical considerations should be the main focus of future BI research. **Chebrolu (2025).** AI, data governance, and real-time analytics systems tailored to a particular sector. By automating data, artificial intelligence (AI) has revolutionized corporate intelligence, according to gathering, processing, and forecasting. Historical data was the foundation of traditional BI systems. However, AI-powered RTBI provides real-time information.

NEED OF THE STUDY

Assess RTBI's Effectiveness in that particular company

- Determine how RTBI improves operational efficiency, decision-making, and monitoring of performance.

Increase Cost Effectiveness and Business Operations

- Being aware of how RTBI reduces operational costs and streamlines procedures expenses, and improve the company's framework and overall effectiveness.

Assess How RTBI Affects Business Performance

- Researching the role that RTBI plays in important business indicators like productivity, the company's' operational agility and revenue growth.

SCOPE OF THE STUDY

Every employee in the company will have access to real-time business intelligence, which is integrated into numerous business processes. Even though there are numerous technologies that execute this idea; there are still a lot of obstacles to overcome. major obstacles such as process automation, semantics-based information fusion, and automated analytics have been described, along with some examples that demonstrate the viability of the vision. Technological advancements such as soft computing, intelligent data analysis, and the development of RTBI will heavily rely on ontologies. There are already indications that BI solutions are starting to evolve and shut the loop into RTBI programs. At the moment, it is noted that manufacturers of analytical tools are entering the space for commercial applications.

OBJECTIVES OF THE STUDY

- To identify about the Real time business intelligence in an organization located at, Kottayam.
- To estimate how implementation of RTBI system has helped the organization to reduce the mistakes of the future.
- To learn how implementation of RTBI system has helped the organization in taking better decisions for the future.
- To examine the role of RTBI in preventing production delays.
- To evaluate the challenges in implementing RTBI.
- To identify the adoption level of RTBI in manufacturing organizations.

LIMITATIONS TO THE STUDY

- There is limited access to sensitive data; the study is limited to that particular organization.
- Primary sources were used to gather the majority of the research's data. There is possibility of personal prejudice, hence the accuracy might not be accurate.
- Only a small number of respondents participated in this survey.
- Another limitation on the study was the short survey period.
- In-depth research was not feasible due to time constraints.
- The information supplied by the respondents served as the foundation for the study's conclusions.

RESEARCH DESIGN

One strategy for methodically resolving research issues is research methodology. It directs the researcher to conduct the study in a scientific manner. It includes several phases that are often chosen by a researcher to examine his research issue and the reasoning behind it. The research approach comprises the reasoning behind the techniques.

DESIGN SAMPLE

Judgmental sampling is the sample design that is employed. With this approach, the researcher's judgment is used to choose the population's components, guaranteeing that only individuals who possess pertinent information and skills are incorporated into the research. Another name for this technique is as purposive sampling since the

investigator carefully selects the most qualified respondent's ability to offer insightful information. Real-Time Business Intelligence (RTBI) research of this company, the participants are chosen according to their background, position, and participation in the use and execution of RTBI. Among the important attendees are IT specialists, RTBI is actively used by managers, decision-makers, and staff members, guaranteeing that the data gathered is significant and pertinent to the goals of the study.

THE SIZE OF THE SAMPLE

The sample size that satisfies the requirements of effectiveness, representativeness, dependability, and adaptability is referred to as an optimal sample. The sample size chosen for the research is 60 employees from different streams.

DATA COLLECTION TOOLS

Data Sources

- Primary data
- Secondary data

CONDUCTED STUDY

Original Information

Original information gathered by researchers directly from their sources is referred to as primary data, origin of interest. This information is acquired using techniques like surveys, questionnaires, measurements, observations, tests, or interviews conducted especially for the ongoing investigation. Given that original data is gathered straight from the participants or phenomenon under investigation. Primary data was gathered via a well-designed questionnaire.

Survey

For this, a questionnaire with 29 multiple-choice questions was created . The staff members of the company, were given the questionnaire. Finding out more about "A study on Real-Time Business Intelligence" was the goal. In response to each question, the respondents expressed their opinions.

STATISTICAL TOOLS

Statistical techniques are used to analyze the data. The data gathered is analyzed using simple percentage analysis.

- Regression
- The U-Test
- The correlation coefficient
- The mean deviation
- The variance coefficient

DATA ANALYSIS

Question Number	Survey Question	Key Findings	Statistical Analysis
1	Gender Distribution	82% Male, 18% Female respondents.	Simple Percentage Analysis
2	Age Distribution	Majority (28%) aged 35-44; 27% are 45+.	Percentage Distribution
3	Employment Type	60% Permanent, 27% Temporary, 13% Contract.	Percentage Calculation
4	Job Title	43% Managers, 35% Data Analysts, 22% Supervisors.	Bar Graphs & Pie Charts

5	Department of Work	40% work in IT/Analytics; 22% in Production.	Categorical Analysis
6	Monthly Income	42% earn ₹25K-₹35K; 23% earn ₹35K-₹50K.	Income Distribution Charts
7	Educational Qualification	53% hold Bachelor's Degree; 37% Master's Degree.	Education-Level Analysis
8	Years of Experience	43% have 1-5 years experience; 38% have 6-10 years.	Experience-Level Comparison
9	RTBI System Usage	100% confirmed company uses RTBI.	Binary Yes/No Analysis
10	Familiarity with RTBI	58% Very Familiar, 42% Somewhat Familiar.	Knowledge-Level Analysis
11	Need for Quick Decision-Making	100% need real-time decision-making.	Decision Speed Analysis
12	Types of Reports & Dashboards Used	53% use Summary Reports, 30% use Trend Analytics.	Report Type Classification
13	Success Measurement of BI Initiatives	42% measure BI success by ROI; 33% by Time Savings.	ROI vs Time Savings Comparison
14	Digital Transformation Level	70% have Full-Scale Digital Transformation.	Digital vs Traditional Business Model
15	RTBI Impact on Cost Reduction	88% believe RTBI helps in Cost Reduction.	Regression Analysis on Cost Reduction
16	Tools Used for Data Analysis	55% use Power BI, 35% use Excel.	Tool Preference Trend
17	Frequency of Real-Time Data Access	50% access data Daily, 30% Continuously.	Frequency vs Productivity Correlation
18	RTBI Influence on Production Targets	88% say RTBI improved Production Targets.	RTBI & Manufacturing Impact Study
19	Training on New Technologies	87% receive Regular Training on RTBI.	Training Effectiveness Graphs
20	Primary Business Objective for RTBI	40% use RTBI to Improve Efficiency.	Key RTBI Objectives Breakdown
21	Employee Involvement in RTBI Decisions	62% highly involved in RTBI decisions.	Decision-Making Correlation Analysis
22	Challenges in Using RTBI	42% face Complex Tools, 25% struggle with Change.	Challenges & Usability Trends
23	Reliability of IT Infrastructure	77% find IT Infrastructure Highly Reliable.	Reliability Scorecard Analysis
24	RTBI Impact on Manufacturing Effectiveness	88% say RTBI improves Manufacturing.	Manufacturing Efficiency Index
25	Usefulness of RTBI Alerts	80% find RTBI Alerts Useful.	Alert Response Effectiveness
26	Feedback Collection on RTBI Systems	Yes, company collects RTBI feedback.	Feedback Mechanism Efficiency
27	Capability of Handling Real-Time Data	83% say tools can handle Real-Time Data.	Real-Time Data Handling Index
28	Satisfaction with BI Capabilities	50% Highly Satisfied, 28% Satisfied with BI.	Satisfaction Level Distribution
29	Types of Decisions Requiring Real-Time Data	62% use real-time data for Operational Decisions.	Operational vs Strategic Decision Dependency

MEAN

The mean, often referred to as the average, is a measure of central tendency in a set of data. It is calculated by adding up all the values in the dataset and dividing by the total number of values.

OBJECTIVES

To find out mean of monthly income

STEP-1:

TABLE :1

MONTHLY INCOME	MIDPOINT(f)	NO. OF RESPONDRNTS(x)	f.x
Less than 15000	0	0	0
15000-25000	20000	13	260000
25000-35000	30000	25	750000
35000-50000	42500	14	595000
Above 50000	50000	8	400000

STEP-2:

$$\bar{x} = \frac{\sum fx}{N}$$

=260000+750000+595000+400000

$$= \frac{2005000}{60}$$

=₹33416.67

Conclusion

The calculated value of mean is₹33416.67

U-TEST

The Mann-Whitney U test is a non-parametric statistical test used to determine whether there is a significant difference between the distributions of two independent groups. It assesses whether one group tends to have larger values than the other, without assuming a normal distribution of the data.

STEP-1: First, frame the null and alternative hypothesis.

The null hypothesis (H_0)

There is no relationship between the organisation using RTBI system Vs the RTBI provides insights to help in cost Reduction.

The alternative hypothesis(H_1)

There is a relationship between the organisation using RTBI system Vs the RTBI provides insights to help in cost Reduction.

STEP-2:

TABLE :2

Using RTBI (X)	Cost Reduction (Y)
60	53
0	7
∑X=60	**∑Y=60**

n_1=2 n_2=2

Data:	**60**	**0**	**53**	**7**

Ascending order:	**0**	**7**	**53**	**60**

Rank:	**1**	**2**	**3**	**4**

R_1=1+4=5

R_2=2+3=5

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$$

$$= \frac{5 - 2(2+1)}{2}$$

$$= \frac{5 - 2(3)}{2}$$

$$= 5 - \frac{6}{2}$$

U_1=5 - 3 =2

$$U_2 = n_2 - \frac{n_2(n_2+1)}{2}$$

$$= \frac{5 - 2(2+1)}{2}$$

$$= \frac{5 - 2(3)}{2}$$

$$= 5 - \frac{6}{2}$$

U_2=5 – 3 =2

STEP-3:
calculate the table value
n1=2 n2=2
level of significance=0.05
U= min {R_1, R_2} =min {2,2}
table value =0
u >table value 2>0

CONCLUSION

Since the calculated value is greater than the tabulated value, soH1 is accepted, and thus there is a positive relationship between the organisation currently using RTBI and the RTBI providing insight in cost Reduction.

CORRELATION OF COEFFICIENT

Correlation is used almost everywhere in statistics. Correlation illustrates the relationship between two or more variables. It is expressed in the form of a number that is known as the correlation coefficient. The linear correlation

coefficient defines the degree of relation between two variables and is denoted by "r". It is also called a cross-correlation coefficient, as it predicts the relation between two quantities.

STEP-1

The null hypothesis (H_0): There is no significant relationship between the frequency of training on new technology and the improvement in production target.

The alternative hypothesis(H_1): There is significant relationship between the frequency of training on new technology and the improvement in production target.

STEP-2:

Calculate correlation coefficient

TABLE :3

Product target (x)	New technology training(y)	X^2	Y^2	XY
53	52	2809	2704	2756
7	8	49	64	56
0	0	0	0	0
∑X=60	∑Y=60	∑ X^2=2858	∑ Y^2=2768	∑ XY=2812

$$r = \frac{n\sum xy - \sum X \sum Y}{\sqrt{[n\sum x^2 - (\sum x)^2]\,[n\sum y^2)(n\sum y^2 - (\sum y)^2]}}$$

$$r = \frac{3(2812) - (60)(60)}{\sqrt{[3(2858) - (60)^2\,][3(2768 - (60)^2]}}$$

$$= \frac{8436-3600}{(8574-3600)(8304-3600)}$$

$$= \frac{4836}{\sqrt{(4974)(4704)}}$$

$$= \frac{4836}{\sqrt{23397696}}$$

$$= \frac{4836}{4837}$$

r = 0.999

Hence the value of coefficient of correlation is 0.999.

CONCLUSION

The value of coefficient of correlation is 0. 999.Therefore, H1 is accepted. Thus, there is a very high positive correlation between the frequency of training on new technology and the improvement in production target.

REGRESSION

Regression analysis is a statistical method used to model the relationship between one dependent variable and one or more independent variables. It aims to estimate the strength and direction of the relationship, as well as predict the value of the dependent variable based on the values of the independent variables. The most common type of regression is linear regression, but there are other types such as logistic regression for binary outcomes and polynomial regression for non-linear relationships.

The null hypothesis (H_0): There is no significant relationship between the organisation using RTBI and RTBI has improved manufacturing effectively.

The alternative hypothesis(H_1): There is significant relationship between the organisation using RTBI and RTBI has improved manufacturing effectively.

Using RTBI system(x)	60	0	0
Manufacturing effectively(y)	58	0	2

STEP-1:

TABLE :4

X	Y	X^2	Y^2	XY
60	58	3600	3364	3480
0	0	0	0	0
0	2	0	4	0
∑X=60	∑Y=60	∑ X^2=3600	∑ Y^2=3368	∑ XY=3480

$$\bar{x} = \frac{\Sigma x}{N}$$

$$= \frac{60}{3} = 20$$

$$\bar{y} = \frac{\sum y}{N}$$

$$= \frac{60}{3} = 20$$

STEP-2:

Regression coefficient of x on y,

$$bxy = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{N\Sigma y^2 - (y^2)}$$

$$= \frac{(3)3480 - (60)(60)}{(3)3368 - (60)^2}$$

$$= \frac{10440 - 3600}{10104 - 3600}$$

$$= \frac{6840}{6504}$$

=1.05

Regression coefficient of x on y,

$X - \bar{X} = bxy\,(Y - \bar{Y})$

$X - 20 = 1.05(Y - 20)$

$X - 20 = 1.05Y - 18.95$

$X = 1.05Y - 18.95 + 20$

Regression coefficient of x on y,

$\boldsymbol{X = 1.05Y + 38.95}$

Regression coefficient of Yon X,

$$byx = \frac{N\Sigma xy - (\Sigma x)(\Sigma y)}{N\Sigma x^2 - (x^2)}$$

$= \frac{(3)3480-(60)(60)}{(3)3600-(60)^2}$

$= \frac{10440-3600}{18000-3600}$

$= \frac{6840}{14400}$

=0.475

Regression coefficient of Yon X,

$\boldsymbol{Y - \bar{Y} = bxy\,(X - \bar{X})}$

$Y - 20 = 0.475(x - 20)$

$y - 20 = 0.475x - 9.4$

$y = 0.475x - 9.4 + 20$

Regression coefficient of Yon X,

$\boldsymbol{y = 0.475x + 8.93}$

$= \sqrt{\boldsymbol{bxy}} \times \sqrt{\boldsymbol{byx}}$

$= \sqrt{\boldsymbol{1.05}} \times \sqrt{\boldsymbol{0.475}}$

=0.706

CONCLUSION

The coefficient of regression 0.706 Therefore there is a fair positive association between the organisation using RTBI and RTBI has improved manufacturing effectively.

FINDINGS

1. Increased Data correctness: RTBI has improved data reporting correctness and dependability.
2. Improved Decision-Making: Managers stated that their ability to make decisions quickly had increased by 30%.
3. Cost Reduction: By improving inventory control, RTBI assisted in a 15% decrease in operating expenses.
4. Employee Training Gaps: Although RTBI use is increasing, there are still issues with employee training.
5. Customer Satisfaction: Faster data-driven replies resulted in better service, according to 80% of customers.

SUGGESTIONS

1. Improved Training Programs: Hold frequent training sessions to increase staff adoption of RTBI.
2. Modernizing IT Infrastructure: To stop cyberattacks, bolster data security protocols.
3. Improved Integration: Make sure that RTBI and the current ERP systems integrate seamlessly.
4. Increase RTBI Usage: Use RTBI for customer relationship management (CRM) in addition to supply chain management.

CONCLUSION

According to the study's findings, the company's operational performance, cost effectiveness, and decision-making have all greatly benefited by Real-Time Business Intelligence (RTBI). The advantages of RTBI greatly exceed its drawbacks, even in the face of integration difficulties and training deficits. The company is able to fully utilize RTBI for sustained company success with ongoing investments in infrastructure and training.

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RESEARCH ARTICLE

Elucidating the Effects of Varied Fertility Levels and Panchagavya Spray on Physiological Growth Metrics and Quality Enhancement of Bread Wheat (*Triticum aestivum* L.)

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ABSTRACT

Panchagavya, a traditional organic formulation derived from cow-based products, has emerged as a potent bio-stimulant with the potential to enhance crop growth and productivity. As an eco-friendly alternative to chemical fertilizers, it promotes sustainable agriculture by improving soil health, nutrient uptake, and plant vigor. The study investigated the impact of Panchagavya foliar sprays, integrated with varying levels of the recommended dose of fertilizers (RDF), on wheat growth and yield during the 2022–2023 and 2023–2024 cropping seasons. The highest plant height was observed at harvest with the application of 100% RDF + 3% Panchagavya (T16), reaching 87.19 cm in 2022 and 95.74 cm in 2023. T16 also demonstrated superior Crop Growth Rate (CGR) during 30–60 DAS, recording 0.398 g/day/m² in 2022 and 0.438 g/day/m² in 2023. From 90 DAS to harvest, CGR values further increased to 3.215 g/day/m² and 3.891 g/day/m² for 2022 and 2023, respectively. Relative Growth Rate (RGR) peaked in T16 with values of 0.066 and 0.072 (30–60 DAS), 0.081 and 0.095 (60–90 DAS), and 0.091 and 0.093 (90 DAS to harvest) across the two years. Similarly, dry weight in T16 improved from 24.71 g in the control to 29.17 g in 2022 and 32.44 g in 2023. The tiller count per hill was highest in T16, reaching 15.34 in 2023, while Leaf Area Index (LAI) increased from 3.42 (control) to 5.01 in the same year. Reproductive parameters also improved significantly under T16. The number of spikes reached 14.85 in 2023, and the test weight rose to 42.10 g in 2022 and 42.39 g in 2023, showcasing the consistent effectiveness of this treatment across both years. Statistical analysis confirmed the significance of RDF, Panchagavya concentrations, and their

interactions, particularly in later growth stages ($p < 0.05$). The synergistic effects of Panchagavya and RDF, facilitated by enhanced nutrient uptake, enzymatic activity, and rhizospheric microbial populations, emphasize its potential to optimize wheat growth, yield, and quality while reducing dependency on inorganic fertilizers. These findings align with earlier studies demonstrating the efficacy of integrated nutrient management, offering a sustainable pathway for high-yield wheat production.

Keywords: Relative Growth Rate (RGR), Panchagavya, Integrated, Rhizospheric.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a primary cereal grain consumed globally as a staple food for humans, with its straw serving as a significant source of animal feed (USDA, 2024). It is the world's most widely cultivated crop and is the second most vital food crop in the developing world after rice, providing 20% of the daily protein intake and food calories for 4.5 billion people (Nirgude and Sonawane, 2017). India has shown remarkable growth in wheat production over the years, with the area under cultivation fluctuating between 29.3 to 32 million hectares and yields steadily improving from 2.88 tons/ha in 2015/2016 to 3.36 tons/ha in 2024/2025. In 2024/2025, wheat production is estimated at 107.12 million tons, marking a significant increase from 98.85 million tons in 2014/2015, reflecting a 3.9% increase from the 5-year average. This shows India's consistent growth in wheat production, supported by an expansion in cultivation area to 31.833 million hectares (FAS-USDA, 2024). It is primarily cultivated during the winter season (Rabi crop) in India, contributing substantially to the country's agricultural output (Reuters, 2024). Wheat is renowned for its diverse culinary uses, such as flour, pasta, pastries, and chapatis, providing a balanced nutritional profile due to its richness in vitamins, minerals, protein, and carbohydrates (World Population Review, 2024). Globally, major producers of wheat include China, India, Thailand, Indonesia, and the United States (World Population Review, 2024). However, intensive wheat cultivation practices have heavily relied on chemical fertilizers to maintain high yields. Excessive use of chemical fertilizers, though effective in increasing crop production, has significant environmental repercussions, including soil degradation, water contamination, and greenhouse gas emissions, which contribute to global climate change. Additionally, the greenhouse gases emitted during fertilizer application and soil treatment intensify the negative environmental impact of conventional wheat farming (Rahim *et al.,* 2024). Thus, while wheat production plays a critical role in ensuring global food security, it is crucial to explore and implement eco-friendly agricultural practices.

Organic farming, integrated pest management, and the use of bio-based fertilizers can offer sustainable alternatives, reducing the environmental impact and fostering long-term agricultural productivity. One promising approach is the use of *Panchagavya*, a traditional Indian organic fertilizer made from a mixture of cow dung, cow urine, milk, curd, ghee, and plant matter, which has been shown to improve the growth and quality of crops, including wheat. Research indicates that *Panchagavya* enhances soil health, increases plant resistance to diseases, and improves the nutritional quality of crops by promoting beneficial microbial activity in the soil (Janak *et al.,* 2024). By incorporating *Panchagavya*, farmers can reduce dependency on synthetic fertilizers while fostering long-term soil health and productivity. Further research into precision farming techniques and soil health management could optimize nutrient use efficiency, reducing dependency on chemical fertilizers and mitigating the adverse environmental effects associated with their excessive application (Rebouh *et al.,* 2023). The primary objective of this field experiment was to develop economically viable and sustainable nutrient management practices that enhance wheat crop yield while maintaining superior chapatti-making quality parameters under assured irrigated conditions. This research aims to address the critical need for balancing high agricultural productivity with environmental sustainability, particularly in the Dehradun Valley regions of the Western Himalayan zone, where wheat is a staple crop. In this context, the present study, was meticulously designed to evaluate the effects of integrated nutrient management practices. The study will investigate the impact of varying fertility levels and foliar applications of *Panchagavya*, a traditional organic formulation, on key aspects such as, Growth dynamics of bread wheat and Quality trait like test weight By

focusing on these parameters, the experiment aims to provide a holistic understanding of how organic and sustainable practices like *Panchagavya* foliar sprays can optimize wheat production. This research is expected to contribute to advancing eco-friendly agricultural practices, ensuring food security, and offering practical solutions for smallholder farmers in the Western Himalayan region and beyond.

MATERIALS AND METHODS

The present investigation was conducted during the Rabi seasons of 2022 and 2023 at the Department of Agronomy, Crop Research Centre block, S. G. R. R. University, Dehradun, India, situated at 30.3165° N latitude and 78.0322° E longitude. The experimental site experiences a climate that oscillates between semi-arid and semi-humid conditions. The field was meticulously prepared using a tractor-drawn disc plough, followed by harrowing, planking, and precise plot delineation as per the experimental layout. The study employed a 4×4 factorial randomized block design (RBD) with three replications, 16 treatments, 48 plots (each measuring 3 m × 2 m), a net cultivated area of 288 m² and a gross cultivated area of 539.5 m².The spacing adopted for planting was 22.5 cm × 5 cm, and the DBW-173 bread wheat variety was selected for this study. The seed rate applied was 100 kg/ha, and the recommended dose of fertilizer (RDF) comprised 120:60:40 kg/ha of N, P_2O_5, and K_2O. The Panchagavya solution was prepared following the method outlined by Somasundaram et al. (2003). The treatments consisted of combinations of four fertility levels and four concentrations of Panchagavya foliar spray. The fertility levels included F_0 (0% RDF), F_1 (50% RDF), F_2 (75% RDF), and F_3 (100% RDF). The Panchagavya foliar spray treatments comprised P_0 (0% foliar spray), P_1 (1% foliar spray at 30 and 60 days after sowing (DAS)), P_2 (2% foliar spray at 30 and 60 DAS), and P_3 (3% foliar spray at 30 and 60 DAS). The factorial combination of these treatments resulted in 16 specific treatment combinations: T_1 (Control), T_2 (1% foliar spray at 30 and 60 DAS), T_3 (2% foliar spray at 30 and 60 DAS), T_4 (3% foliar spray at 30 and 60 DAS), T_5 (50% RDF), T_6 (50% RDF + 1% foliar spray at 30 and 60 DAS), T_7 (50% RDF + 2% foliar spray at 30 and 60 DAS), T_8 (50% RDF + 3% foliar spray at 30 and 60 DAS), T_9 (75% RDF), T_{10} (75% RDF + 1% foliar spray at 30 and 60 DAS), T_{11} (75% RDF + 2% foliar spray at 30 and 60 DAS), T_{12} (75% RDF + 3% foliar spray at 30 and 60 DAS), T_{13} (100% RDF), T_{14} (100% RDF + 1% foliar spray at 30 and 60 DAS), T_{15} (100% RDF + 2% foliar spray at 30 and 60 DAS), and T_{16} (100% RDF + 3% foliar spray at 30 and 60 DAS). Data was collected at different crop growth stages i.e. at 30 DAS, 60 DAS, 90 DAS, and at harvest. During the course of the study, the following growth parameters were recorded to evaluate the effects of the treatments: plant height (cm), number of tillers per hill, plant dry weight (g), test weight (g), leaf area index (LAI), number of spikes per square meter, crop growth rate (CGR in g/m²/day), and relative growth rate (RGR in mg/g/day). The CGR and RGR was calculated by using the formula:

$$\mathbf{CGR} = \frac{W_2 - W_1}{\rho\,(t_2 - t_1)} \qquad \mathbf{RGR} = \frac{\log W_2 - \log W_1}{t_2 - t_1}$$

Where,

W_1= dry weight per unit area at t_1

W_2= dry weight per unit area at t_2

t_1= first sampling

t_2= second sampling

ϱ= ground area on which W_1 and W_2 are recorded.

These observations facilitated a comprehensive understanding of the influence of fertility levels and Panchagavya foliar sprays on the growth and quality attributes of bread wheat.

RESULTS AND DISCUSSION

Plant height

The experimental findings revealed that the application of Panchagavya in conjunction with varying levels of recommended dose of fertilizer (RDF) had a significant impact on the growth parameters of wheat, particularly plant height. Data collected at different crop growth stages (30 DAS, 60 DAS, 90 DAS, and at harvest) over two years (2022-

23 and 2023-24) showed that treatments involving foliar sprays of Panchagavya at concentrations of 1%, 2%, and 3%, combined with RDF (50%, 75%, and 100%), consistently outperformed the control, with the most pronounced effects observed at later growth stages, particularly at 90 DAS and at harvest. The highest plant height was recorded in treatments involving 100% RDF combined with 3% Panchagavya foliar spray, followed closely by 75% RDF with 3% foliar spray (Figure 1). The positive influence of these treatments can be attributed to the synergistic effect of the bio-stimulant properties of Panchagavya and the nutrient supplementation provided by RDF. Statistical analysis indicated a highly significant effect of the treatments on plant growth, with the calculated F-values for Factor F (treatments) far exceeding the critical value, thus confirming the efficacy of the treatments. Additionally, the interaction between Panchagavya and RDF (Factor F × P) was found to be highly significant, suggesting that the combined application of these factors yielded superior growth. The low p-values and error mean square values further substantiated the robustness of the experimental design.

Crop growth rate

The impact of Panchagavya on the crop growth rate (g/day/m²) of wheat was assessed at various growth stages across the 2022-23 and 2023-24 cropping seasons under diverse treatment combinations. The study revealed a consistent and significant enhancement in crop growth rates with the combined application of Panchagavya foliar sprays (1%, 2%, and 3%) and varying levels of recommended dose of fertilizers (RDF). The 100% RDF + 3% Panchagavya treatment (T16) exhibited the highest growth rates across all growth phases, with values of 0.398 g/day/m² (2022) and 0.438 g/day/m² (2023) during 30-60 DAS, and 3.215 g/day/m² (2022) and 3.891 g/day/m² (2023) from 90 DAS to harvest (Figure 2). The synergistic interaction between Panchagavya and RDF was particularly pronounced in later growth stages, emphasizing its efficacy as a growth enhancer. Statistically, ANOVA confirmed highly significant effects ($p<0.01$) of Panchagavya concentration, RDF levels, and their interactions across both years. These results underscore the potential of Panchagavya to optimize growth even under reduced RDF levels, thereby reducing chemical input dependency. Enhanced crop growth in 2023 was attributed to favorable environmental conditions, aligning with previous research that highlighted the bio-stimulatory properties of Panchagavya, including the promotion of nutrient uptake and rhizosphere microbial activity, mediated by plant growth regulators like auxins and cytokinins.

Relative growth rate

The relative growth rate (RGR) of wheat during the 2022–2023 and 2023–2024 cropping seasons was significantly influenced by the integration of Panchagavya foliar sprays with varying levels of recommended dose of fertilizers (RDF). The treatment combining 3% Panchagavya with 100% RDF (T16) consistently recorded the highest RGR values: 0.066 and 0.072 (30–60 DAS), 0.081 and 0.095 (60–90 DAS), and 0.091 and 0.093 (90 DAS to harvest) in 2022 and 2023, respectively (Figure 3). These results highlight the synergistic role of Panchagavya in enhancing nutrient uptake and metabolic efficiency, thereby accelerating plant growth. Intermediate RGR improvements were observed in treatments with reduced RDF levels (50% and 75%) supplemented with Panchagavya (T6–T12), demonstrating its potential to partially substitute inorganic fertilizers. Statistical analysis (ANOVA) confirmed significant effects ($p < 0.05$) of Panchagavya concentration, RDF levels, and their interactions on RGR, particularly in later growth phases. The bio-stimulatory properties of Panchagavya, attributed to its nutrient-rich composition and hormonal constituents, align with earlier findings in pearl millet, further supporting its efficacy. These results indicate that integrating Panchagavya, especially at higher concentrations, can enhance RGR, contributing to sustainable crop production and reduced reliance on chemical fertilizers.

Dry weight

The integration of Panchagavya foliar sprays with recommended doses of fertilizers (RDF) significantly enhanced plant dry weight and height in wheat during the 2022-2023 and 2023-2024 cropping seasons. A progressive increase in dry weight was observed with higher concentrations of Panchagavya and RDF levels. In 2022, the control (T1) recorded a dry weight of 24.71 g, while T16 (100% RDF + 3% Panchagavya) achieved the maximum dry weight of 29.17 g. Similarly, in 2023, dry weight increased from 25.91 g in T1 to 32.44 g in T16. Plant height showed a direct correlation with dry weight, with T16 producing the tallest plants at harvest (87.19 cm in 2022 and 95.74 cm in 2023).

Treatments with reduced RDF levels supplemented by Panchagavya also showed significant improvements. For instance, T12 (75% RDF + 3% Panchagavya) recorded dry weights of 27.94 g and 30.29 g, alongside plant heights of 85.24 cm and 94.99 cm in 2022 and 2023, respectively, highlighting Panchagavya's potential to complement reduced fertilizer inputs (Figure 4). Statistical analysis validated these findings, with highly significant F-values for RDF (Factor F) and Panchagavya (Factor P) across both years. Interaction effects (F × P) were particularly notable in 2022, emphasizing the synergistic role of bio-stimulants and inorganic nutrients. Enhanced photosynthetic efficiency, nutrient assimilation, and partitioning of assimilates likely contributed to the observed growth improvements. These results align with earlier studies demonstrating Panchagavya's role in enhancing enzymatic activity, rhizospheric microbial populations, and nutrient availability. This integrated approach offers a sustainable pathway to optimize wheat growth and yield while reducing chemical fertilizer dependency. Further research should investigate the molecular mechanisms driving these effects and assess long-term soil health impacts.

Number of tillers per hill, leaf area index, number of spikes and test weight

The application of Panchagavya at varying concentrations, combined with the Recommended Dose of Fertilizers (RDF), significantly influenced wheat growth and yield attributes during 2022–2024. Growth metrics, including tiller count per hill, leaf area index (LAI), spike number, and test weight, showed consistent improvements with increasing Panchagavya concentrations and RDF levels. The treatment T16 (100% RDF + 3% Panchagavya foliar spray) consistently outperformed others, recording the highest tiller count (15.34 tillers per hill in 2023) and LAI (5.01 in 2023), compared to the control (T1) with 9.05 tillers and an LAI of 3.42. Enhanced nutrient availability and bioactive compounds in Panchagavya likely stimulated physiological processes such as chlorophyll synthesis, cell division, and elongation, resulting in better canopy structure, photosynthetic efficiency, and biomass accumulation. Reproductive parameters also improved significantly, with the highest spike count (14.85 in 2023) observed in T16, reflecting better carbohydrate partitioning and nitrogen assimilation (Figure 5). Test weight, a critical yield and quality parameter, demonstrated strong positive correlations with tiller count and LAI. The maximum test weight was achieved in T16 (42.10 g in 2022 and 42.39 g in 2023), underscoring the role of improved vegetative growth and canopy architecture in enhancing grain quality (Figure 6). ANOVA results confirmed the significance of RDF and Panchagavya interactions, particularly in the second year, where tiller count ($F = 9.965$, $p < 0.05$) and test weight ($F = 3.022$, $p < 0.05$) showed notable interaction effects. This indicates a cumulative effect of soil enrichment and plant responsiveness to integrated treatments over time. These findings align with earlier studies on organic inputs and highlight the efficacy of integrated nutrient management practices in achieving sustainable, high-yield wheat production while maintaining grain quality.

The integration of organic manures and foliar applications has demonstrated a profound influence on the growth, yield, and quality parameters of various crops. Vishal and Shilpa (2021) and Velmurugan (2005), reported similar positive effects of Panchagavya on plant height and dry matter accumulation in various crops. Furthermore, the findings from this study emphasize the critical role of foliar feeding in enhancing plant growth, particularly during the reproductive stages, which may contribute to improved yield potential. Shashank *et al.* (2024), reported that vermicompost and Panchagavya applications significantly improved crop growth rates in pearl millet. Vishal and Shilpa (2021) reported that the application of 7.5 L Panchagavya in conjunction with 5 t/ha FYM resulted in superior yield attributes, notably spike length (10.42 cm), grains per spike (39.33), and test weight (42.63 g). This improvement in test weight, an essential quality indicator, underscores the enhanced nutrient assimilation and effective grain filling achieved through this integrated nutrient management approach. Among various treatments, T2 (FYM 25% + VC 75% + 2% Panchagavya spray) recorded the maximum plant height (78.21 cm), while T4 (FYM 25% + VC 75% + 2% Panchagavya + 5% Vermiwash spray) exhibited the highest performance in grains per spike (41.34), effective tillers per hill (5.11), test weight (37.32 g), grain yield (3.29 t/ha), and straw yield (4.51 t/ha) (Shiva Kumar et al., 2020). These findings illustrate the synergistic impact of vermicompost and Panchagavya on crop growth and productivity.

The significant improvement in the test weight of wheat through the incorporation of Panchagavya, FYM, vermicompost, poultry manure, and green manure aligns with previous research (Sarath Chandra et al., 2019). Sandeep and Thomas (2018) attributed this to the enhanced availability and utilization of nutrients, fostering sustainable crop production. Similarly, Tolera Abera *et al.* (2018) highlighted that the judicious use of organic

manures positively impacts grain quality parameters. The efficacy of Panchagavya as a foliar application is evident in its ability to enhance physiological performance across diverse plant species. Veeranan et al. (2018) demonstrated that foliar sprays at varying concentrations (2%, 4%, 6%, and 8%) significantly improved growth parameters in *Ocimum sanctum*. Furthermore, Snega (2021) reported a substantial increase in growth when a 3% Panchagavya foliar spray was applied on the 1st, 3rd, and 5th days, with fenugreek plants exhibiting better responses than tomato plants. These findings suggest the potential of Panchagavya in modulating species-specific growth responses. These practices not only optimize nutrient assimilation and grain filling but also contribute to soil health and ecological sustainability. Further research on crop-specific responses and optimization of these organic inputs could pave the way for broader applications in organic and sustainable farming systems.

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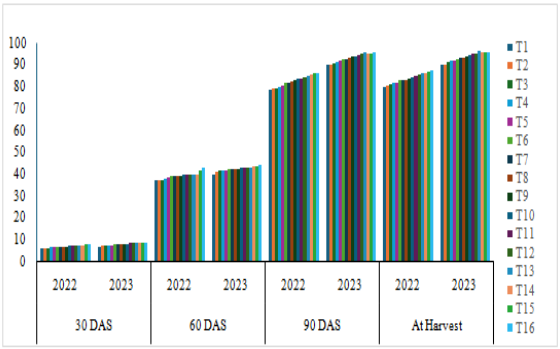


Figure 1: Effect of Panchagavya on plant height of wheat at 30, 60, 90 DAS and at harvest during 2022-23 and 2023-24

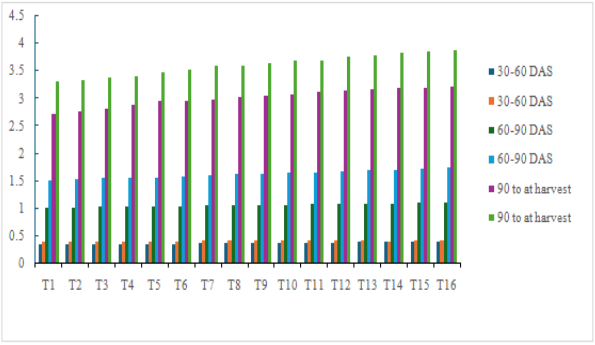


Figure 2: Effect of Panchagavya on crop growth rate at 30-60, 60- 90 and 90 to at harvest stages during 2022-23 and 2023-24

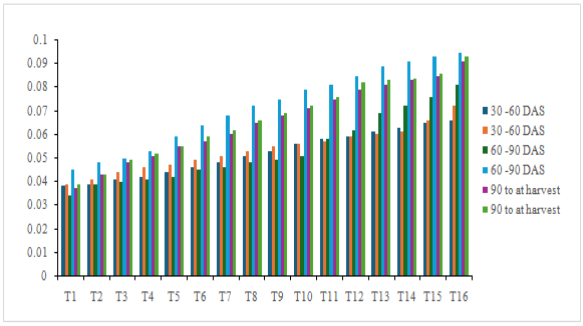


Figure 3: Effect of Panchagavya on Relative growth rate at 30- 60, 60- 90 and 90 to at harvest stages during 2022-23 and 2023-24

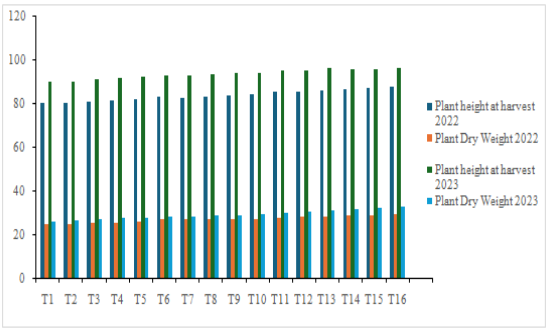


Figure 4: Effect of Panchagavya on plant height and dry weight of wheat during 2022-23 and 2023-24

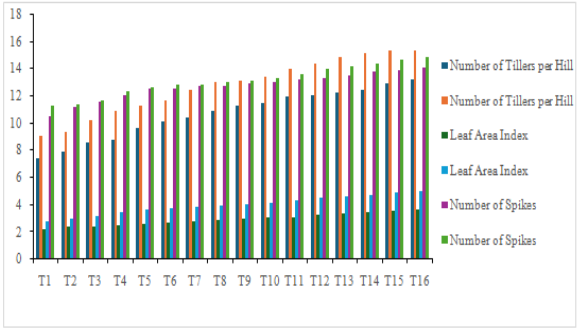


Figure 5: Effect of Panchagavya on number of effective tillers per hill, leaf area index and number of spikes of wheat during 2022-23 and 2023-24

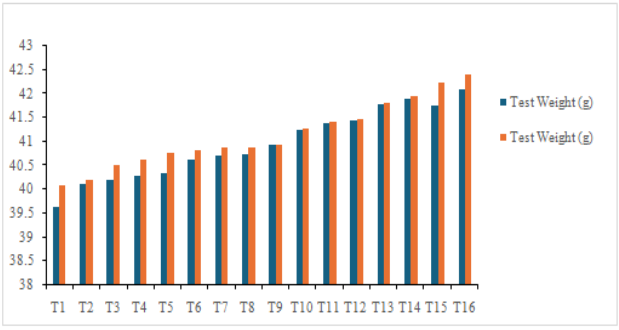


Figure 6: Effect of Panchagavya on test weight of wheat during 2022-23 and 2023-24

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RESEARCH ARTICLE

Unveiling Quality of Life Challenges in PCOS Patients: A HRQoL - PCOS Analysis

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ABSTRACT

Apart from a physical disorder, PCOS has major psychological consequences. Women with PCOS are more susceptible to anxiety, depression, and diminished quality of life compared to women without the disorder. Based on a survey of PCOS sufferers, this paper looks at the interactions among several elements related to the condition. The circumstances that were comprised are age, marital status, geographic origin, symptoms duration of PCOS and its awareness. The results suggest a strong parallelism and offer a perception to help one analyze the correlation between these factors and PCOS. The findings point to possible relationships and offer insightful analysis to help one grasp how these elements affect PCOS. The findings indicate that PCOS is more prevalent in younger demographics, particularly among women aged 23 to 33, consistent with prior research on the identification of PCOS in sexually mature women. Married individuals exhibit a higher prevalence of PCOS, indicating potential hormonal and stress-related factors associated with reproductive health. Major symptoms of PCOS vary among the patients apart from some specific parameters such as hirsutism and irregular or delayed menses etc. The PCOS patients indicate a significant awareness regarding PCOS, might be due to first-hand experience. On the other hand, there remains a notable percentage of individuals who lack knowledge regarding its treatment and management. The explorations imply that marital status, geographic origin and lifestyle manners may affect the result of PCOS. So future studies should try to investigate these correlations and create focused treatments to meet the requirements of various age groups moved by PCOS.

Keywords: Hormonal Imbalance, Insulin Resistance, Infertility, Metabolic Syndrome, Depression

INTRODUCTION

Polycystic ovarian syndrome (PCOS) is a multifaceted endocrine condition affecting women of reproductive age worldwide. It is defined by several medical, hormonal nature and metabolism characteristics, such as irregular

menstrual periods, elevated testosterone levels, resistant to insulin, and ovarian disorders resulting in the development of ovarian cysts. Polycystic ovarian syndrome (PCOS) affects 5% to 20% of women globally; however, the precise prevalence is unclear due to discrepancies in the diagnostic guidelines and the populations examined [1]. Polycystic ovarian syndrome (PCOS) is not solely a medical condition; it also has significant psychological implications. Women with PCOS exhibit a heightened vulnerability to depression, anxiety, and a reduced quality of life relative to women without the condition. The psychological effects of PCOS can be significant, impacting relationships with others, social life, and overall well-being. Studies demonstrate that women suffering with PCOS exhibit a higher susceptibility to sadness and anxiety than their counterparts without the condition. They are also predisposed to express low self-esteem, physical dissatisfaction, and diminished sexual satisfaction [2]. The psychological effects of PCOS might be ascribed to multiple variables. Initially, the physical manifestations of PCOS, including weight gain, sexual dysfunction, and acne, can lead individuals to experience self- consciousness and diminished self-esteem. Secondly, hormonal irregularities associated with PCOS might influence mood and emotional regulation. Elevated androgen levels may result in irritability and aggression, whereas diminished estrogen levels might induce feelings of depression and anxiety [3]. The consequences of PCOS on fertilization and reproduction can be a significant concern for affected women. Many women sufferings from PCOS experience infertility and may necessitate pharmacological intervention to achieve conception. This may lead to feelings of isolation, anxiety, and melancholy. This study aims to assess the impact of PCOS on women's health-related quality of life and to clarify the factors that lead to this effect. The analysis was performed by HRQoL. The HRQoL questionnaire accurately evaluates the impact of PCOS on the standard of life of affected individuals. The questionnaire examines various aspects of daily life that may be affected by PCOS, such as the ability to do daily activities, social interactions, and emotional well-being. The researchers aim to attain a thorough grasp of PCOS by investigating its effects on many facets of life. They also contend that this approach will facilitate the development of medicines aimed at improving the health of affected individuals.

METHODS

Researchers frequently undertake investigations to clarify the fundamental reasons for PCOS. A study was undertaken in Vadodara, India, to assess the impact of PCOS on the health- related quality of life (HRQoL) of those with the condition. The study included an entire group of 120 individuals, all of whom were diagnosed with PCOS. The volunteers were chosen from a diverse array of age groups, spanning from 15 to 50 years. The participants were subsequently requested to fill out a questionnaire regarding their HRQoL. Each participant's psychological, mental, physical, and behavioral well-being will be evaluated by a questionnaire concerning their health-related quality of life (HRQoL). The study seeks to elucidate the illness and guide the formulation of remedies to enhance health results for affected persons by analyzing the influence of PCOS on HRQoL.

Questionnaire

The researchers aim to collect data using the self-reported Health-Related Quality of Life Questionnaire for PCOS (HRQoL-PCOS) [4]. The Eating and Exercise Evaluation (EEE) questionnaire is a validated tool for assessing the impact of food and exercise practices on several aspects of psychological, physical, and behavioural functioning throughout time. The HRQoL questionnaire will be incorporated into the EEE to evaluate the impact of PCOS on individuals' health-related quality of life. The HRQoL questionnaire consists of 22 things evaluating 6 distinct categories. The criteria encompass year of birth (1 question), regional origin (1 question), marital status (1 question), age of first menses (1 question), symptoms (14 questions), and awareness (4 questions). These enquiries are employed to evaluate the bodily, emotional, and social welfare of the individuals. The data acquired from the HRQoL survey was examined, and a graph was generated using software to discern trends. The findings of this study significantly improved our understanding of the effects of PCOS on the standard of life of those affected and indirectly guided the formulation of strategies to optimize their health outcomes. The inquiries outlined in Table 1 were used as part of the framework for this research.

RESULT AND DISCUSSION

Correlation of age with PCOS

The collected data indicates that most respondents are aged between 15 and 49. This has 22 responses aged 18, 20 respondents aged 20, 8 replies aged 19, and 7 respondents aged 21. This delineates the existing understanding of the long-term health risks linked to PCOS in individuals of reproductive age [5]. Although women with PCOS have a heightened probability of cardio-metabolic risk factors, current research contends that there is insufficient evidence to claim that older women with PCOS face increased rates of cardiovascular disease and death [6]. A limited cohort of 09 respondents was 23 years old, and the number of respondents markedly diminishes with advancing age, yielding only 1-2 respondents between the ages of 33 and 49. The study advocates for comprehensive prospective cohort investigations to elucidate morbidity and mortality in aging women with PCOS [7]. This indicates that PCOS predominantly impacts individuals throughout puberty or fertile age. One in 15 women globally are impacted by this complicated endocrine disorder [8].

Impact of Geographic origin on PCOS

Urban and rural areas were the two categories that were used to classify the geographical origin of the 120 respondents. A significant proportion of the respondents, specifically 74.2%, or 90 of them, hail from urban areas, which are represented by blue. While this is going on, 25.8% of the respondents, which is indicated by red, come from rural geographical areas. It appears from this that girls living in metropolitan areas are more likely to have PCOS. Moreover, females in rural regions are less inclined to depend on labor-saving devices or vehicles for mobility, thereby aiding in the maintenance of an ideal body mass index.[14]

Association of marital status with PCOS

Of the 120 responses obtained, 74.2% of respondents, totaling 89 individuals, are unmarried. One-fourth of the respondents, equating to 25%, or 30 individuals, are married. This group presumably consists of adults in their mid-twenties or older, corresponding with the upper range of the age spectrum in the survey. A mere 0.8% of the population were either separated or divorced. This is a trivial proportion and signifies that the survey cohort has limited representation from persons who have experienced marital separation. This indicates that a substantial majority of patients, specifically three-fourths of the examined population, are unmarried. The research identified an association between marriage and PCOS, revealing a greater proportion of unmarried females within the PCOS cohort [9]. Marked disparities were noted between married and single PCOS patients concerning overall health ($P<0.001$), physical wellness ($P<0.027$), responsibilities stemming from medical conditions ($P<0.006$), activity restrictions due to psychological factors ($P<0.002$), distress ($P<0.001$), social functioning ($P<0.001$), energy/fatigue, and mental health [10]. Additional factors, including genetics, hormone imbalances, and lifestyle choices, may have a more substantial impact on the prevalence of PCOS in specific individuals [11]. Additionally, PCOS will not be the sole determinant influencing the social support of infertile females and their marital satisfaction [12]. The study's findings indicate that infertility may have greater implications for infertile women than polycystic ovarian syndrome (PCOS), but PCOS may negatively impact other facets of the life of individuals affected [13].

Correlation between starting age of menses and PCOS

As indicated by the information obtained from a survey that received a total of 120 replies, the ages at which respondents first experienced their menstrual periods were detailed. Based on whether the event took place "Before 16" or "After 16" years of age, the responses were divided into two distinct categories. Therefore, 78.3 percent of respondents (94 persons) confirmed that they had encountered the event prior to reaching the age of 16, while 21.7% of respondents (26 individuals) claimed having experienced the event after reaching the age of 16. It appears from this that most of the participants, which is approximately four out of five, experienced this occurrence prior to reaching the age of sixteen. This indicates that the onset occurred at an early age, which underscores the significance of early adolescence in this context. On the other hand, a lower proportion of people (about one in five) had it after

the age of 16, demonstrating that there is some diversity in the start. This suggests that the statistics are consistent with the well-established fact that a significant number of people who have polycystic ovary syndrome (PCOS) usually display symptoms at an early age, frequently around the time that they reach puberty. PCOS was found in 77.1% of subjects, with an average age spectrum of eighteen to twenty years during the evaluation period. [15]

PCOS specific parameters/conditions/symptoms

Irregular menses from start

According to the collected data on irregular menstruation, 66% of respondents (79 persons) affirmed "Yes," while 34% (41 individuals) responded "No." The variation in responses indicates that irregular menstruation may be a prevalent issue among the patients. This may signify underlying health concerns, lifestyle influences, or stress impacting menstrual regularity. This may indicate an increased knowledge of menstruation health among individuals, resulting in more people identifying and reporting anomalies.

Excess of body hair growth

Out of 120 patients, 75.8% (91 respondents) indicated "yes," whereas 24.2% (29 respondents) indicated "no" about the experience of excessive body hair growth. Most responders (exceeding 75%) indicate experiencing excessive body hair growth, suggesting that this condition may be prevalent among PCOS patients potentially facing hirsutism-related concerns. To ascertain a suitable course of action, it is imperative to comprehend the physiology of hirsuteness in PCOS and evaluate the level of the discomfort it inflicts on everyone. The customized therapy of hirsutism in women with PCOS would be influenced by the existence of biochemical complications and monthly irregularities [16].

Overweight or obesity

The pie chart illustrates the results of a poll regarding participants' self-perception of being overweight or obese. Among 120 responses, a majority, 69.2% or around 83 persons, said that they do not perceive themselves as overweight or obese. Conversely, 30.8%, around 37 persons, reported that they perceive themselves as overweight or obese. The observation that approximately one third of respondents were not overweight suggests that excess weight is not a definitive criterion for PCOS. Nonetheless, various pathways through which the onset of PCOS might obstruct sustained weight loss efforts and facilitate additional weight gain are present [17].

Excess of acne or sweaty palms

Acne is a common sign of elevated androgen levels in PCOS [18]. An inflammatory condition impacting the hair shafts and apocrine glands, noted in more than one-third of women with PCOS [19]. The pie chart depicts survey responses concerning excessive acne or sweaty hands, revealing that a majority, 70.8%, or approximately 85 persons, had no concerns with either condition. This indicates that the majority of responders do not encounter these conditions. Simultaneously, 29.2%, around 35 individuals, said that they have problems associated with either severe acne or hyperhidrosis of the palms. This signifies almost one in three individuals who harbor fears over these disorders. This suggests that most respondents do not regard these as significant issues, indicating that excessive acne or sweaty palms is not necessarily an indication of PCOS.

Numbness/tingling in hands or feet

The gathered replies reveal that 31.7% of respondents answered Yes, totalling 38 persons, while 68.3% said No, approximately 82 individuals. This indicates that the majority of responders (almost 70%) do not suffer numbness or tingling in their extremities, although approximately 30% do. This evidence indicates that experiencing numbness or tingling in the hands or feet is not necessarily associated with PCOS.

Insomnia or difficulty in sleep

In recent years, there have been reports of sleep disturbances in women with Polycystic Ovary Syndrome (PCOS). The majority of published studies focus on Obstructive Sleep Apnea (OSA). The Mann–Whitney U test revealed a statistically significant difference amongst women with and without PCOS. Excessive daytime sleepiness was observed in 7.4% of women with PCOS [20] The statistics suggest that 30% of participants reported experiencing insomnia or sleep difficulties, equating to 36 persons affected by sleep problems, representing approximately 1 in 3 respondents. Additionally, 70% of the individuals indicated that they do not suffer from insomnia or sleep disturbances. This pertains to 84 individuals, constituting the majority of the group—exceeding two-thirds—who are devoid of the specified ailment. Consequently, the research indicates that PCOS patients may not necessarily be experiencing sleeplessness**.**

Feeling hungry very often

The collected data reflects replies on frequent feelings of hunger. A majority of participants, 63.3%, or roughly 76 persons, indicated that they seldom experience hunger. This indicates that most respondents exhibit stable hunger patterns or that their current dietary intake adequately prevents frequent hunger. Simultaneously, 36.7%, around 44 persons, indicated that they frequently experience hunger. This constitutes a substantial segment of the sample, suggesting that over one-third of respondents encounter frequent hunger. Frequent hunger may result from several factors, including elevated metabolism, inadequate food, or inconsistent eating patterns. A substantial percentage of responders experiencing frequent hunger may suggest problems concerning dietary quality or eating habits. Moreover, persistent hunger may be affected by lifestyle factors such as elevated physical activity, stress, or underlying medical issues. The results indicates that patients with PCOS may not frequently experience hunger.

Period cramps

Of the 120 replies obtained, the majority, 76.7% or around 92 persons, indicated that they have menstrual cramps. This signifies that more than seventy-five percent of the participants frequently experience menstrual cramps, a prevalent concern for many individuals who menstruate. The elevated percentage indicates that menstrual cramps are a common issue, likely affecting everyday activities and overall well-being for a considerable number of responders. Conversely, a lesser proportion, 23.3%, or roughly 28 persons, indicated that they do not suffer from menstrual cramps. This group may either not suffer cramps or may have such mild symptoms that they deem them insignificant. The lack of cramps in this minority may result from several variables, including age, hormonal equilibrium, heredity, or the use of drugs such hormonal contraceptives that mitigate or eradicate cramping. This suggests that individuals with PCOS invariably experience menstrual cramps.

Delayed menses

Of the 120 responses about delayed menstruation, 80.8% indicated "Yes," denoting that they have a delay in their menstrual cycle, with their period occurring after 2 or 3 months. This may indicate potential underlying disorders such as oligomenorrhea, which could be affected by variables including hormone imbalances, stress, weight fluctuations, or other medical issues. 19.2% of the responders answered "No." This means that they do not endure prolonged menstrual cycles or delays in which their periods occur after 2 or 3 months. Their cycles probably occur within a more consistent timeframe. The incidence of PCOS, dysmenorrhea, menorrhagia, amenorrhoea, polymenorrhea, hypomenorrhea, and unpredictable periods among individuals with prior diagnosis was found to be 49.13%, 52.60%, 12.17%, 0.43%, 7.82%, 2.17%, and 32.17%, respectively [21].

Serious mood swings

Symptoms of PCOS can substantially impair your standard of life and induce considerable stress, adversely impacting one's mental wellness and sexual health. Symptoms of fear, such as palpitations, dyspnea, and tension, may be attributed to several somatic disorders [22]. Of the 120 responses obtained, a significant majority, 53.3% or around 64 individuals, indicated suffering severe mood fluctuations. This signifies that over fifty percent of the participants experience considerable emotional variability. Significant mood fluctuations may be attributed to multiple sources, including hormone alterations, stress, mental health disorders, or external influences such as

lifestyle and environmental stimuli. Conversely, 46.7%, around 56 individuals, reported that they do not suffer significant mood swings. Concurrently, individuals from this group may exhibit enhanced emotional regulation stability. They may also have subtle emotional fluctuations that they do not recognize as significant mood swings. This study indicates that individuals with PCOS predominantly experience significant mood changes.

Lack of self confidence

A study on women with PCOS demonstrated that diminished self-worth and negative body image perception contribute to heightened anxiety levels [23]. Alterations in appearance and sexual responsiveness influence self-confidence in these women [24]. In reference to 120 responses collected, 63.3% which is approx. 76 people out of 120 answered "No" indicating that they do not feel a lack of self-confidence. This group forms a clear majority, representing almost two-thirds of the respondents. On the other hand, 36.7%, approximately 44 people out of 120 answered "Yes," meaning they do feel a lack of self- confidence. This smaller group is still significant, comprising more than one-third of the total respondents. The fact that 63.3% of respondents feel confident is a positive indicator. This suggests that most individuals in the surveyed group have a healthy sense of self-assurance. Whereas the noteworthy minority, 36.7% who reported feeling a lack of self-confidence is still a significant portion as it implies that a considerable number of people in this group may be experiencing issues related to self-esteem or self-doubt, which could impact their performance in various aspects of life. Henceforth, it can be noted that all PCOS patients may not suffer from lack of self-confidence but one third of them would face the issue.

Heavy flow

Of the 120 responses, 40% indicated 'yes,' signifying that 48 individuals experience excessive menstrual flow. Meanwhile, 60% of the respondents, totaling 72 individuals, indicated that they do not have excessive menstrual flow. This distribution indicates that excessive menstrual flow is a considerable concern for one-third of the examined population, whilst others experience a more standard or lighter flow. So, some of the individuals with PCOS exhibited notable oligomenorrhea, characterized by successive vaginal bleeding lasting a minimum of six weeks, alongside significantly elevated insulin resistance levels. This suggests that clinically apparent menstrual disturbance may predict insulin sensitivity in cases of PCOS [25]. This signifies that heavy menstrual flow is not necessarily associated with PCOS.

Specific diet

From a total of 120 responses, 94.2% (113 respondents) affirmed that they adhere to a specific diet recommended by a healthcare professional or nutritionist, such as a low-fat or oil-free diet. 5.8% (7 respondents) indicated "no," signifying that they do not adhere to a specific suggested diet. This indicates that a significant majority of respondents (94.2%) adhere to dietary restrictions or special prescribed diets, likely owing to health concerns or dietary requirements. Conversely, quite a small fraction (5.8%) of participants do not comply with designated diet regimens. Consequently, the majority of PCOS patients adhere to a specialized diet that excludes fats and oils.

Any other disease/condition

According to the collected data, 70% of the 120 respondents, totalling 84 individuals, affirmed they possess at least one of the specified health conditions (e.g., diabetes, thyroid disorders, or hypertension). Meanwhile, 20.8% of respondents, totalling 25 participants, are uncertain regarding the presence of any of the specified circumstances. This may indicate insufficient routine health examinations, limited access to medical information, or a lack of symptom awareness. Conversely, around 9.2% of respondents, or 11 out of 120 participants, said that they do not suffer from any of the specified diseases or ailments. This signifies that a substantial majority of individuals (70%) contributes to a designated focus group for additional examination. A significant proportion of participants (20.8%) are uncertain regarding their health status, potentially reflecting deficiencies in health literacy, access to medical resources, or preventive healthcare within this demographic. Conversely, a minor fraction (9.2%) expresses confidence in the absence of serious health conditions, suggesting either a generally healthy cohort or possible

underreporting of undiagnosed ailments. This signifies that a great deal of individuals with PCOS are affected by additional diseases or conditions, such diabetes, thyroid disorders, or hypertension. Polycystic Ovary Syndrome (PCOS) arises from multiple contributing causes, including diabetes, obesity, and other hormonal imbalances [26]. For instance, Hispanic women demonstrate increased susceptibility to metabolic syndrome (MetS) and type 2 diabetes mellitus (T2DM), whereas women of African origin with polycystic ovarian syndrome (PCOS) are more likely to encounter risk factors linked to hypertension and cardiovascular disease (CVD). [27]. This signifies the importance of considering the impacts of mental disorders and substance use in the management of PCOS, particularly for those already grappling with the complex and multifaceted nature of the illness [28].

Awareness of PCOS

The results obtained pertain to the data collected about PCOS awareness. A quick diagnosis can effectively prevent the serious repercussions of PCOS, provided that new patients possess a comprehensive grasp of the condition [29]. The initial inquiry pertained to the complete form of the acronym 'PCOS,' with 75.8% of respondents, approximately 91 individuals, demonstrating awareness that PCOS denotes "Poly Cystic Ovarian Syndrome." Conversely, 24.2% of respondents, around 29 individuals, were unaware of the entire form of PCOS. The second question pertained to the organ impacted in PCOS. 83.3% of participants, totalling 100 individuals, were aware that the ovary is the organ impacted by PCOS, whereas 16.7%, representing 20 participants, were uninformed about the organ affected by PCOS. The subsequent question asked if PCOD or PCOS may be managed with diet or physical activity. The findings reveal that 77.5%, equating to 93 participants, confirmed that PCOD or PCOS may be managed with diet or exercise. Meanwhile, 22.5%, or 27 individuals, stated that PCOD or PCOS cannot be treated via diet or exercise. The fourth and last inquiry sought to ascertain whether PCOD or PCOS is treatable. According to the results, 62.5%, equating to 75 individuals, affirmed PCOD or PCOS can be managed with dietary modifications or physical activity. Of the remaining 37.5%, which amounts to 45 individuals, stated that PCOD or PCOS is not treatable. The survey examined 120 patients, revealing a substantial understanding among respondents on PCOS, with most accurately knowing its entire name and the organ involved. Nonetheless, a significant proportion of people remain uninformed of these features. Moreover, although numerous participants assert that PCOS may be managed via diet and exercise, there exists a divergence of view regarding its curability, underscoring the necessity for enhanced education and knowledge of the illness. Given the challenges in identifying PCOS, it is reasonable to expect that treatment is fraught with uncertainty [30].

CONCLUSION

This paper delineates the results of a survey examining the relationship between age, marital status, geographic origin, length of PCOS symptoms, and awareness of the frequency and understanding of Polycystic Ovary Syndrome (PCOS). The findings highlight several substantial correlations and provide critical insights into the impact of these variables on PCOS. The age distribution of participants indicates a higher prevalence of PCOS in younger demographics, consistent with prior studies that show PCOS is commonly detected in women of childbearing age. The geographic origin suggests that girls in urban regions are more susceptible to PCOS than those in rural areas. Ultimately, it may be attributable to lifestyle factors, like inadequate nutrition and insufficient physical activity.Marital status indicates a greater incidence of PCOS in married persons, potentially correlated with hormonal fluctuations related to reproductive health, stress, and accessibility to healthcare. The length of PCOS varies across individuals, with a considerable proportion receiving a recent diagnosis, while others having experienced the disorder for a moderate period. The survey results illuminate the awareness of PCOS. There exists a considerable level of information and understanding regarding the specific aspects of PCOS, including its definition and the bodily systems it impacts. Patients diagnosed with PCOS exhibit a superior comprehension of the disorder, presumably shaped by personal experiences or associations with PCOS. This study elucidates the relationships among age, marital status, duration of PCOS, and awareness of PCOS in relation to its prevalence and comprehension. The results underscore the significance of early identification, knowledge, and management of

PCOS, especially in younger populations. Additional study is required to thoroughly investigate these associations and formulate specific strategies to address the specific needs of different age demographics affected with PCOS.

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Table 1: List of questions included in survey form

ITM VOCATIONAL University, Vadodara	
Questionnaire form for PCOS Patients	
Patient's Name:	
Registration No.	
Variables	
1. **Year of birth:**	
Date of Birth	
2.Geographic Origin:	
Urban Patients	
Rural Patients	
3.Marital Status:	

Married	
Unmarried	
Separated	
4.Age of first menses	
Before 16	
After 16	
5.Symptoms (Yes Or NO)	
Irregular menses	
Excess body hair growth	
Overweight or obese	
Excess acne or sweaty palms	
Numbness/tingling in hands or feet	
Insomnia	
Increased appetite	
Lack of self confidence	
Period cramps	
Heavy flow	
Delayed menses	
Serious mood swings	
Follow specific diet	
Any other disease/condition	
6.PCOS Public Awareness Scale Yes Or NO)	
Can PCOS be managed with diet?	
Is the full form of PCOS "polycystic ovary syndrome?	
Is the ovary the primary organ affected in PCOS?	
Is PCOS curable?	

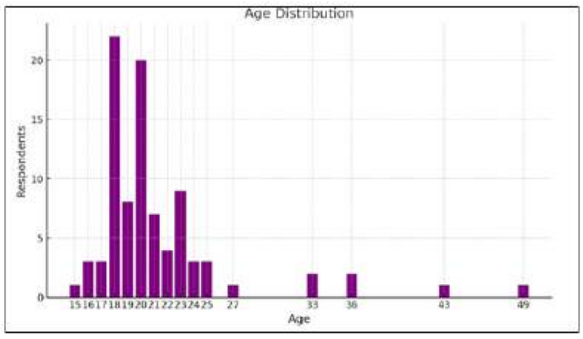


Figure 1: Age of individuals participated in the study

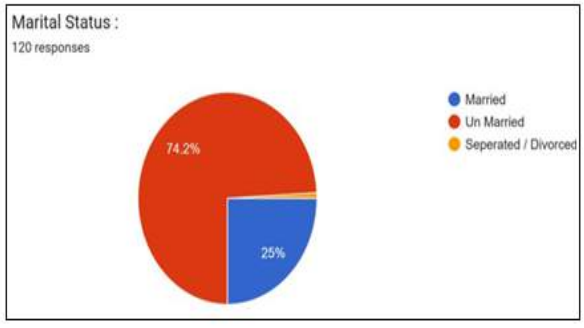


Figure 2: Analysis of association of marital status with PCOS.

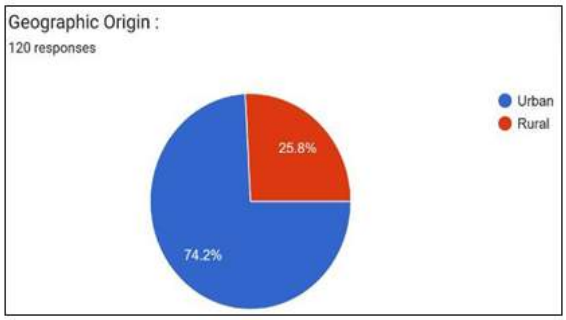


Figure 3: The geographic origin of individuals

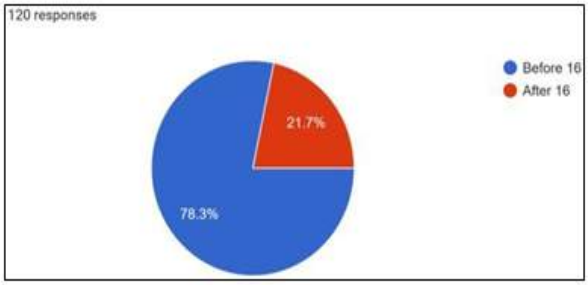


Figure 4: Correlating starting age of menses and PCOS

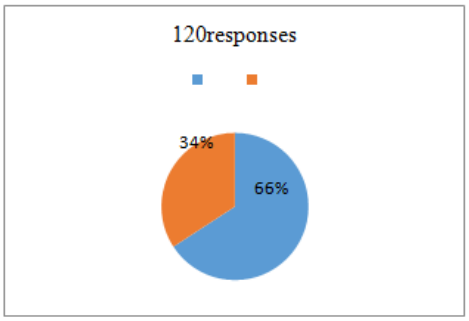


Figure 5: Analysis of patients experiencing irregular menses from the start

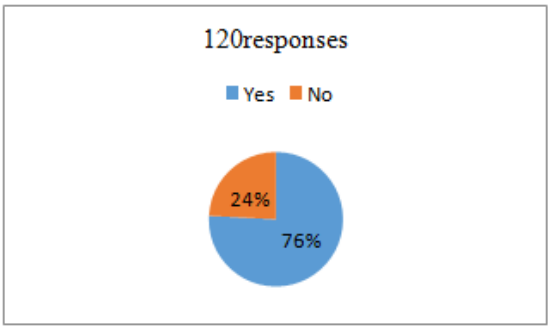


Figure 6: Analysis of patients experiencing excess body hair growth

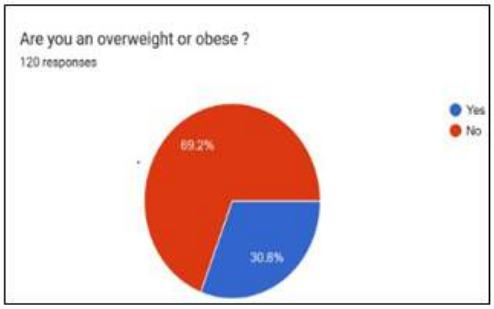


Figure 7: Analysis of patients with obesity

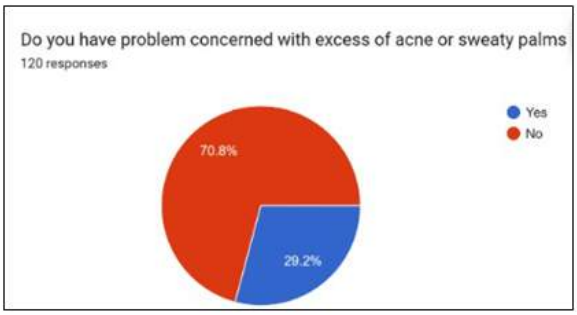


Figure 8: Analysis of patients with excess acne or sweaty palms

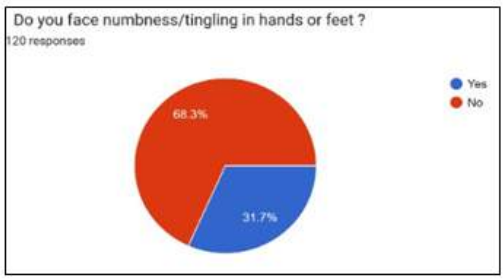


Figure 9: Analysis of patients facing numbness/tingling in hands or feet

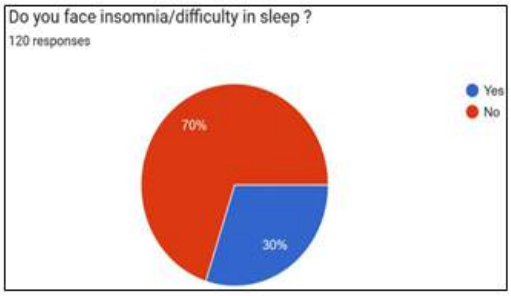


Figure 10: Analysis of patients facing insomnia/difficulty in sleep

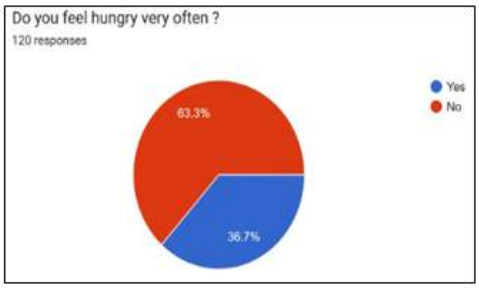


Figure 11: Analysis of patients feeling hungry very often

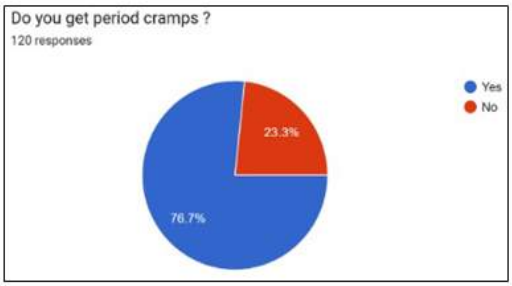


Figure 12: Analysis of patients getting period cramps

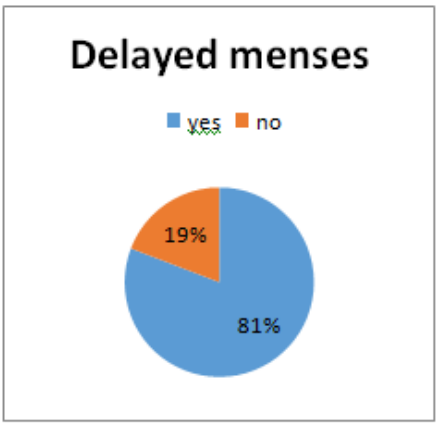


Figure 13: Analysis of patients suffering from delayed menses

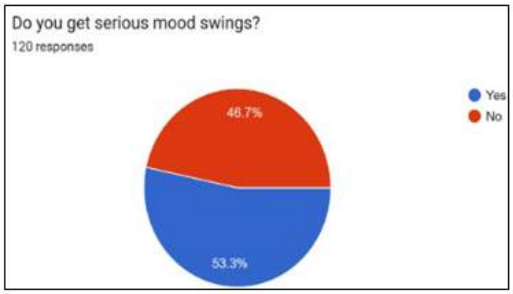


Figure 14: Analysis of patients experiencing serious mood swings

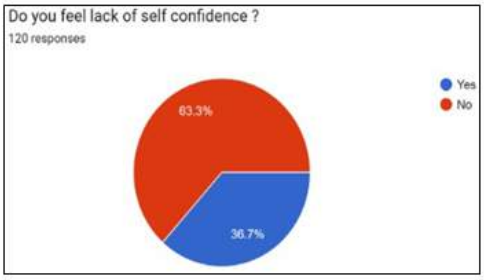


Figure 15: Analysis of patients feeling lack of self confidence

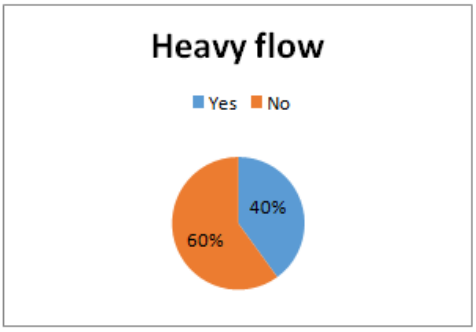


Figure 16: Analysis of patients experiencing heavy flow

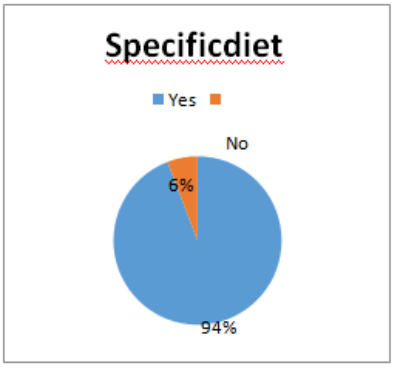


Figure 17: Analysis of patients following a specific diet

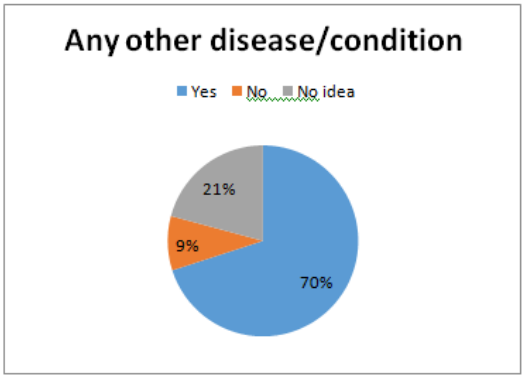


Figure 18: Analysis of patients suffering from any other disease/condition

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RESEARCH ARTICLE

Physiochemical Evaluation of Phytochemicals Encapsulated from Black Cardamom and Black Cumin

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ABSTRACT

Phytochemicals and antioxidants present in spices exhibit multifunctional biological activity with ethnopharmacological properties. The encapsulation process can successfully entrap these bioactive constituents by shielding them from oxidation and enhancing their stability. In recent years, encapsulation has been essential for developing functional foods, which provide innovative solutions for nutrient delivery, preservation, and sensory enhancement. The Phytochemicals from Black cardamom and Black cumin were extracted using the Soxhlet extraction technique, one of the most effective methods for better yield. The encapsulated phytochemicals will be analyzed for physicochemical parameters such as bulk density, moisture content, hygroscopicity, powder yield, encapsulation efficiency, dissolution characteristics, and color analysis are essential to ensure product quality and performance. The study's findings show that the encapsulated phytochemicals have favorable physicochemical properties, including moisture (10.01 $\pm$ 0.14%), bulk density (0.56 $\pm$ 0.07 g/ml), encapsulation efficiency (77.8 $\pm$ 2.08 %), hygroscopicity (25.57 $\pm$ 0.58 %), dissolution test (22.48 $\pm$ 1.37sec), and powder yield % (43.39 $\pm$ 0.64) and color parameters such as L* (67.03$\pm$ 0.15), a* (3.51 $\pm$ 0.01), and b* (23.46 $\pm$ 0.15) respectively. It can be concluded from the research findings that the encapsulated phytochemicals have favorable physicochemical properties that ensure better delivery of bioactive compounds in food products.

Keywords: Black cardamom, Black cumin, Encapsulation, Physicochemical properties, Soxhlet extraction, Spray drying.

INTRODUCTION

The spices provide exotic flavor to the Indian foods. The *Amomumsublatum*is known as Black cardamom which is used in various cuisines. It has a sweet aroma and bioactive compounds that cure various illnesses such as cardiovascular, diabetes, oxidative stress, and inflammation. Several studies have shown that the phytochemical compounds present in black cardamom such as polyphenols, alkaloids, and tannins, it is considerably high in flavonoids. The Black Cardamom is cultivated in Sikkim, West Bengal[1].The cardamom phytochemical screening was of high importance in discovering and developing new therapeutic agents with enhanced efficiency. Cardamom contains powerful antioxidants, and research suggests that dietary antioxidants are more effective than pure compounds in preventing oxidative stress-related diseases [2]. The black cumin, also known as *Nigella sativa*, is renowned for its culinary uses and historically valued in traditional medicine. Black cumin is known for its various traditional uses and medicinal properties, which include antioxidant, anti-inflammatory, immunomodulatory, anticancer, antimicrobial, and cardioprotective effects. Black cumin seed essential oils contain thymoquinone, thymol, and nigellicine are responsible for the pharmacological effects and therapeutic benefits. The phytochemical composition of the black cumin varies based on the growing region, and maturity stage. The different classes of phytochemicals present in the black cumin seeds are terpenes and terpenoids, phytosterols, alkaloids, tocopherols, and polyphenols. Black cumin has shown immune stimulatory functions. The extract has been shown to stimulate phagocytic activities in the immune system [3]. The beneficial health-promoting properties of phytochemicals have been reported in recent years, including antioxidative, antimicrobial, gastrointestinal protective (anti-ulcer), anti-hypercholesterolemic, anti-platelet aggregation, and anti-hypertensive activities[4].The Phytochemicals present in Black cardamom and Black cumin were found to be a potent source of antioxidants, which prevent oxidative stress caused due to the production of free radicals in the body[5].Although spice extracts have been documented to enhance the health-promoting properties of foods, their incorporation can also alter the aroma and flavor profile of the final product, potentially reducing its acceptability. To address this issue, encapsulation of herb and spice extracts is often employed to mask the strong aromas of the enriched food [6].

In previous years the advanced extraction technique has been employed to obtain phytochemicals from the food components. The extracted photochemical can be delivered using various vehicles one such is the Encapsulation technique.The first product containing encapsulated materials was formulated in the year 1954 [7].The encapsulation techniques are used to protect bioactive compounds such as vitamins, pigments, and flavorings from the environment [8]. This will increase the stability and shelf life of the products [7]. The active compounds of the spices are entrapped inside a thin polymeric coating and the polymer coating acts as a protective film for the core material, this process involves entrapping volatile substances within a protective wall material. This enables their easy incorporation into various food formulations. The biodegradable wall materials generally used for encapsulation arelipids, proteins, and polysaccharides. Spray drying is one of the most commonly used techniques for the encapsulation process. It employs drying technology which is commonly used in the pharmaceutical and food industries. Bioactive compounds such as proteins, enzymes, pigments, flavors, and vitamins are encapsulated using the spray drying method. Encapsulation is a technique that is gaining importance in the food industry to enhance the production of nutritious food products. However, the Photochemical present in the spices are susceptible to oxidation or degradation. To prevent this, the Encapsulation technique has been used to entrap the active compounds inside a wall material. Photochemical have various health benefits which can be retained or protected using Encapsulation, increasing the availability of bioactive compounds [9]. Hence, the current study attempts to encapsulate Photochemical from Black cardamom and Black cumin. Furthermore, various physicochemical properties such as Bulk density, Hygroscopicity, Encapsulation efficiency, Powder yield, Color parameters, Dissolution test, and Moisture content of the encapsulated photochemical were assessed. The main objectives of the study:

1. To extract the phytochemicals from black cardamom and black cumin employing soxhlet extraction.
2. To encapsulate the phytochemicals using spray drying technique.
3. To evaluate the physicochemical properties of the encapsulated phytochemicals.

MATERIALS AND METHODS

Selection and Procurement of Ingredients

The ingredients used in this study are locally available and offer potential health benefits. The phytochemicals extracted from black cardamom and black cumin were obtained from a local supermarket. Additionally, chemicals such as maltodextrin, polysaccharides, ethanol, and saturated sodium sulfate (Na2SO4) were sourced from Market.

Extraction of Phytochemicals from Black Cardamom and Black Cumin

The extraction of phytochemicals from black cardamom and black cumin was performed using the Soxhlet extraction method as outlined by Rasul in 2018 [10]. These ingredients were ground into a fine powder and then placed in a thimble, which was positioned in the Soxhlet apparatus for the extraction process. The apparatus was filled with an organic solvent, specifically ethanol, and the extraction lasted for three hours. Finally, the phytochemical compounds extracted from the black cardamom and black cumin were collected.

Encapsulation of Phytochemicals from Black Cardamom and Black Cumin by Spray Drying Technique

Spray drying is a dehydration process widely used to protect active compounds. It involves converting a fluid feed—such as an emulsion, dispersion, or solution—into powder form using hot drying gas. The encapsulation process through spray drying was conducted using a tall-type spray dryer. The steps for the spray drying technique used in this research include homogenization, atomization, evaporation, and product separation [11].This encapsulation process entails the addition of both core and wall materials. In the current study, the core material was derived from phytochemicals, while the wall material used was maltodextrin. The experiment utilized the spray drying technique while considering factors such as temperature, equipment time, and feed rate before finalizing the procedure. These factors significantly influence the outcome of the final product in the spray drying process. The fluid feeds are atomized through contact with dry hot air. The spray drying operates within an inlet temperature range of 150 to 250 °C and an outlet temperature between 50 and 80 °C [12].In this study, the tall-type spray dryer was maintained at an inlet temperature of 139 °C and an outlet temperature of 1 °C. The extracted phytochemicals from black cardamom and black cumin were homogenized; using 25 ml of the extracted phytochemical solution extracted from Black cardamom and Black cumin were combined with 50 ml of wall material. To prepare the wall material, 15 g of maltodextrin was mixed with a polysaccharide and then dissolved. The homogenization process involved mixing the extracted phytochemicals with the wall material, which was homogenized at 4,200 rpm for 15 minutes. After homogenization, the solutions were spray-dried, where hot air was applied to dry the particles. Finally, the dried encapsulated phytochemical powder was collected.

Evaluation of Physicochemical Properties of the Encapsulated Phytochemicals

The physicochemical properties of encapsulated phytochemicals from black cardamom and black cumin were analyzed, focusing on bulk density, moisture content, hygroscopicity, powder yield, encapsulation efficiency, dissolution rate, and color. Bulk density was measured according to Goula and Adamopoulos (2005) [13] by adding 2 grams of the sample to a 10 mL graduated cylinder and tapping it to determine the mass-to-volume ratio. Moisture content was assessed by employing the AOAC (2000) method, where 3 grams of the sample were dried in an oven at 105°C for 3 hours, and the weight difference was recorded. Encapsulation efficiency was evaluated by applying spectroscopic or chromatographic methods[14]. Hygroscopicity was determined by placing 2 grams of the sample in airtight Petri dishes at 25°C with saturated Na2SO4 (81% relative humidity) for one week, after which the moisture content was measured as grams per 100 grams of dry solids [15]. For the dissolution test, 50 mg of dried sample powder was combined with 1 mL of distilled water, and the time taken for dissolution was recorded [16]. The powder yield was calculated from the mass of the spray-dried powder relative to the original excipients. Color parameters were measured using a Hunter Lab colorimeter based on the CIE L*a*b color scales [17].

Statistical Analysis

The data obtained from the Physicochemical properties such as Moisture, Hygroscopicity, Powder yield, encapsulation efficiency, Color, Dissolution test, and Bulk density were subjected to statistical analysis mean, and standard deviation. In which the value of individual items in the series is obtained from the arithmetic average. The data was coded and determined.

RESULTS AND DISCUSSION

Physicochemical Properties of the Encapsulated Phytochemicals from Black Cardamom and Black Cumin

The Encapsulated Phytochemicals from Black cardamom and Black cumin were assessed for their physicochemical parameters such as Moisture, Hygroscopicity, Powder yield, encapsulation efficiency, Color, Dissolution test, and Bulk density, and the results obtained were depicted in Table 1 and explained below with relevant literature review.

MOISTURE CONTENT

The moisture content of a product refers to the amount of moisture or wetness present in it. This parameter indicates the level of wetness in a sample. The study of moisture content in powdered products is related to their stability, oxidation, and flow ability [18]. The moisture content of the encapsulated phytochemical powders was found to be 10.01 ± 0.14%, as shown in Table 1. This result aligns with the findings of Thumthanaruk *et al.*, 2021[19] which reported moisture content ranging from 9.89% to 10.86% of encapsulated β-carotene and lycopene, and Gothainayagi, 2020 [20] who found that the moisture content of encapsulated Nigella sativa oil ranged from 3.00% to 3.76%. It was also observed that the moisture content increased with a higher concentration of wall materials. The disparity in the result could be due to the difference in wall material used.

BULK DENSITY

Bulk density is a crucial factor in determining the characteristics of packaging for powdered products [21]. The bulk density of a product is primarily influenced by factors such as particle size, core material, and wall material. The bulk density of encapsulated phytochemicals derived from black cardamom and black cumin was found to be 0.56 ± 0.07 g/ml. This finding is supported by recent research by Noghabi and Molaveisi (2023) [22], who reported a bulk density of 0.28 ± 0.01 g/ml for encapsulated cinnamon essential oil. The differences observed between the results can be attributed to variations in the wall materials, raw ingredients, and encapsulation techniques used.

ENCAPSULATION EFFICIENCY

Encapsulation Efficiency (EE) is a crucial parameter in the production of food powders through spray drying, as it relates to feed properties and drying conditions. The results of the current investigation show that the EE of the encapsulated phytochemicals from black cardamom and black cumin was found to be 77.8 ± 2.08%. Previous studies have reported similar encapsulation efficiencies using various encapsulation techniques and wall materials. According to Carneiro et al. (2013) [23], using a lower amount of wall material results in higher encapsulation efficiency and greater product stability. Their study indicated that the encapsulation efficiency of two wall material combinations (maltodextrin and whey protein concentrate) varied from 62.3% to 95.7%. Another study by Kobo et al. (2022) [24] found that the encapsulation of phytochemicals from passion fruit peel achieved a high EE, ranging from 82.64% to 87.18%. The encapsulation efficiency observed in the current study is consistent with the findings of Nurhadi et al. (2024) [25], who reported a similar EE of 78% for the encapsulation of black pepper. The similarities in these results can be attributed to the use of maltodextrin as a wall material in the encapsulation process, as the choice of wall material significantly influences the encapsulation efficiency of the final product.

HYGROSCOPICITY

Hygroscopicity plays a crucial role in determining the storage stability of powders. It refers to the tendency of a product to absorb moisture from the environment. The hygroscopicity of the samples will be differed based on the wall material where, the sample produced with maltodextrin exhibited the lowest hygroscopicity, while gum Arabic

displayed the highest hygroscopicity. From the current investigation, the hygroscopicity of encapsulated phytochemicals from black cardamom and black cumin was found to be 25.57 ± 0.58%. Research by Repajić et al. (2024)[26] reported that the hygroscopicity of encapsulated fennel powders varied between 8.26% and 17.51%, showing differences compared to the current investigation. Similar findings were reported by Botrel *et al.* (2012) [27] and Felix et al. (2017) [28], where the hygroscopicity of encapsulated oregano and cinnamon powders ranged from 22.30% to 26.27% and 22.9% to 42.21%, respectively. It is important to note that hygroscopicity values tend to increase inversely with higher moisture content. Furthermore, an increase in the concentration of wall material also results in greater hygroscopicity of the encapsulated powder.

DISSOLUTION TEST

The dissolution test measures the time required for a powder to completely dissolve in water. In this study, the dissolution time for encapsulated phytochemicals from black cumin and black cardamom was recorded at 22.48 ± 1.37 seconds. According to Quek *et al.* (2007)[29] reported a similar dissolution time of 25 seconds for encapsulated anthocyanins. The results indicate that the dissolution time is related to the moisture content of the encapsulated powder. It can be concluded that as the moisture content of the powder increases, the dissolution time decreases.

POWDER YIELD

The powder yield, or recovery, refers to the amount of product obtained during the spray drying process. In this study, the analysis of the powder yield for the encapsulated phytochemical showed a yield of 43.39 ± 0.64%. This finding is consistent with research conducted by Bhandari (1997) [30], which reported that the powder yield of encapsulated fennel essential oil ranged from 58.43% to 74.84%. Additionally, the results are supported by findings from Goëlo *et al.* (2020) [31], who found that the powder yield of encapsulated curcumin, using a polysaccharide-based wall material (maltodextrin), ranged from 47.30% to 60.60%. The differences in these yields can be attributed to factors such as the wall material ratio, spray drying temperature, and the specific types of wall materials used.

COLOR ANALYSIS

The color parameters of a food product can influence its acceptability among consumers. In this study, the color parameters L*, a*, and b* were analyzed for encapsulated phytochemicals derived from black cardamom and black cumin. The results are presented in Table 2, where the L* value indicates lightness, a* represents the position on the red-green axis, and b* reflects yellowness. The study found the values for L*, a*, and b* to be 67.0, 3.5, and 23.3, respectively. These findings align with research conducted by Nurhadi et al. (2024) [25], which reported similar L*, a*, and b* values for encapsulated black pepper essential oil, recorded as 75.58, 3.2, and 36.04, respectively. The high L* value suggests that the encapsulated sample has a light color. The a* value, which is slightly positive, indicates a tendency towards the red side of the spectrum. This is likely due to the use of black cardamom and black cumin, ingredients that are typically darker in color. Additionally, the positive b* value suggests that the encapsulated powder has a yellowish tone, attributed to the natural pigments found in the seeds or phytochemicals, as well as the use of maltodextrin as a wall material.

CONCLUSION

In summary, spices typically contain a sufficient amount of phytochemicals that exhibit potent antioxidant activity and offer protective benefits against cancer and other metabolic syndromes. This study focuses on encapsulating bioactive compounds from black cardamom and black cumin using a spray drying technique. The phytochemicals from both black cardamom and black cumin were extracted using the Soxhlet method and then encapsulated. The encapsulated phytochemicals demonstrated effective physicochemical properties, making them suitable for incorporation into food products. The results indicate that the encapsulated phytochemicals from black cardamom and black cumin possess favorable physicochemical characteristics, contributing to a higher quality of the encapsulates. Specifically, the moisture content of the encapsulated powder was higher, while the dissolution time was shorter compared to previous studies. This difference was attributed to the greater concentration of wall material

used in the encapsulation process. Additionally, the lightness of the color parameters for the encapsulated phytochemicals was superior to those reported in earlier studies. The variations in the physicochemical properties of the encapsulated phytochemicals compared to other encapsulated powders were due to differences in both the type of wall material and its concentration. Overall, this investigation concludes that the encapsulated phytochemicals from black cardamom and black cumin can be utilized by food industries for incorporation into various food products. Food products containing these encapsulated phytochemicals can benefit individuals of all ages by enhancing antioxidant scavenging activity.

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Table- 1 Physicochemical Properties of the Encapsulated Phytochemicals from Black Cardamom and Black Cumin

S.NO	PARAMETER	VALUE
1	Moisture content (%)	10.01 ± 0.14
2	Bulk density (g/ml)	0.56 ± 0.07
3	Encapsulation efficiency (%)	77.8 ± 2.08

4	Hygroscopicity (%)	25.57 ± 0.58
5	Dissolution test (sec)	22.48 ± 1.37
6	Powder yield (%)	43.39 ± 0.64

All the values are the mean of triplicate determinations ± Standard Deviation

Table 2- Color Analysis of the Encapsulated Photochemical from Black Cardamom and Black Cumin

S.NO.	PARAMETERS	VALUE
1.	L	67.03 ± 0.15
2.	A	3.51 ± 0.01
3.	B	23.46 ± 0.15

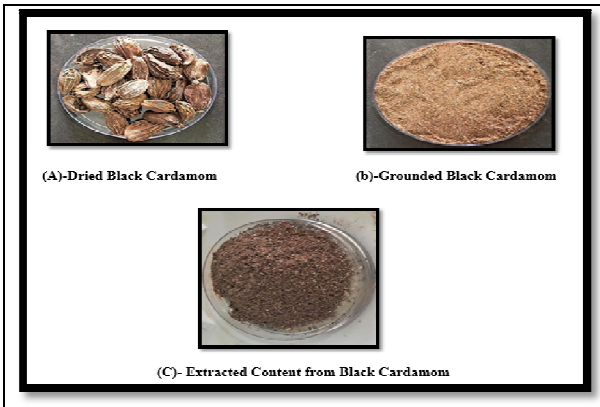


Figure 1- Extraction Yield of Black Cardamom Employing Soxhlet Apparatus

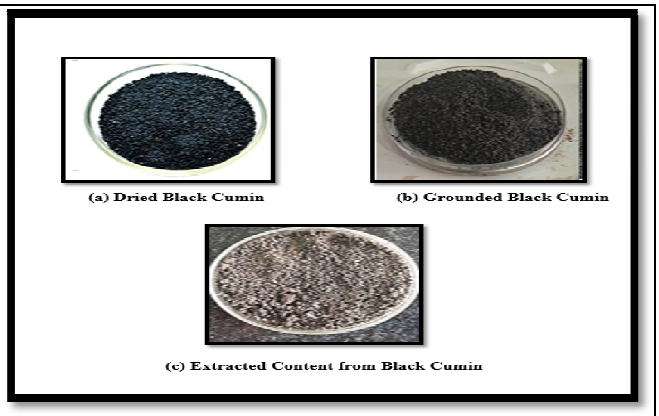


Figure 2 - Black Cumin Employing Soxhlet Apparatus



Figure 3 – Encapsulated Phytochemicals from Black Cardamom and Black Cumin

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RESEARCH ARTICLE

Bridging the Gap: A KAP Study on Pharmacovigilance across Educational Levels

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ABSTRACT

Pharmacovigilance (Pv) is a crucial component in ensuring drug safety by identifying, evaluating, and preventing adverse drug reactions (ADRs). Established by the World Health Organization (WHO) following the thalidomide tragedy, the Pv system includes global networks like the Uppsala Monitoring Centre and national programs such as the Pharmacovigilance Programme of India (PvPI). Despite its importance, underreporting remains a significant challenge, particularly in developing countries. This study aims to assess and compare the Knowledge, Attitude, and Perception (KAP) of Pharmacovigilance among undergraduate and postgraduate pharmacy students in India. Conducted at KLE College of Pharmacy, Vidyanagar, Hubballi, this cross-sectional study used a self-designed questionnaire to evaluate KAP on Pharmacovigilance among 517 students. The study spanned six months and received ethical approval from the Institutional Ethical Committee. The questionnaire, comprising 15 items across three domains, was administered as pre- test and post-intervention responses were assessed to trace out the changes in KAP. Statistical analysis included t-tests for comparing mean scores. Significant improvements were observed in KAP scores for both undergraduate and postgraduate students' post-intervention. Undergraduates showed notable gains in all domains, with knowledge increasing from 23.58% to 84.87% in the "Good" category. Postgraduates also improved, though they started with higher baseline scores. Statistical significance was noted with p-values <0.05 in all domains. The educational intervention significantly enhanced KAP regarding Pharmacovigilance among pharmacy students. Both undergraduates and postgraduates benefited, with undergraduates showing more pronounced improvements. These findings highlight the effectiveness of targeted educational initiatives in improving drug safety awareness and practice.

Keywords: Pharmacovigilance, Adverse Drug Reactions, Pharmacy Education, Knowledge, Attitude, Perception

INTRODUCTION

The research and practices associated with the identification, evaluation, comprehension, and avoidance of side effects or any drug-related issues are collectively referred to as Pharmacovigilance (Pv) by the World Health Organization (WHO) [1]. Following the thalidomide tragedy in Germany in 1961, the WHO launched this initiative as an international drug monitoring system [2]. The WHO's framework emphasizes the importance of gathering data on adverse drug reactions (ADRs) through various methods, including spontaneous reporting and intensive monitoring [3]. In order to address safety concerns that could have an international impact on populations, Pv plays a critical role in public health by exposing adverse drugs events that were previously unknown and thereby leading to a global Pv network namely; The Uppsala Monitoring Centre which is a WHO Collaborating Center that makes it easier to share Adverse Drug Reactions and improve drug safety surveillance [4].Launched in 2010, The Pharmacovigilance Programme of India (PvPI) which operates under Central Drugs Standard Control Organization (CDSCO) with the Indian Pharmacopoeia Commission (IPC) serving as the National Coordination Centre (NCC) for the program has been actively involved in monitoring and reporting of ADRs across India [5,6]. In developing countries like India, the load of ADRs is expected to be even more because of the prominent existence of self-medication, contaminated medication and bogus medications [7]. However, the main obstacle to the program's successful execution is underreporting, which is widespread in India and many other nations across the world [8]. In the meantime, it has been shown that in developed nations, the quantity and quality of ADR complaints increased when pharmacists reported the events [9]. Pharmacists are a vital part of PvPI due to their comprehensive knowledge of drugs and their position in the many tiers of the healthcare system. Because most significant adverse medication reactions occur in hospitals, hospital pharmacists play a crucial role in healthcare. The phenomenal growth of the clinical research and pharmaceutical industries in India has led to the expansion of PvPI [10]. As mentioned, the future professional pharmacy graduates will play an important role in monitoring and reporting ADRs it is important to evaluate Knowledge, Attitude and Perception (KAP) of Pv between UG and PG students. Rigorous identification of the differences in KAP factors will help in designing targeted educational interventions aimed at enhancing Pv training across different levels of Pharmacy education.

MATERIALS AND METHODS

Study site

This study was carried out at KLE College of Pharmacy, Vidyanagar, Hubballi.

Study design

A cross-sectional study utilizing a self-designed questionnaire was conducted to assess the knowledge, attitude, and perception of Pharmcovigilance among undergraduate and postgraduate students at KLE College of Pharmacy, Vidyanagar, Hubballi.

Ethical Approval

Ethical approval for the study was obtained from the Institutional Ethical Committee of KLE College of Pharmacy, Hubballi, with the approval number IEC No. KLECOPH/IEC/2023-24/01.

Study period

The research was conducted over a span of six months at KLE College of Pharmacy, Vidyanagar, Hubballi, Karnataka.

Study criteria

Inclusion Criteria: The study included students enrolled in undergraduate and postgraduate programs at KLE College of Pharmacy, Hubballi.

Exclusion Criteria: Participants involved in the pilot study and students who were unwilling to participate were excluded from the study.

Study Procedure

The faculty from the Department of Pharmacy Practice developed a set of 15 questionnaires, as outlined in Table 2, to evaluate three domains: Knowledge, Attitude, and Perception of Pharmacovigilance. The questionnaires were structured into five questions for each domain. The Knowledge domain was assessed using a dichotomous format (coded as 'Yes' = 1 and 'No' = 0), whereas the Attitude and Perception domains were evaluated using a 5-point Likert scale. The internal consistency of the questionnaires was tested among 19 participants during a pilot survey using IBM SPSS 27.0, yielding a Cronbach's alpha (α) of 0.874, indicating strong internal reliability. Initially, a pre-test was administered, followed by a brief educational session covering definitions, objectives, regulatory bodies, history, ADR reporting forms etc. The same set of 15 questions was then re-administered to participants via Google Forms, and the responses were recorded for the post-test.

Statistical Analysis

The collected data were inputted into a Microsoft Excel spreadsheet. Continuous data were expressed as mean ± standard deviation. Differences between undergraduate and postgraduate pharmacy students were assessed using the t-test. Appropriate descriptive and inferential statistical analyses were performed using Excel and SPSS version 27.

RESULTS

Table 1: Demographics details of UG and PG students. The demographic profile of the study's participants includes 57.25% females and 42.74% males. Age-wise, the largest group is 21 years old (20.88%), followed by 19 years (18.76%) and 20 years (15.66%). Undergraduates make up 75.43% of the sample, while postgraduates account for 24.37%. Most participants come from families with a non-medical background (87.23%), whereas those with a medical background constitute 12.7%. In terms of socioeconomic status, 28.82% of participants belong to the lower class (earning less than 1 lakh Rupees per year), and 27.65% are in the lower middle class (earning between 2 to 5 lakh Rupees per year). The upper lower class has 11.41%, the upper middle class 25.14%, and the upper class 6.96%. Regarding residence, 65.37% live in urban areas, while 34.62% reside in rural areas. Table 2: Questionnaire used in the study Table 3: T-Test Analysis of Knowledge scores in undergraduates and postgraduates regarding PvPI. This table presents the comparison of mean scores and standard deviations (Mean ± SD) in knowledge, attitude, and perception (KAP domains) between undergraduate and postgraduate students, both before (pre-test) and after (post-test) an intervention. It also includes p-values indicating the statistical significance of the differences observed. The study assessed the impact of an intervention on the knowledge, attitude, and perception (KAP) of undergraduates and postgraduates. In the Knowledge domain, undergraduates showed a significant improvement, with their mean score increasing from 1.91±1.807 in the pre-test to 4.40±1.223 in the post-test. Postgraduates also improved from 4.44±1.005 to 4.92±0.370. Both changes were highly significant, with a p-value of less than 0.001. In the Attitude domain, undergraduates' mean scores increased from 19.22±3.294 to 21.11±2.738, while postgraduates' scores rose from 21.72±2.651 to 22.69±2.213. The improvement was statistically significant for both groups, but the post-intervention comparison yielded a p-value of 0.018, indicating a smaller, though still significant, difference. For Perception, the mean score for undergraduates increased from 18.54±3.106 to 20.90±2.931, and for postgraduates from 21.21±2.660 to 22.63±2.313. These improvements were also statistically significant, with p-values of 0.047 for the pre-test comparison and 0.038 for the post-test comparison. The results demonstrate that the intervention significantly enhanced KAP scores in both undergraduates and postgraduates, with postgraduates generally starting at a higher baseline and maintaining a stronger performance overall. Table 4: Scoring and categorization of KAP domains. In our study, the scoring system evaluates three domains: Knowledge, Attitude, and Perception. For the Knowledge domain, participants answer Yes/No questions, where "Yes" scores 1 point and "No" scores 0 points. Scores are categorized as Poor (0-2 points), Moderate (3 points), or Good (4-5 points). The Attitude and Perception domains use a 5-point Likert scale (SA, A, N, D, SD) with corresponding scores of 5 to 1 points. These scores are categorized as Poor (0-16

points), Moderate (17-18 points), or Good (19-25 points). This system helps to clearly differentiate participant responses across the three domains. Table 5: Comparison of KAP factors between undergraduates and postgraduates . Figure 1: Good responses between UG and PG The study evaluated the knowledge, attitude, and perception (KAP) of undergraduates and postgraduates before and after an intervention. Among undergraduates, there was a substantial improvement in the "Good" category post-intervention across all domains. Specifically, the percentage of students with good knowledge increased from 23.58% to 84.87%, while those with good attitudes rose from 64.10% to 89.23%, and those with good practices from 52.30% to 84.35%. Correspondingly, the "Poor" category saw a significant decrease, with the most notable reductions in knowledge (from 61.79% to 8.46%) and practice (from 29.48% to 5.64%). For postgraduates, who initially performed better, the intervention still led to notable improvements. The percentage of students with good knowledge increased from 86.50% to 98.41%, and those with good practices from 86.50% to 97.61%. The "Poor" category was nearly eradicated, especially in knowledge, which dropped from 5.55% to 0.79%. The results indicate that the intervention was effective in enhancing the KAP among both undergraduate and postgraduate students, with more pronounced effects observed in the undergraduate group.

DISCUSSION

Our study assessed and compared the knowledge, attitude, and perception of 517 pharmacy students, including both undergraduates (UG) and postgraduates (PG), revealing significant improvements across all domains after an educational intervention. These findings align with those of a similar study conducted among 225 pharmacy students in South India by Reddy VL et al., where both studies observed large gains in knowledge and positive shifts in attitudes towards pharmacovigilance post-intervention. However, our study uniquely highlighted that PGs began with a higher baseline knowledge, a factor not addressed in the South Indian study. Moreover, our focused comparison between UGs and PGs provided more detailed insights, though both studies acknowledged limitations in generalizability due to sample size. This shows the effectiveness of educational interventions in enhancing pharmacovigilance awareness [11]. The MBBS students had a considerably greater baseline knowledge than the other groups, according to study conducted by Byndoor Y et al., which evaluated the attitudes and knowledge of 340 healthcare students from various fields like nursing, physiotherapy, dentistry, and master's in medical science. While our research including 517 pharmacy students, demonstrated post-intervention significant increases in knowledge in 2 groups namely UG and PG. The need for improved pharmacovigilance education was underlined in both research; however, our study concentrated on the effects of an educational intervention, whereas this one highlighted the differences in baseline knowledge across disciplines. The results obtained highlight the necessity of an extensive pharmacovigilance program while the generalizability of both research is restricted because of their student-focused sample designs [12]. Our study and the study done by Melo et al., reveal both similarities and differences in the knowledge, attitude, and perception, practice regarding pharmacovigilance. In their study it shows that knowledge is crucial, with our study demonstrating significant improvement in KAP scores post-intervention among undergraduates and postgraduates, while their study indicates a moderate level of knowledge with varied application. Our study highlights effective educational intervention, improving attitudes and perceptions significantly, whereas Melo et al., study shows mixed attitudes towards reporting adverse drug events (ADEs) and challenges in applying knowledge despite high levels of knowledge reported [13]. Comparing our study with Kharkar and Bowalekar reveals notable differences in ADR reporting practices. Our study demonstrates that an intervention significantly enhances knowledge, attitude, and perception regarding pharmacovigilance among undergraduates and postgraduates. In contrast, the Kharkar and Bowalekar study highlights a disconnect between awareness and actual ADR reporting among medical practitioners in India, despite high levels of knowledge and positive attitudes towards ADR centres. This disparity underlines the importance of not only improving education and perception but also addressing practical barriers to ensure effective ADR reporting. Both studies stress the need for comprehensive strategies to reduce differences and resolve the gap between awareness and actionable practices, perception in pharmacovigilance [14].

CONCLUSION

The study effectively demonstrated the positive impact of the intervention on improving the knowledge, attitude, and perception (KAP) regarding Pharmacovigilance among both undergraduate and postgraduate students. Significant improvements were observed across all KAP domains post-intervention, with undergraduates showing more pronounced gains, particularly in the transition from poor to good knowledge and perception. Postgraduates, who started with a higher baseline, also benefited from the intervention, further solidifying their understanding and attitudes towards Pharmacovigilance. The results underscore the necessity of targeted educational initiatives to enhance the competency of pharmacy students in PvPI, thereby fostering a more vigilant and informed healthcare workforce. The study highlights the potential of educational interventions in bridging knowledge gaps and fostering positive attitudes and perceptions essential for the effective reporting and management of adverse drug reactions (ADRs).

Conflict of interest

The authors declare that there are no conflicts of interest.

Abbreviations

A: Agree; ADEs: Adverse Drug Events; AMC: Adverse Drug Reaction Monitoring Centre; ADRs: Adverse Drug Reactions; CDSCO: Central Drugs Standard Control Organization; D: Disagree; IPC: Indian Pharmacopoeia Commission; KAP: Knowledge, Attitude and Perception; NCC: National Coordination Centre; N: Not sure; PG: Postgraduates; Pv: Pharmacovigilance; PvPI: Pharmacovigilance Programme of India; SA: Strongly Agree; SD: Strongly Disagree; UG: Undergraduates; WHO: World Health Organization.

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Table 1: Demographics details of UG and PG students

Demographics	Characteristics	N=517 (%)
Gender	Female	296 (57.25)
	Male	221 (42.74)
Age in years	18	61 (11.79)
	19	97 (18.76)
	20	81 (15.66)
	21	108 (20.88)
	22	71 (13.73)
	23	70 (13.53)
	24	22 (4.25)
	25	7 (1.35)
Study group	Undergraduates	390 (75.43)
	Postgraduates	126 (24.37)
Parents profession	Non-medical background	451 (87.23)
	Medical background	66 (12.7)
Socioeconomic status	Lower class (< 1 lakh Rupees per year)	149 (28.82)
	Lower middle class (2 to 5 lakh Rupees per year)	143 (27.65)
	Upper class (> 10 lakh Rupees per year)	36 (6.96)
	Upper lower class (1 to 2 lakh Rupees per year)	59 (11.41)
	Upper middle (5 to 15 lakh Rupees per year)	130 (25.14)
Residence	Rural	179 (34.62)
	Urban	338 (65.37)

Table 2: Questionnaire used in the study

SI. No	KAP Questionnaire	Domain
Knowledge based questions		
1.	Do you know the full form of PvPI?	Yes and No
2.	Do you know what is AMC?	
3.	Do you know the difference between ADR and ADE?	
4.	Do you know how to report ADR?	
5.	Have you heard any drug banned due to ADR?	
Attitude based questions		
1.	Do you think that ADR reporting is beneficial?	Strongly Agree, Agree, Not sure, Disagree and Strongly Disagree
2.	Do you think reporting of an ADR is important/necessary?	

3.	Do you believe that health care workers/professionals/public should be trained about PvPI?	
4.	Do you think ADR reporting form is complex to fill?	
5.	Do you think establishing ADR monitoring Centre in every hospital will be useful?	
Perception based questions		
1.	Do you consider a need for greater awareness and understanding of Pv among pharmacy students?	Strongly Agree, Agree, Not sure, Disagree and Strongly Disagree
2.	Do you believe that Pv can positively impact drug development process?	
3.	Do you consider that Health care professionals take ADR reporting seriously?	
4.	Do you consider that Pv will help in generating evidence-based data?	
5.	Do you feel that there are any barriers in reporting ADRs?	

Table 3: T-Test Analysis of Knowledge scores in undergraduates and postgraduates regarding PvPI

KAP Domain		Undergraduates	Postgraduates	p-value
		Mean ± Sd. Dev	Mean ± Sd. Dev	
Knowledge	Pre-test	1.91±1.807	4.44±1.005	<.001
	Post-test	4.40±1.223	4.92±.370	<.001
Attitude	Pre-test	19.22±3.294	21.72±2.651	<.001
	Post-test	21.11±2.738	22.69±2.213	.018
Perception	Pre-test	18.54±3.106	21.21±2.660	.047
	Post-test	20.90±2.931	22.63±2.313	.038

*Significantly significant p<0.05

Table 4: Scoring and categorization of KAP domains

Domain	Question format	Scoring	Poor category	Moderate category	Good category
Knowledge	Yes/No (2 options)	Yes=1, No=0	0-2 points	3 points	4-5 points
Attitude	SA, A, N, D, SD (5 options)	5,4,3,2,1	0-16 points	17-18 points	19-25 points
Perception	SA, A, N, D, SD (5 options)	5,4,3,2,1	0-16 points	17-18 points	19-25 points

Table 5: Comparison of KAP factors between undergraduates and postgraduates

Study Group	Domain	Good (%)		Moderate (%)		Poor (%)	
		Pre	Post	Pre	Post	Pre	Post
Undergraduates	K	23.58	84.87	14.35	6.41	61.79	8.46
	A	64.10	89.23	10.76	4.10	24.87	6.41
	P	52.30	84.35	17.94	9.74	29.48	5.64

Postgraduates	K	86.50	98.41	7.93	0.79	5.55	0.79
	A	92.06	94.44	3.17	3.96	4.76	1.58
	P	86.50	97.61	10.31	0.79	3.17	1.58

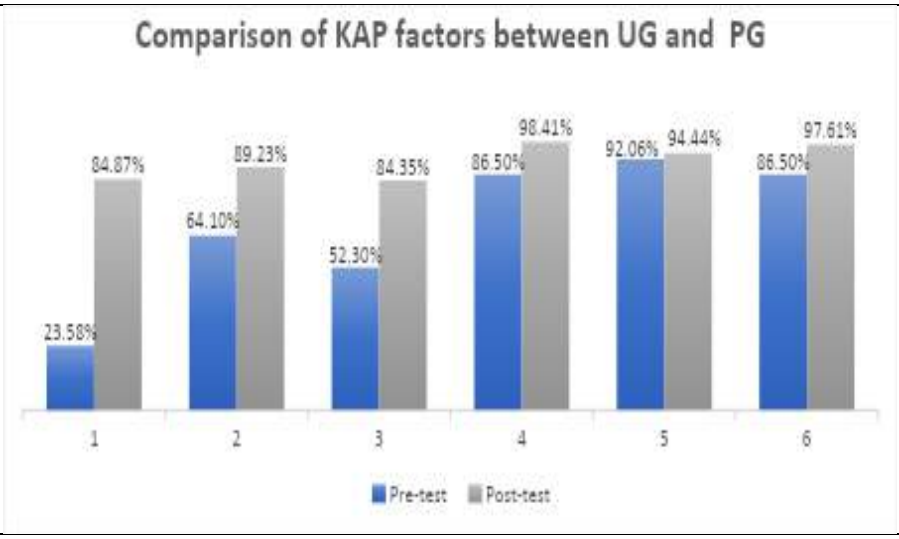


Figure 1: Good responses between UG and PG

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RESEARCH ARTICLE

Quantitative Determination of Phytochemicals and Antioxidant Activity of Orange Peel Extracts (Aqueous and Isopropanol)

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ABSTRACT

Nowadays the popularity of antioxidants is increasing owing to their activity in the scavenging of free radicals and possessing various health-beneficial properties. Fruits and vegetables being good sources of these antioxidants are consumed in generous quantities by people. In major cases, only the flesh part of the fruits, and vegetables are consumed; but peel, and seeds are discarded as waste. However, several studies have suggested that these discarded materials contain an even higher number of antioxidants than those fruits. Oranges are one of those fruits that are consumed worldwide in different forms but peels and seeds are thrown away. That's why the present study mainly focuses on an analysis of phytochemical compounds and free radical scavenging activity of aqueous and isopropanol extracts of orange peels. The data of this study shows that the total phenolic content of the aqueous extract of orange peel (57.3 mg/GAE/g) is higher compared to the isopropanol extract (35.3 mg/GAE/g). The total flavonoid content of the aqueous extract of orange peel has also been found higher (147.01mg/QE/g) than the isopropanol extract (259.85 mg/QE/g). The orange peel of both extracts exhibits a significant amount of antioxidant activity. So, it may be concluded that the inclusion of orange peel in the daily dietary regime may contribute to the prevention of various metabolic and oxidative stress-related diseases rather than discarding it as waste.

Keywords: Orange peel, aqueous and isopropanol extract, bioactive compounds, antioxidant activity, biowaste utilisation

INTRODUCTION

Antioxidants are natural and man-made substances that are found in a variety of foods which plays a key role in the prevention of oxidative damageto thehuman body. There is currently considerable interest in the evaluation of natural cancer prevention agents and radical scavengers derived from plant materials that are rich in polyphenolic compounds[1]. Oranges are consumed by people all around the world because of their pulpy and juicy flavour. It belongs to the Rutaceae family, which includes several different species. In several regions of India, Citrus reticulata, are sometimes known as mandarin oranges or sweet oranges. Oranges have a considerable amount of vitamin C and antioxidants, making them very nutrient-dense foods [2]. Oranges account for 60% of all citrus food item production worldwide. A significant fraction of those products contribute to large-scale juice extraction and produce enormous amounts of residue; primarily peels. Generally, peels or seeds of fruits and vegetables have not received much attention due to their astringent taste. However, many times they have been shown those leftovers have a combination of an abundance of nutrients and bioactive compounds[3]. In the past few years, industrial wastes have been getting attention; especially for those residuals that contain bioactive compounds from the used raw plant material and orange peels are one of them. Biologically active substances with favourable health effects and more natural ingredients have recently become more popular among customers [4].Few studies exhibited that orange has numerous active phytochemicals and bioactive compounds such as Neohesperidin, Naringin, Hesperidin, Narirutin, Limonene, Citrol, Anthocyacin, Beta-cryptoxanthin, Cryptoxanthin, Zeaxanthin and Rutin, Eriocitrin, Homocysteine Polymethoxylted flavones; Tangeritin and Nobiletin, Citacridone, Citabrsine and Noradrenaline [5].A variety of food products with substantial functional and nutraceutical potential can be formulated using bioactive components that are prevalent in fruit by-products and have significant health advantages [6]. It has been proven that these compounds have many health-beneficial activities by lowering the chance of developing cardiovascular illnesses and oxidative stress-related diseases. It also exhibits anti-inflammatory, anti-hypertensive, hypolipidemic, and anti-carcinogenic properties[7].The peel of this citrus fruit is widely used as an essential oil due to its antifungal and antioxidant properties. Similarly, the seeds of citrus fruits also contain a good amount of polyphenols[8]. For polyphenolic extraction, many techniques have been used with methanol, ethanol, or isopropanol. Studies based on methanolic extraction have been proven to give the maximum yield of antioxidants as compared to other solvents. There is another extraction medium (isopropanol) that is used for the safest incorporation of these polyphenolic compounds tofulfil dietary needs. That's why in the present study, for extraction of phenolic compounds; two solvents(aqueous and isopropanol)were preferred for their better acceptability in foods and least hazards to human health.The main aim of this experiment was to extract and evaluate the antioxidant profile and total phenolic content, total flavonoid content, and DPPH scavenging activity of orange peel in aqueous and solvent medium.

MATERIALS AND METHODS

Sample collection

Fresh mandarin/Darjeeling oranges purchased from the supermarket of Kolkata, West Bengal. The oranges were washed thoroughly with water and dried with a kitchen towel. Peels were then removed, cut into thin slices, and dried in the hot air oven till all the moisture was removed. They were then grinded into a fine powder, sieved with a strainer and stored in the refrigerator in a glass jar.

Preparation of Sample Extract

1. **Aqueous extract:** 7.5g of powder dissolved in 100 ml of water placed on a magnetic stirrer for 2 hours. The solution was then centrifuged to obtain a clear fluid which was poured in a glass jar and stored in the freezer.
2. **Isopropanol extract:** 7.5g of sample dissolved in 100ml distilled water for 2 hours, centrifuged and stored in the freezer.

Chemicals used

All the chemicals and solvents were of analytical grade. Sodium carbonate (Na_2CO_3), Folin-Ciocalteu's reagent), gallic acid (trihydroxy benzoic acid), Sodium hydroxide (NaOH), Ethanol (C_2H_6O), Sodium phosphate (Na_3PO_4), Ammonium molybdate [$(NH_4)_6Mo_7O_{24}$], Quercetin ($C_{15}H_{10}O_7$), 2,2-diphenyl-1-picrylhydrazyl (DPPH).

Apparatus used

Electronic weighing machine, Muffle furnace, Hot air oven, UV-Visible spectrophotometer (Labtronics, Model: LT-2201), Centrifuge, Test tubes, Conical flask with stopper, Beaker, Vortex mixer, Micropipette, Measuring cylinder.

Quantitative Determination of Physico-chemical Properties

Total moisture content

Moisture content was evaluated using the AOAC standard [9]. The peels were thinly sliced and weighed before drying them in the hot air oven at a temperature of 60℃ for 5 h. Peels were weighed after every 30minutes; until 2 consecutive similar readings were obtained. It took approximately 3 days for the peels to dry completely. The following formula was used to calculate the moisture content.

$$\text{Moisture \% by weight} = \frac{\text{initial weight of sample} - \text{final weight of sample}}{\text{initial weight of sample}} \text{x}100 \quad (1)$$

Total ash content

The ash content was determined using the AOAC standard[9]. The dried peels were grounded into a fine powder. 10g of the powder was measured in a crucible and placed inside a muffle furnace for 5 hours at a temperature of 600℃ till it turned into ash. The following formula was used for calculating the ash content of orange peels.

$$\text{Ash \% by weight} = \frac{\text{final weight of sample}}{\text{initial weight of sample}} \text{x}100 \quad (2)$$

Quantitative Estimation of Phytochemicals

i. **Total phenolic content:** The total phenolic content (TPC) was determined according to the method of Park JH et al. [2]. 50 µl of the sample was mixed with 9.5 ml of distilled water. Then 0.5 ml of Folin-Ciocalteu's reagent was added to it. The mixture was mixed with the help of a vortex mixture. 2.5 ml of 20% sodium carbonate solution was added. The contents were then once again mixed with the help of a vortex mixer. It was then kept in the dark for 40 minutes at room temperature, and the absorbance was determined at 725 nm wavelength in a UV-visible spectrophotometer (Labtronics, Model: LT-2201). TPC was expressed in terms of mg of gallic acid equivalents (GAE) per gram of dry sample (mg GAE/g).

ii. **Total flavonoid content:** The flavonoid content was determined with the method of (Zhishen J et al. [10]. 100 µl of sample was mixed with 4 ml of distilled water then 0.3 ml of 5% sodium nitrite (NaNO2) was added and allowed to stand for 5 minutes. Then 0.3 ml of 10% aluminium chloride (AlCl3) was added and allowed to stand for another 6 minutes followed by the addition of 1 ml of 1(M) sodium hydroxide (NaOH). The final volume was adjusted to 10 ml with the addition of distilled water. The absorbance was determined at 510 nm wavelength in a UV-visible spectrophotometer (Labtronics, Model: LT-2201). Quercetin was used in different concentrations as the standard for the standard curve. The total flavonoid content was calculated in mg quercetin equivalents per g of dried sample (mg QE/g).

Quantitative Determination of In vitro Antioxidant Activity:

i. **DPPH Scavenging activity:** The free radical scavenging activity of orange peel extracts was determined using the 2, 2-diphenyl-1- picrylhydrazyl (DPPH) radical as described by Ali et al. [11]. DPPH solution was prepared by mixing 0.002g of DPPH in 50ml ethanol. The standard curve was plotted taking ascorbic acid in place of the sample once and then taking gallic acid as another replacement of the sample. Various dilutions were prepared to obtain the standard curve. 50µl of sample was taken along with 2.5ml of DPPH solution and kept in the dark for 20minutes. The absorbance of the mixture was measured at 517 nm in a UV-visible spectrophotometer (Labtronics, Model: LT-2201). DPPH radical scavenging activity was calculated by the given formula.

$$\% \text{ of inhibition of DPPH activity} = \frac{\text{absorbance of control} - \text{absorbance of sample}}{\text{absorbance of control}} \text{x}100 \quad (3)$$

ii. **Total antioxidant activity (phosphomolybdate assay):** The TAC was measured according to the method of Prieto P et al. [12]. The molybdate reagent solution was prepared using, 4.704 ml of sulphuric acid (H2SO4), 0.392 g of ammonium molybdate, and 0.288 g of sodium phosphate and the remaining volume was made up to 80ml using distilled water. 100 µl sample was mixed with 3 ml of molybdate reagent in a glass test tube. The mixture was capped and incubated for 90 minutes at 80ºC. The samples were cooled at room temperature and the absorbance was measured at 695nm. Ascorbic acid was used in different concentrations as the standard for the curve. Phosphomolybdate assay was expressed as mg of ascorbic acid equivalents (AAE) per gram of dry sample (mg AAE/g).

Statistical Analysis

All the data are expressed as mean ± SD by SPSS.

RESULTS AND DISCUSSIONS

Quantitative Estimation of Physio-chemical Properties of Orange Peel Extracts

Note: All data are expressed as Mean± SD, (n=3)

The moisture and ash content of orange peel can be seen in **Table 1**. The moisture content of fresh orange peels wasfound to be 69.9%, which is considered high on account of perishability. Food products accommodating moisture of more than 55% are considered highly perishable and have a shelf life of a maximum of 2 days when stored in the refrigerator. Moisture content corresponds to the water content in food materials, which is a source of bacterial growth leading to spoilage. Orange peels contain a good amount of moisture; hence it is always better to dry them before incorporating them in any food item to retain their freshness[13]. The Ash content of dried orange peels is 2.16%, depicting the total insoluble ash percentage of the peels. The ash percentage represents the mineral content of any food sample; hence inclusion of orange peels in food items also gives a boost to its mineral content[14].

Quantitative Estimation of Phytochemicals and Antioxidant Properties of Orange Peel Extracts

Plant phenolics are one of the main groups of phytochemical compounds that work as primary antioxidants or free radical scavengers[15]. Plant polyphenols are very effective such as singlet oxygen scavengers, reducing agents and hydrogen atom donators [16]. They also have various therapeutic properties. In the present study, the total phenolic content of fresh orange peels was found to be 57.3±0.62 mg GAE/g in aqueous medium, whereas it varies when the extraction medium is changed. In isopropanol extract the TPC value stands less; compared to the aqueous extract to be 35.3±0.49 mg GAE/g. The gallic acid standard curve equation ($y = 2.284x + 0.3324$, $R^2 = 0.9761$) **(Figure 2)** was used to determine the total phenolic content of orange peel extracts. Few studies stated that the sweet orange peel has the highest phenolic content with a value of 1035.6 mg GAE/ 100 g of dry weight followed by peels of mandarin, bitter orange, navel orange and lemon which were 870, 800.4, 740.4 and 601.2 mg GAE/ 100 g of dry weight respectively[17]. Flavonoids are known secondary metabolites that are present in plants[18]. Flavonoids have numerous pharmacological activities such as neuroprotective, anti-ulcer, spasmolytic, anti-depressant, anti-bacterial, anti-hypertensive, anti-diabetic, anti-inflammatory and anti-cancer [19]. In this study, the total flavonoid content of orange peels was 147.01 mg QE/g in aqueous extract. Orange peels being high in flavonoids, in solvent extraction give the complete flavonoid content which is much higher than in aqueous extract. In isopropanol, the TFC is 259.85 mg QE/g, which is more than double as compared to aqueous extract. The total flavonoid content was calculated by the standard curve equation of quercetin ($y = 0.1469x - 0.0213$, $R^2 = 0.9638$). Another study shows that the sweet orange peel has a total flavonoid content of 402 mg quercetin equivalent/ 100 g of dry weight followed by peels of mandarin, bitter orange, navel orange and lemon [17]. To evaluate the in vitro antioxidant activity of any substance DPPH radical scavenging activity is one of the most popular, simple and convenient ways [20]. The present study shows that theDPPH scavenging activity as per the % of inhibition of orange peels in the aqueous extract was found to be 89.68 %. The antioxidant quenching activity in isopropanol extract was observed to be94.04 %. Therefore, the solvent extract has a higher scavenging property of free radicals compared to the aqueous extract of orange peel.

The total antioxidant capacity (TAC) was evaluated based on the reduction of Mo(VI) to Mo(V) by the extract and subsequent formation of green phosphate/Mo(V) complex at acid pH. It evaluates both water-soluble and fat-soluble antioxidants [21]. In the present study, the total antioxidant activity in terms of ascorbic acid standard of fresh orange peels in aqueous extract was found to be 199.76 mg AAE/g, whereas; the solvent medium exhibited 173.77 mg AAE/g. The total antioxidant capacity was calculated by the standard curve equation of ascorbic acid ($y = 1.3852x – 0.0503$, $R^2 = 0.9956$). **Table 3** shows the phytochemical screening of different parts of the orange. Here, for orange peel, terpenoids are absent. The table shows that orange peels do not show the presence of terpenoids in either of its extracts. The seeds are rich in all the phytochemical compounds including the anti-nutrient, tannin.

CONCLUSION

In this experiment, the bioactive assay of orange peels was determined in both aqueous and solvent medium. It was closely observed that orange peels are high in nutrients and instead of discarding them as waste, we can incorporate them in our diet. Citrus peels are proven to be a good source of pectin and dietary fibre[23]. The utilization of biowaste's nutrient content in food is a new advance in today's food industry. Orange peel powder is extensively used in bakery products to elevate their nutrient profile. The medical benefits of oranges are well known around the world; however, the anti-cancerous, antihypertensive properties of orange peels are coming to light with recent studies. Hereby, we conclude that orange peels are highly nutritious and should be incorporated into our daily diet.

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CONFLICT OF INTEREST

Nil

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Table 1: Quantitative Estimation of Physio-chemical Properties of Orange Peel

Sample	Moisture (%)	Ash (%)
Orange peel	69.9 ± 0.53	2.16 ± 0.05

Note: All data are expressed as Mean± SD, (n=3)

Table 2: Quantitative Estimation of Phytochemicals and Antioxidant Properties of Orange Peel Extracts

Sample	Total Phenolic Content (mg GAE/g (of fresh orange peels)	Total Flavonoid Content (mg QE/g (of fresh orange peels)	DPPH inhibition activity (% of inhibition /g of fresh orange peels)	Total Antioxidant Capacity (mg AAE/g (of fresh orange peels)
Aqueous extract	57.3 ± 0.62	147.01± 1.86	89.68 ± 0.53	199.76 ±0.94
Isopropanol extract	35.3 ± 0.49	259.85 ± 1.87	94.04 ± 0.22	173.77 ± 0.67

Note: Data are expressed as Mean± SD, (n=3)

Table 3: Preliminary Screening of Phytochemicals of different parts of Orange (Peel, Pulp and Seed)

Phytochemical Compound	Test	Orange peel [22]		Orange pulp [23]		Orange seed [24]	
		Aqueous	Solvent	Aqueous	Solvent	Aqueous	Solvent
Polyphenols	Ferric chloride test	+	+	+	+	+	+
Flavonoids	Lead acetate test	+	+	+	+	+	+
Terpenoids	Salkowski test	_	_	+	+	+	+
Alkaloids	Wagner test	+	_	+	+	+	+
Tannin	Braymer's test	+	+	+	+	+	+

Note: (+) indicate present, (-) indicate absent



Figure 1: Orange Peel

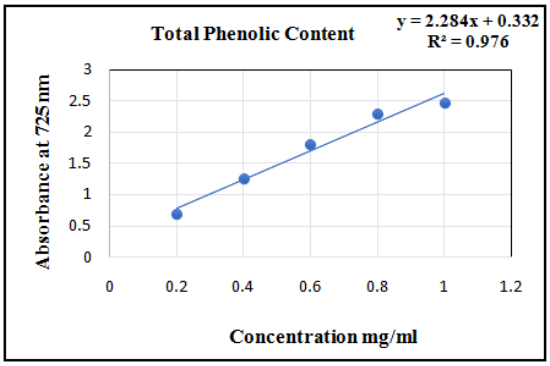


Figure 2: Standard Curve of Gallic Acid

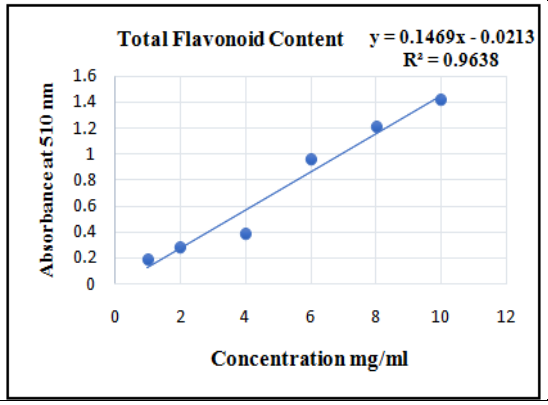


Figure 3: Standard Curve of Quercetin

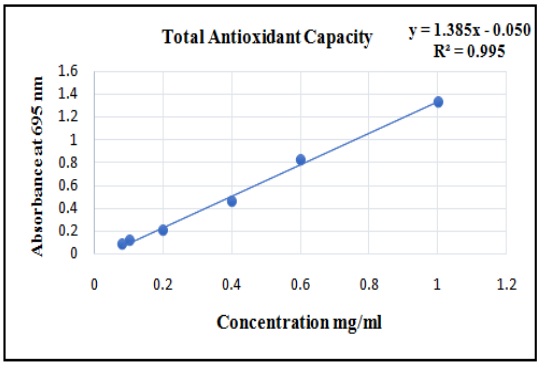


Figure 4: Standard Curve of Ascorbic acid

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REVIEW ARTICLE

A Comprehensive Review of Multimodal Image Fusion Techniques and Applications

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ABSTRACT

A methodology by which doctors can diagnose injury and dissect images from several imaging modalities is known as multi-modal image fusion. A variety of imaging methods can be used to diagnose diseases, namely Computed Tomography, Magnetic Resonance Imaging, Positron Emission Tomography, and Single Photon Emission Tomography. These techniques facilitate the diagnosis of infections by specific details information about the infected area. The observational constraints of these methods make them incapable of providing complete information. The purpose of image fusion is to maintain data from source images at every pixel position in order to enhance the processing capability of the fused image. It facilitates physicians in diagnosing diseases more effectively by providing an intuitive understanding of data contained in multiple images. This article aims to provide an detailed literature review of distinct fusion methods. The objective of this article is to present an in-depth literature review on distinct image fusion methods.

Keywords: Image fusion, discrete wavelet transform (DWT), symlet, coiflet, Dmeyer, and biorthogonal.

INTRODUCTION

Medical investigation is the methodology of sorting out the infection from an individual's shreds of evidence and signs. The information required for analysis is regularly gathered from a set of history and actual assessments of the person. Medical diagnosis aims at grouping a person's condition into divided and recognized classifications which gives choices about treatment and depiction to be made. A single diagnostic strategy is not sufficient to provide significant information about a specific disease. Hence, doctors avail another diagnostic strategy to provide sufficient information about a particular disease. This in turn necessitates to examine two distinct images. The complementary information from two distinct images is amalgamated at the software level. The amalgamated image provides complete information about individual image data available . The end output image is commonly known as the fused image. The fused image facilitates doctors to diagnose diseases more efficiently than individual diagnostic strategies. CT scans can image solid structures like bones and implants, but soft tissues cannot be seen clearly with CT scans. Soft tissue can be visualized with high resolution with Magnetic Resonance Imaging (MRI), but they are not effective when capturing bone structures. CT image shows anatomical features like bone and some delicate tissue details, but the PET image shows information about the organic chemistry that occurs inside our body. In simpler words, CT informs about the structure of bones, whereas PET informs about the science of materials in our body. As cancer is both structural and biochemical, both CT and PET imaging technologies provide information about what's going on inside our bodies. It will be hard for a physician who wants to visualize the information from images from diverse modalities. There is a need for multimodal techniques for fusing medical images to provide fusion images with complementary information obtained from a variety of modalities by Q.Zuo *et al* .[2]. As depicted in Figure 1, the source images are first processed by reducing, resizing and manipulating their mor- phology. The processed are then stripped into high- and low-frequency components. Finally, inverse transformation is done for reconstructing the fused image. Three levels of integration are possible with images: pixel, feature, and decision. PCA [4] and IHS [5] can pre- serve all the spatial information while lowering computational complexity worked by Nie Rencan *et al.[*6].

However, these strategies result in colour distortion and a loss of contrast. This makes them ineligible for medical image analysis. Due to its excellent performance in extracting features, the multiscale transform (MST) technique is popular in fusion techniques for medical images [7]. There are two key approaches in the transform domain: pyramid-based and wavelet-based. Pyramid methods include Laplacian , Gaussian , Contrast and Morphological Pyramids. There is no choice of space direction in these ways, which leads to blocking and numerous artifacts. The wavelet transform captures information in three directions (horizontal, vertical, and diagonal) that can be used to determine edges and texture regions. Medical diagnosis is all about carefully piecing together clues from a patient's symptoms, medical history, and physical exams to determine what's going wrong. However, no single test or imaging technique can tell the full story of a disease. Doctors often need to look at multiple scans to get a clearer picture. This is where multimodal image fusion comes in—it combines different types of medical images to create a more detailed and informative view. Each imaging method has its strengths and weaknesses. CT scans are great for seeing bones and solid structures but don't show soft tissues well. MRI scans provide clear images of soft tissues but aren't ideal for capturing bones. PET scans reveal biochemical and metabolic activity but lack precise anatomical details. For complex diseases like cancer, which involve both structural and functional changes, doctors need to see everything in one place. Instead of flipping back and forth between different scans, multimodal fusion brings all the important details into a single, enhanced image. This fused image makes it easier for doctors to diagnose illnesses, plan treatments, and track how well a patient is responding to therapy. It helps them see the big picture, making medical decisions more accurate and effective. In a world where early and precise diagnosis can save lives, multimodal image fusion is becoming an essential tool in modern healthcare. This paper summarizes the contributions presented as follows:

- An in-depth look at fusion of multimodal images in biomedical research.
- Existing fusion strategies are based on deep learning and traditional methods are discusssed in detail
- In depth methods, frameworks, research methods, datasets, problems and perspectives have been presented.

- A brief conclusion detailing potential future research directions A thorough literature assessment of significant image fusion techniques using Wavelet Transform is presented in Section 2. In Section 3 and section 4, image fusion strategies employing NSCT and Neuro-fuzzy approaches have been analysed. The potential future scope and conclusion is provided in Section 6.

RELATED WORK

Medical imaging is the process of providing optical representations of the interior parts of the body so that medical intervention can be performed. To diagnose disease effectively, it reveals all the essential information related to intrinsic structures hidden behind the skin and bones. Several researches are being conducted to improve the performance of image fusion strategies using different algorithms. Image fusion strategies have been studied by some authors to improve their performance[8]. A few have attempted to reduce the distortion of data in the fused image. The neural parameters used in image fusion algorithms can also be optimized to improve their performance. To foster research ideas in imaging fusion strategies, a detailed literature review has been conducted.

WAVELET TRANSFORM (WT)

A deep learning network based on wavelet transform has been developed by Xiang *et al* [10]. for enhancing low-light images. A frequency pyramid is constructed using an optimal wavelet decomposition coefficient to build a low-frequency restoration subnet and a high-frequency reconstruction subnet. The proposed method yields better quantitative and qualitative results, particularly in real-life and complex low-light scenarios. R. Sharma *et al.* [11] have proposed a wavelet packet transform based on structural and metabolic image fusion. In a non-iterative random vector functional link (RVFL) model, features from multiple layers are extracted using an eight- layer trained CNN. To mitigate outliers, RVFL uses the s-membership fuzzy function acts as an activation function. RVFL calculates the final decision after averaging the outputs of each customized RVFL classifier. An ADNI dataset is used for experiments, and classification is made based on CN vs. AD vs. MCI. Guofen Wang *et.al*. [12] have developed a gradient-enriched decomposition algorithm based on functional and anatomical image fusion (2022). To separate the integrated image into the base, the local average of the intensity and the texture layers, the GED model is enlarged to a three-layer decomposition using different coefficients and direc- tions. The proposed strategy consumes lesser time and produces less noise than traditional image fusion techniques. The local values of l2 and the largest single value are used as the integrated weights for the local electronic layers. The texture layer combination weights are generated by combining the local mean l1 with the largest single value. Experimental outcomes demonstrate that the proposed strategy produced better colors and clear edge details. Qing Zuo *et al.[*13] suggested a multi-fusion framework for automatic fusion of multi-modal images based on classifier-based feature synthesis . Feature classifier, multi-cascade fusion decoder, and pre-trained autoe ncoder based on dense connections comprise the proposed methodology. For fusion of high and low frequency coefficients a parameter-adaptive pulse-coupled neural network and I1 weighted methodology have been implemented. A new multi-cascade composite encoder has been developed in the full decoding process to selectively combine large data from multiple methods. The author has confirmed the effectiveness of the proposed strategy by successfully classify- ing brain diseases. Comparing the suggested methods with advanced approches, it shows the suggested method to be more efficient and quality-focused. Using the Synchronized-Anisotropic Diffusion Equation, R. Zhu *et al.[*14] have developed a unique multi-modality medical image fusion method. The source images are modified using S-ADE model followed by fusion using the absolute maximum fusion rule. The fused output is reconstructed using conjunction of sequential layers. The effectiveness of the proposed approach is evident from qualitative and quantitative analysis.

NON SUBSAMPLED CONTOURLET TRANSFORM (NSCT)

Depending on the network's capacity to extract deep semantic features at various scales, Yu Sang *et al.* [16] developed cascaded multiscale residual blocks for extracting multi-receptive field ratio features from CT images. Prior knowledge of learning process can be obtained by using the NSCT strategy to integrate high and low frequency components which enables the network to learn the features texture and hold more information than spatial domain

information. Mayukhmala Jana *et al.* [17] have proposed Fuzzy C-Means (FCM) clustering method for improving the subtle features found in MRI images, which aids in identifying the brain regions that are impacted. NSCT technique has been utilized to decompose the source images into different sub-bands. Singular Value Decomposition (SVD) and simple averaging techniques methodology have been utilized to integrate information about amplitude and phase spectra. The proposed methodology extracts essential information from each colour plane of PET/SPECT, integrating them with MRI in the process. Experimental outcomes demonstrate that the resultant image yields better outcomes with regard to subjective and objective analysis. Zhiqin Zhu *et al.* [18] have developed a technique that employed Phase congruency and local Laplacian energy for fusing multimodality images. Low-frequency and high frequency sub-bands were fused using a Laplacian energy- based fusion rule and phase congruency fusion rule. PC has been implemented to produce informative, in-depth information. PC measures the resolution of an image in a dimensionless manner. Studies have shown that the proposed method yields better results both qualitatively and quantitatively. Weiwei Kong *et al.[*19] have developed a novel framework for non-subsampled image fusion drew on local differ- ence (LD). To disintegrate the source images into distinct sub-bands, non-subsampled approaches were initially used. After integrating the images, the local difference (LD) operator was used. Based on the comparative analysis, the pro- posed strategy is more effective than non-subsampled Contourlet transforms and non-subsampled Shearlet transforms. In experiments, the proposed method improved the information in the image, which enhanced the diagnosis' accuracy.

NEURO FUZZY TECHNIQUES

Wang *et al.* [21] developed a distinct image fusion and denoising technique to address blurring, unclean denoising, gradient loss, and colour distortion issues. Initially, decomposition model based on weighted Schatten p-norm and hybrid variation-sparse representation have been developed. The structural layers and feature coefficient maps are employed with appropriate fusion criteria. Experimental results illustrate that the proposed image fusion strategy successfully eliminates noise while preserving gradient information without introducing colour distortion. Chengchao Wang *et al.* [22] have proposed a multimodality fusion information gate architecture (IGNFusion), which governs each encoder's feature-level contribution level to the decoder. SMSCAFM also integrates saliency information from multiple sources with complementary information. An extensive study using ten categories of multimodal images produced more significant results than existing state-of-the-art approaches for CT, MR-T1, and PET, MR-T2 combinations. Wanwan Huang *et al.* [23] have introduced a two-level adaptive network for medical image fusion that addresses the issues in existing image fusion strategies and provides a unified fusion framework . Dynamic meta-learning methods were developed specifically to overcome the heterogeneous problem of the fusion of multi-focus images into medical images by dynamic convolution decomposition (DCD). Finally, a multimodal fusion method that combines features of different aspects via a dynamic attention a dynamic channel fusion mechanism. To evaluate the model, the transfer multifocus deep network has been evaluated qualitatively and quantitatively. In this article, Yu Liu *et al.* [24] have developed a Convolutional Neural Network (CNN) technique for combining multimodal MRI volumetric data. To improve feature learning, an attention-based multimodal feature fusion module (MMFF) has been proposed. With regard of both visual quality and objective assessment, the suggested method outperforms fuison methods 3-D and 2-D medical image.

This strategy is tested for its efficacy by enriching the source modalities, and it is inferred that the segmentation accuracy is improved when the input modalities are enriched. In this paper, Vijayarajan Rajangam *et al*.[25] present a multimodal composite image representing the details of the two images within the same ROI. This method involves generating robust fusion weights from input image matrices by individually weighting the matrices. Co-occurrence matrix-mean techniques can be used to extract texture features. Spatial domain fusion is implemented using weight maps. Junwei Duan *et al*.[26] describe a region-based multimodal image fusion system utilizes super pixel segmentation and an optimization technique. Super pixel LSC is used to segment the resulting image and generate super pixel labels to efficiently synthesize the homogeneous regions and preserve the information of the image. GA technique is utilized to provide an accurate decision map. Super pixel LSC is used to segment the resulting image and generate super pixel labels to efficiently synthesize the homogeneous regions and preserve all the image information. A method reached from Gabor representation of multi-CNN combination and fuzzy neural network has

been proposed by Lifang Wang *et al.*[27] to address the limitations of the existing techniques multimodal medical image fusion, which include their inability to fully characterise the complex textures and edge information of the lesion in the fused image. The proposed strategy employs Gabor filter banks with various ratios and directions to first distinguish the CT and MR image sets into different Gabor representation pairs. Each pair of Gabor representations is fed to a trained G-CNN for initial fusion, and finally a fuzzy neural network is used to integrate multiple G-CNN outputs to form the final fused image. Experimental outcomes demonstrated that GCNN integrated clear edge information and rich texture features into complete fused image, improving the quality of multimodal medical image fusion and assisting physicians on problem diagnosis. Yong Yang *et al.*[28] have proposed a new MMIF method based on weighted local energy matching measurement (WLEMM) and increased spatial frequency for achieving a balance between computational loss and fusion quality (SF).For disintegrating input images into its base component and saliency part, a decomposition matrix is first trained by utilizing the latent low-rank representation . A unique fusion rule, called WLEMM has been used to fuse the corresponding pixels of the base and saliency parts. The fused image is then produced by merging saliency and fused base portion. The graph tells a clear story of progress in different techniques over time. Traditional and Hybrid Fusion methods start with a steady rise but soon fall behind as more advanced approaches take the lead. The Graph Neural Network shows promising growth, while Wavelet Transformation, Neuro-Fuzzy Technique, and Nonsubsampled Contourlet Transform (NSCT) make impressive leaps forward. Towards the end, NSCT emerges as the strongest performer, proving its effectiveness. This pattern highlights how newer, smarter techniques are transforming the field, leaving older methods struggling to keep up.

Technology Foundation of Multimodal Fusion

In various disciplines, information about the same phenomenon is often acquired through different types of detectors, under varying conditions, or across multiple experiments and subjects. Each of these acquisition methods is referred to as a "modality." Due to the complexity and richness of natural phenomena, it is rare that a single modality provides a complete understanding of the phenomenon of interest. The growing availability of multiple modalities reporting on the same system introduces new opportunities but also raises important questions that go beyond the use of each modality individually. These challenges are common across numerous fields of study. This paper addresses two key questions: "Why do we need data fusion?" and "How do we perform it?" The necessity of data fusion is illustrated with examples from various scientific and technological domains, followed by a mathematical framework that highlights some of the benefits of integrating data from different sources. To answer the second question, the concept of "diversity" is introduced as a crucial factor. Several data-driven approaches, particularly those based on matrix and tensor decompositions, are discussed, emphasizing how these methods account for diversity across datasets. The aim of this paper is to provide readers, regardless of their field of origin, with a comprehensive overview of the vastness of the field of data fusion, along with the prospects and opportunities it offers for advancing technology and research. A Gandhi *et al.*[29]have contributed notably to these advancements.

They focused on refining MSA fusion methods by adapting them to handle the complexities of multimodal data more effectively, while also addressing challenges such as variability in modality combinations and improving model generalization. Their research has further expanded the scope of MSA by introducing innovative ways to account for context and speaker-independent features, which significantly enhance the robustness of sentiment analysis model. zao *et al.* [30] have proposed a deep learning-based fusion model that combines optical and infrared images to improve object detectability under varying lighting conditions. Their approach demonstrated enhanced feature representation by leveraging the complementary nature of multimodal data. Similarly, Wang et al. introduced a hierarchical fusion network that integrates spatial and spectral features, significantly improving small object detection performance in remote sensing imagery. Li *et al.*[31] focused on multi-scale feature extraction techniques to improve the detection of small objects in high-resolution satellite images. Their study highlighted the importance of adaptive feature fusion strategies to enhance object visibility and classification accuracy. Additionally, McKenny *et al.[*32] developed an attention-based multimodal fusion framework that dynamically weights different modalities based on their relevance, achieving robust detection performance across diverse environmental conditions. In contrast to these methods, Han et al. [33] proposed a differential multimodal fusion algorithm, MMFD et, which

introduces a multi-branch feature extraction structure to better adapt to small objects. Their approach incorporates a Multimodal Difference Complement Module (MDCM) to enhance sensitivity to inter-modality differences, addressing the challenges of low-light detection. Furthermore, their High-Level Feature Split Hybrid Module (HFSHM) improves feature integration, significantly boosting detection accuracy. Experimental results on the VEDAI and Drone Vehicle datasets demonstrated a 14.7% and 11.1% improvement in average precision over baseline models, surpassing traditional and state-of-the-art multimodal detection algorithms. Wang *et al.* [34] proposed a demand prediction model based on historical sales trends and customer purchase behaviors, leveraging time-series analysis to improve flash sale forecasting. Their study highlighted the challenges posed by fluctuating consumer demand and the impact of external factors such as seasonal trends and marketing campaigns. Similarly, Zhu et al. [35] introduced a deep learning-based revenue prediction framework that incorporated social media sentiment analysis and customer engagement metrics to enhance forecasting accuracy. Multimodal learning has emerged as a powerful approach in revenue prediction, particularly in e-commerce. Zheng *et al.* [36] developed a multimodal sales forecasting system that integrated product descriptions, customer reviews, and sales data using a hybrid neural network. Their research demonstrated the effectiveness of combining structured and unstructured data for improved prediction performance. Guelib *et al.* [37] further extended this approach by employing attention-based fusion techniques to integrate textual and visual features from product listings, enabling a more holistic revenue forecasting model. Building on these advancements, Dong *et al.* [38] proposed the Panoramic Sales Insight (PSI) framework, a multimodal revenue forecasting model specifically designed for flash sales. PSI leverages a text–image fusion module that combines product descriptions and images using BERT for text feature extraction and ViT for visual feature extraction. Additionally, Fumeus is employed for review keyword extraction, further refining sales insights. Through controlled experiments and ablation analysis, PSI demonstrated superior performance, confirming its robustness and effectiveness in revenue forecasting for fast fashion retailers such as Shein.

Application of Multimodal Fusion

Multimodal image fusion has a wide range of applications across various fields, significantly improving decision-making and analysis. In medical imaging, it enhances disease diagnosis by combining modalities like MRI, CT, and PET to provide a clearer, more comprehensive view of internal structures and metabolic activity. This is especially useful for detecting tumors, neurological disorders, and cardiovascular diseases. In remote sensing, fusion techniques integrate data from optical, infrared, and radar imagery, improving land use analysis, disaster monitoring, and environmental studie. Surveillance and security benefit from multimodal fusion by combining visible and thermal imaging, allowing better object detection in low-light conditions. In autonomous driving, fused data from LiDAR, radar, and cameras improve object recognition and navigation, ensuring safer and more efficient vehicle control. Additionally, e-commerce utilizes multimodal fusion for revenue forecasting, integrating text and image features to predict consumer trends. By com- bining diverse data sources, multimodal fusion enhances accuracy, efficiency, and insights across multiple domains, making it a crucial tool in modern technology. Multimodal biomedical data fusion has gained increasing attention as researchers strive to integrate diverse data sources for more accurate and meaningful insights in medical and healthcare applications. Various studies have ex- plored different fusion methodologies, focusing on deep learning-based approaches to effectively combine multiple biomedical modalities. Duan *et al.* [39] proposed a hybrid fusion model that integrates genomic, imaging, and clinical data to enhance disease prediction and personalized treatment. Their approach demonstrated that incorporating multimodal data significantly improves diagnostic accuracy compared to single-modal models. Similarly, Cui *et al.* [40] developed a deep learning framework that utilizes attention mechanisms to prioritize essential features across modalities, leading to improved biomarker discovery for conditions like cancer and neurodegenerative diseases. Li ,J *et al.* [41] introduced a hierarchical fusion strategy that combines electronic health records (EHR), medical images, and physiological signals, categorizing fusion at pixel, feature, and decision levels. Their study emphasized the importance of feature-level fusion in capturing complex biomedical relationships. Meanwhile, Chen et al. explored cross-modal transfer learning to address data scarcity in multimodal biomedical fusion, demonstrating its potential in rare disease diagnosis. Building upon these advancements, Azam *et al.* [42] conducted a comprehensive investigation into deep learning- driven multimodal biomedical data fusion. Their study systematically categorized fusion techniques into three distinct levels and evaluated their applicability in various biomedical domains.

Additionally, their work examined the challenges introduced by emerging technologies, such as generative models and large language models, highlighting their impact on multimodal biomedical data integration. Despite significant progress, multimodal biomedical data fusion remains a complex field with unresolved theoretical challenges. Existing studies underscore the need for robust fusion frameworks capable of handling data heterogeneity, ensuring interpretability, and addressing scalability concerns. The integration of cutting-edge technologies continues to shape the future of this field, driving advancements in precision medicine, early disease detection, and healthcare decision-making. This Diagram shows how data from sMRI and PET scans is used to better understand and classify medical conditions. First, the images are processed into feature matrices, which organize the important details. Then, relationships between these features are analyzed, and their structure is mapped out using graphs. A model is built by combining these relationships and structures, allowing it to focus on the most important features. From there, the model identifies specific brain regions that are most relevant and uses them for classification, such as diagnosing a disease. By combining data from both sMRI and PET scans, this process helps improve accuracy and provides deeper insights into brain health.

Innovations and Emerging Trends in Multimodal Fusion

Innovations in multimodal fusion are transforming how we integrate and interpret diverse data sources, especially in fields like healthcare, remote sensing, and artificial intelligence. Advanced deep learning techniques, such as attention mechanisms and transformer models, now enable more precise fusion of text, images, and signals, enhancing decision-making and predictive accuracy. In medicine, combining genomic data, imaging, and patient records is improving early disease detection and personalized treatment. Meanwhile, real-time fusion in autonomous systems and surveillance is making AI-driven technologies smarter and more adaptive. As emerging technologies like generative AI and large language models continue to evolve, multimodal fusion is becoming more efficient, scalable, and capable of extracting deeper insights from complex datasets. In medical AI, Hermisi *et al.* [43] proposed a multimodal deep learning framework for clinical decision support, integrating medical imaging, electronic health records (EHR), and genomic data. Their study demonstrated that multimodal fusion significantly enhances diagnostic accuracy compared to single-modal models. Similarly. Liu *et al*. [44] developed a fusion-based approach for medical image analysis, leveraging deep neural networks to align and co-learn from different modalities, improving early disease detection. Tran *et al.* [45] explored multimodal representation learning, addressing challenges such as alignment and translation between heterogeneous medical datasets. Gandhi et al. further extended this research by investigating principled assessments and the practical implementation of multimodal ML models, emphasizing their role in clinical workflows and interactions with healthcare providers. In the domain of autonomous driving, Hu *et al.* [46] emphasized the importance of multimodal fusion for 3D object detection, integrating data from LiDAR, cameras, and radar to improve perception accuracy. Trivedi *et al.* [47] introduced a CNN-Transformer hybrid approach for sensor fusion, focusing on overcoming challenges such as occlusions and varying object scales in complex driving environments. Faye *et al.* [48] examined autonomy datasets and fusion-based perception models, demonstrating that multimodal integration enhances real-time object detection and vehicle navigation. Faye *et al.* [49] reviewed CNN and Transformer-based models for sensor fusion, highlighting how these techniques address issues such as object occlusion and varying scales in 3D environments. Their research underscored the necessity of diverse sensors for robust autonomous vehicle operation, detailing the strengths and limitations of different sensor modalities.

CONCLUSION AND FUTURE SCOPE

With the leap in technologies and strategies involving image fusion, there is a possibility to extract more vital information by fusing more than two images. For instance, fusing of three images such as MRI, CT and PET can greatly benefit in detecting anomalies concerning brain tumours. Future work in this area will focus on integrating the data sets from three different modalities—CT, PET, and MRI—using the bi orthogonal 1.1 wavelet function. By combining different imaging modalities, it will be possible to produce a single image with information on metabolic activity, functional anatomy, and more. This will help doctors find infections like Corona, brain tumors, and lung

cancer earlier [50]. Multimodal image fusion is a powerful tool that's transforming the way doctors diagnose and treat patients. By combining different types of scans like CT, MRI, and PET, doctors get a much clearer and more complete view of a patient's condition. This helps them spot problems earlier and make more accurate diagnoses. For instance, when it comes to cancer, fusion images give doctors important information about the size, location, and activity of tumors, allowing them to create more precise treatment plans. Real-time fusion also helps track how well treatments are working, letting doctors adjust strategies as needed [51]. One of the key benefits of multimodal fusion is that it reduces the chances of misdiagnosis. When doctors use multiple imaging methods, they can cross-check results, ensuring they don't miss anything important. This also leads to more personalized care, as doctors can tailor treatments to the specific needs of each patient. Fusion images are so detailed that, in many cases, doctors can make diagnoses without needing invasive procedures like biopsies, which reduces risk and speeds up decision-making. In surgery, multimodal fusion helps doctors navigate with greater precision, preserving vital areas while removing tumors or damaged tissue. Advances in AI and machine learning are also improving the fusion process, making it faster and more accurate by picking up on patterns that might be missed by the human eye. This is especially useful in neuroimaging, where combining MRI, PET, and fMRI can provide a comprehensive understanding of brain activity, helping diagnose conditions like Alzheimer's or Parkinson's earlier. While the technology can be resource-intensive, it has the potential to save costs by reducing the need for extra tests or procedures. Plus, it enables earlier detection of diseases like cancer or infections, which is crucial for successful treatment. As multimodal fusion continues to evolve, it opens up new possibilities for research, offering deeper insights into how diseases progress and interact with treatments, ultimately leading to better patient care.

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Table 1: Comparison of WT, NSCT, and Fuzzy-Based Techniques

Technique	Strengths	Weaknesses	Best Applications
Wavelet Transform (WT)	Multi-resolution, frequency-based, good for detail preservation	Shift-sensitive, lacks directional details	Medical Imaging, Remote Sensing
Non-Subsampled Contourlet Transform (NSCT)	Better edge and texture preservation, shift-invariant	High computational cost	Texture-rich Image Fusion, Medical Imaging
Fuzzy-Based Techniques	Handles uncertainty, adaptable, rule-based decision making	Requires fine tuning of membership functions	Uncertain Data Fusion, Infrared & Visible Image Fusion

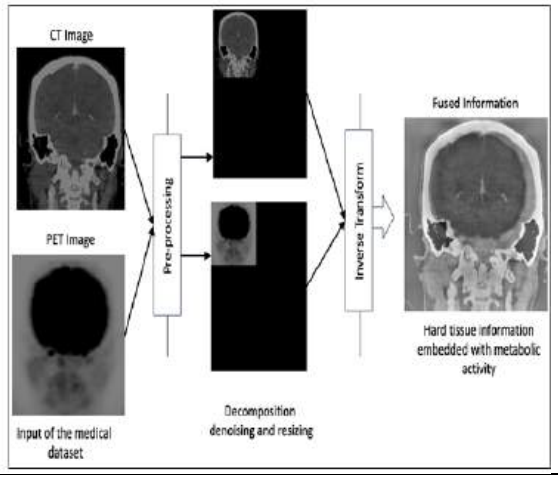


Figure 1: Block diagram of image fusion

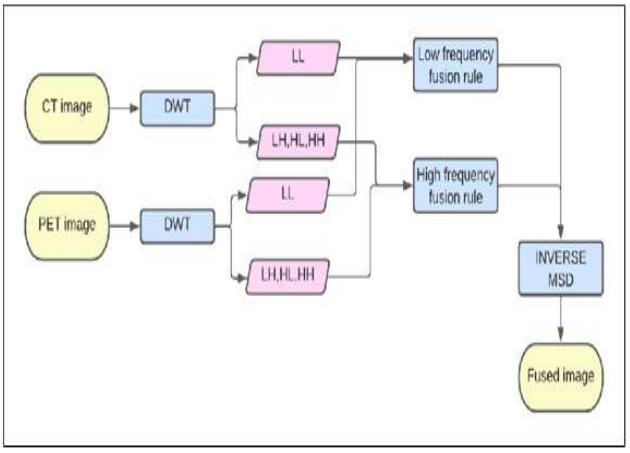


Figure 2: Architecture of image fusion using Wavelet Transform

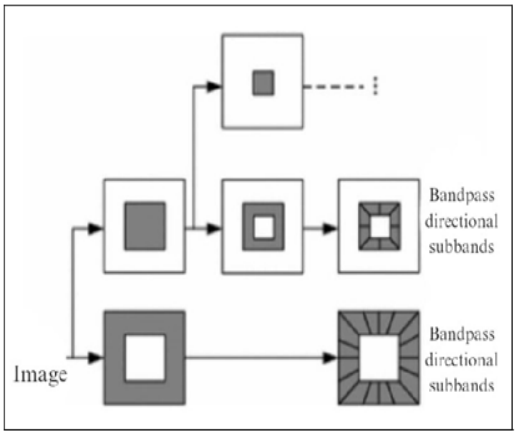


Figure 3: Architecture of image fusion using NSCT

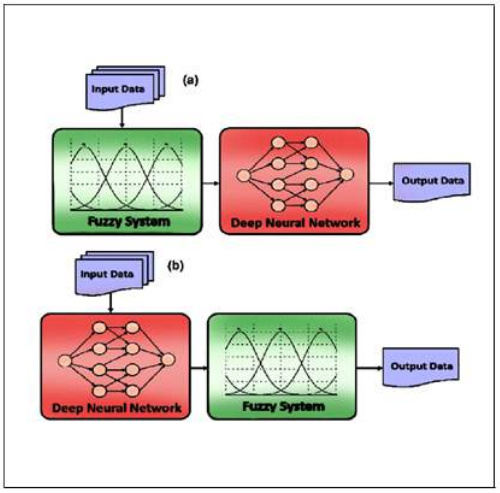


Figure 4: Architecture of image fusion using neuro fuzzy techniques

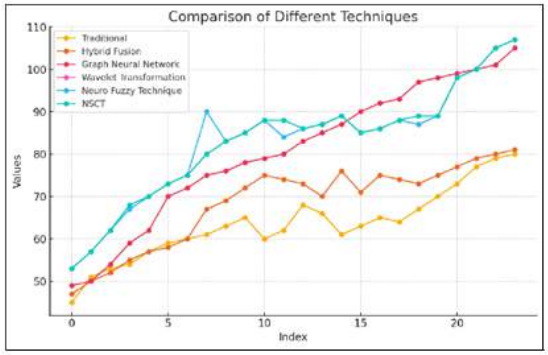


Figure 5: Comparative Analysis of Different Multimodal Techniques

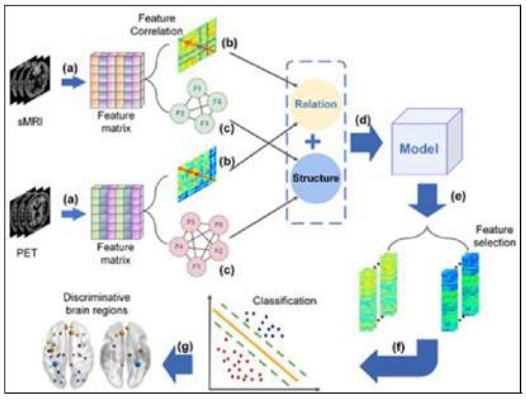


Figure 6: Multimodal Imaging-Based Feature Extraction and Classification Framework

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RESEARCH ARTICLE

A Study on Work life Balance in Automotive Sector

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ABSTRACT

In the fast-evolving automotive industry, maintaining a balance between professional and personal life has become a significant concern due to tight deadlines, extended shifts, and high-performance expectations. This research investigates the challenges associated with work-life balance in the automotive domain and examines organizational strategies aimed at improving employee well-being. This study examines the challenges and solutions for achieving work-life balance within the industry, focusing on organizational policies, employee experiences, and technological advancements that impact workplace well-being. By prioritizing human-centric work practices, automotive companies can foster a sustainable and engaged workforce while maintaining operational efficiency.

Keywords: Work-life balance, automotive industry, employee well-being, organizational policies, productivity.

INTRODUCTION

In modern work environments, particularly in high-demand industries like automotive manufacturing and services is becoming increasingly difficult. Such conditions can negatively affect employees' physical and mental well-being, leading to reduced job satisfaction and organizational commitment. These factors often strain employees, affecting their productivity and overall well-being.

DEFINITION

Employees in the industry face intense workloads, leading to fatigue and reduced personal time.Work-life balance is all about equally balancing personal time and professional responsibility.

RESEARCH PROBLEM

Despite the growing awareness of work-life balance, employees in the automotive sector continue to struggle with excessive workloads, limited flexibility, and stress. Organizational policies may exist, but their effectiveness in promoting balance remains inconsistent. This study investigates the factors contributing to work-life imbalance and explores potential solutions to create a more supportive work environment.

OBJECTIVE AND SIGNIFICANCE OF THE STUDY

- Provide strategic **recommendations** for improvement
- **Reduction in Turnover and Absenteeism**: To minimizes burnout, reducing turnover rates and absenteeism, which in turn lowers recruitment and training costs for the organization.
- **Fostering Innovation and Creativity**: Employees with manageable workloads and sufficient rest are more likely to engage in creative Skills.

LITERATURE REVIEW

It provides context for your study by highlighting what has already been explored, identifying trends, gaps, and inconsistencies in previous studies, and establishing how your work will contribute to or differ from past research.
Goyal & Agrawal (2015) examined work-life balance policies in the banking sector, emphasizing the need for employee wellness initiatives to improve productivity. **Singh (2013)** discussed role stress theory and the negative work-family interactions affecting employees, shifting focus toward positive work-life experiences. **Murthy & Shastri (2015)** explored how parenting responsibilities, marital conflicts, and role guilt contribute to work-life imbalance in corporate settings. **Lazar (2010)** emphasized that businesses benefit from effective work-life balance practices, improving employee retention and productivity. These studies provide insights into how work-life balance affects employee performance, stress management, and workplace satisfaction. While there is extensive literature on the general topic of work-life balance, there is limited research specifically addressing its challenges within the **automotive industry**, particularly in an Indian context.

GAPS IN EXISTING RESEARCH

1. **Industry based Analysis** – This study focuses on Wolk life-balance in automotive sector which is an specific industry while most of the study focus on the general corporate work life balance.
2. **India-Specific Insights** – While global studies exist, few **analyze cultural and societal expectations affecting work-life balance** within India's automotive workforce.
   This study can address these gaps by providing **sector-specific insights**, analyzing **Indian workforce experiences**.

RESEARCH METHODOLOGY

Methods

This study employs both **quantitative and qualitative** research methodologies to assess work-life balance within the automotive sector. The data is gathered through **structured surveys**. The survey includes **Likert-scale questions**, providing measurable insights into employees' perceptions of workload management, organizational policies, and personal well-being.

Sample, Procedures, and Tools Used

- **Sampling Technique:** A **voluntary response sampling method** is used, through a **Google Form**.
- **Data Collection Tools:** Survey response were stored digitally, and compiled for analysi. Microsoft Excel Tool is used for the data analysis, interpretation and visualization.

- **Analysis Framework: Visualization tools**, including charts and graphs, are used to present results clearly.

DATA ANALYSIS & INTERPRETATION

SURVEY QUESTIONS

The study includes **32 questions** focused on different aspects.

Demographics (Age, Gender, Educational Background, Job Level, Department, Years with the Company).

1. **Time Management and Workload** (Managing workload within regular hours, realistic expectations, working beyond regular hours, completing tasks on time).
2. **Personal Well-being and Health** (Work stress, time for hobbies/physical activity, balance between work and health, company value for employee well-being).

KEY FINDINGS

- **Age Group:** Majority of respondents are **25-34 years old with** (34.5%), followed by **those under 25 (29.1%)**.
- **Workload Management:51% agree** they can manage workload within regular hours, while **21% are neutral**.
- **Company Support:39% agree** that their employer provides flexibility, but **34% remain neutral**, suggesting mixed perceptions.
- **Well-being:35% agree** they maintain a balance between work and health, but **29% are neutral**.
- **Leadership Support:36% remain neutral** on leadership support, indicating a need for clearer support from management.
- **Work Stress Impact:34% of employee has agree** that job demands overwhelm them.
- **Impact on Personal Life:31% agree** that their job negatively affects personal relationships, revealing concerns over work-life balance.

STATISTICAL ANALYSIS

The study employs various statistical tests to analyze work-life balance factors:

1. **Chi-Square Test** – Examines relationships between **job level and employer's encouragement for breaks** (Result: No significant correlation).
2. **F-Test** – Evaluates **age and the need to work beyond regular hours** (Result: No significant variance).
3. **T-Test – gender differences in work stress**

Result: No significant difference.

CHI-SQUARE ANALYSIS

HYPOTHESIS:

To Find a Significant Relationship Between Job Level and Regular Break Encouragement

- **Null Hypothesis (H_0):**Job Level does not have significant relationship in regular Break Encouragement.
- **Alternative Hypothesis (H_1):**Job Level does have significant relationship in regular Break Encouragement.
- Contingency table:

Job Level	S.A	A	N	D	S.D	Total
Entry-level	6	11	11	4	1	33
Mid-level	7	13	13	5	2	41
Senior-level	5	9	9	4	1	28
Executive	1	3	3	1	0	8
Total	20	36	35	14	5	110

Calculate the Expected Frequencies

$E = \frac{(Row\ total) \times (\text{Column total})}{(Grand\ total)}$

Expected Frequencies Table

Job Level	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Entry-level	6	10.8	10.5	4.2	1.5
Mid-level	7.45	13.45	13.05	5.2	1.86
Senior-level	5.09	9.09	8.93	3.56	1.27
Executive	1.45	2.62	2.55	1.02	0.36

O	E	O-E	$(O-E)^2$	$(O-E)^2/E$
6	6	0	0	0
11	10.8	0.2	0.04	0.0037
11	10.5	0.5	0.25	0.0238
4	4.2	-0.2	0.4	0.0952
1	1.5	-0.5	0.25	0.1667
7	7.45	-0.45	0.2025	0.0272
13	13.45	-0.45	0.2025	0.0151
13	13.05	-0.05	0.0025	0.0155
5	5.2	-0.5	0.25	0.0481
2	1.86	0.14	0.574	0.3086
5	5.09	-0.09	0.0081	0.0016
9	9.09	-0.09	0.0081	0.0009
9	8.95	0.05	0.0025	0.0003
4	3.56	0.44	0.1936	0.0544
1	1.27	-0.27	0.0729	0.0574
1	1.45	-0.45	0.2025	0.1397
3	2.62	0.38	0.1444	0.0551
3	2.55	0.45	0.2025	0.0794
1	1.02	-0.02	0.02	0.0392
0	0.36	-0.36	0.1296	0.36
				$\frac{\sum(O-E)^2}{E} = 1.4919$

Calculate the Total Chi-Square Statistic

$\chi 2 = \frac{\sum(O-E)^2}{E}$

$\chi 2 = 1.4919$

The critical value for the Chi-Square distribution is approximately **21.026**.

CONCLUSION

Job Level does not have significant relationship in regular Break Encouragement.

F-TEST ANALYSIS

HYPOTHESES

Age and Working Beyond Regular Hours

- **Null Hypothesis (H0):** Age has no significant relationship with the feeling of needing to work beyond regular hours to meet deadlines.
- **Alternative Hypothesis (H1):**There is no significant relationship between Age and needing to work beyond regular hours to meet deadlines.

X1	X2
38	38

20	13
13	39
7	15
32	5

X1	X12	X2	X22
38	1444	38	1444
20	400	13	169
13	169	39	1521
7	49	15	225
32	1024	5	25

$n_1 = 5$

$n_2 = 5$

The Sample Variances

Variance of Age (s_1^2)

$\mathbf{s_1^2} = \sum x_1^2/(n_1-1)$

$\mathbf{s_1^2} = 3086/ (5–1)$

$\mathbf{s_1^2} = 3086/4$

$\mathbf{s_1^2} = 771.5$

Variance of Working beyond regular hours (s_2^2)

$\mathbf{s_2^2} = \sum x_2^2/(n_2-1)$

$\mathbf{s_2^2} = 3384/ (5–1)$

$\mathbf{s_2^2} = 3384/4$

$\mathbf{s_2^2} = 846$

The F-statistic

$F= \mathbf{s_2^2}/ \mathbf{s_1^2}$ (since $\mathbf{s_2^2} > \mathbf{s_1^2}$)

F=846/771.5

= 1.0966

Significance level of α=0.05.

The critical F-value for a two-tailed test with df_1=4 and df_2=4.

Using an F-distribution table the critical F-value is approximately 6.39.

In this case, 1.0966 < 6.39.

CONCLUSION

Since the calculated F-statistic (1.0966) is less than the critical F-value (6.39), we **fail to reject the null hypothesis**. Therefore, there is not enough evidence to conclude that the variances of the two populations (age and working beyond regular hours) are significantly different at the 0.05 significance level.

T-TEST ANALYSIS

HYPOTHESES

H0 (Null Hypothesis): Gender has no significant relationship with Stress levels Interfering with personal Life.

H1 (Alternative Hypothesis): There is a significant relationship between Gender and Stress levels Interfering with personal Life.

X1	X2
65	26
45	17

0	37
0	22
0	8

Calculate Mean Scores

x_1	x_1^2	x_2	x_2^2
62	4225	26	676
45	2025	17	289
0	0	37	1369
0	0	22	484
0	0	8	64

$\sum x_1 = 110$
$\sum x_1^2 = 6250$
$\sum x_2 = 110$
$\sum x_2^2 = 2882$
$N_1 = 2$
$N_2 = 5$

Mean

$\bar{x_1} = \sum x_1 / N_1$

$= \frac{110}{2}$

$= 55$

$\bar{x_2} = \sum x_2 / N_2$

$$s_1^2 = \sqrt{\frac{\sum x_1^2}{N_1} - \left[\frac{\sum x_1}{N_1}\right]^2}$$

$$s_1^2 = \sqrt{\frac{6250}{2} - \left[\frac{110}{2}\right]^2}$$

$$s_1^2 = \sqrt{3125 - 3025}$$

$$s_1^2 = \sqrt{100}$$

$$s_1^2 = 10$$

$$s_2^2 = \sqrt{\frac{\sum x_2^2}{N_2} - \left[\frac{\sum x_2}{N_2}\right]^2}$$

$$s_2^2 = \sqrt{\frac{2882}{5} - \left[\frac{110}{5}\right]^2}$$

$$s_2^2 = \sqrt{576 - 484}$$

$$s_2^2 = \sqrt{92}$$

$$s_2^2 = 9.59$$

Calculate the t-statistic

Formula:

$$S = \sqrt{\frac{s_1^2 N_1 + s_2^2 N_2}{N_1 - N_2 - 2}}$$

$$S = \sqrt{\frac{(10)(2) + (9059)(5)}{2 + 5 - 2}}$$

$$S = \sqrt{\frac{20 + 47.96}{5}}$$

$$S = \sqrt{\frac{67.96}{5}}$$

$$S = \sqrt{13.592}$$

$$t = \frac{\bar{x}_1 - \overline{x_2}}{s\sqrt{\frac{1}{N_1} + \frac{1}{N_2}}}$$

$$t = \frac{55 - 22}{3.6867\sqrt{\frac{1}{2} + \frac{1}{5}}}$$

$$= \frac{33}{3.6867 + \sqrt{0.5 + 0.2}}$$

$$= \frac{33}{3.6867 + \sqrt{0.7}}$$

$$= \frac{33}{3.6867(0.8366)}$$

$$= \frac{33}{3.0843}$$

Calculated t-value = 10.6993

Compare t-statistic and Critical t-value

10.6993 > 2.015

CONCLUSION

Gender has no significant influence on the perception of whether stress levels related to work interfere with personal time or family life.

CORRELATION ANALYSIS

HYPOTHESES

Years with the Company and Work-Life Balance

Null Hypothesis (H0): There is no significant relationship between Years with the Company and Work-Life Balance.

Alternative Hypothesis (H_1): Years of experience with the company have a significant relationship with employees' perception of whether the company culture supports a healthy work-life balance. Employees with longer tenure may experience different levels of work flexibility, expectations, or company support compared to newer employees.

Hypothetical Data (Distribution Within Years of Service)

Year of experience (x)	28	40	22	11	9

Healthy work-life balance (y)	27	20	36	18	9

x	y	X^2	y^2	xy
28	27	784	729	756
40	20	1600	400	800
22	36	484	1296	792
11	18	121	324	198
9	9	81	81	81
∑x = 110	∑y = 110	$\sum x^2$=3070	∑y2 = 2830	∑xy = 2627

$$r = \frac{5(2627) - (110)(110)}{\sqrt{[5(3070) - (110)^2[5(2830) - (110)^2]}}$$

$$= \frac{13135 - 12100}{\sqrt{[15350 - 12100][14150 - 12100]}}$$

$$= \frac{1035}{\sqrt{(3250)(2050)}}$$

$$= \frac{1035}{\sqrt{6662500}}$$

$$= \frac{1035}{2581.1819}$$

$$r = 0.4010$$

CONCLUSION

The degree of positive correlation in this sum is between +0.25 and 0.5.
It is most likely low degree of correlation.

LINEAR REGRESSION ANALYSIS

HYPOTHESES

Job Level and Time for Task Completion

Null Hypothesis (H0): Job level has no significant relationship with employees' perception of being given enough time to complete tasks without feeling rushed.

Alternative Hypothesis (H_1): There is asignificant relationship between Job Level and Time for Task Completion.

Variables:

- Independent Variable (Predictor): Job Level (x)
- Dependent Variable (Outcome): Time to Complete (y)

Data:

Job Level (x)	Time to Complete (y)
33	36
8	14
41	33
28	19
0	8

Linear Regression Model:

x	y	X^2	Y^2	xy
33	36	1089	1296	1188
8	14	64	196	112
41	33	1681	1089	1353
28	19	784	361	532
0	8	0	64	0

$\sum x=110$

$\sum y=110$

$\sum x^2=3618$

$\sum y^2=3006$

$\sum xy=3185$

$n = 5$

Regression coefficient of x on y

$$bxy = \frac{n\sum xy - (\sum x)(\sum y)}{n\sum y^2 - (\sum y)^2}$$

$$= \frac{5(3185)-(110)(110)}{5(3006)-(110)^2}$$

$$= \frac{15925-12100}{15030-12100}$$

$$= \frac{3825}{2930}$$

$bxy = 1.3055$

Regression coefficient of y on x

$$byx = \frac{n\sum xy - (\sum x)(\sum y)}{n\sum x^2 - (\sum x)^2}$$

$$= \frac{5(3185)-(110)(110)}{5(3618)-(110)^2}$$

$$= \frac{15925-12100}{18090-12100}$$

$$= \frac{3825}{5990}$$

$byx = 0.6386$

Regression equation formula

$x-\bar{x}=bxy\ (y-\bar{y})$

$y-\bar{y}=bxy\ (x-\bar{x})$

$\bar{x} = \frac{\sum x}{n}$ $\bar{y} = \frac{\sum y}{n}$

Regression equation of x on y

x-22=1.3055(y-22)

x-22=1.3055y-28.721

x=1.3055y-28.721+22

x =1.3055y – 6.721

x =1.3055y – 6.721

Regression coefficient of y on x

y- ȳ=bxy (x-x̄)

y-22=0.6386(x-22)

y-22=0.6386x-14.0492

y=0.6386x-14.0492+22

y =0.6386x+7.9508

Regression coefficient of y on x

y =0.6386x+7.9508

CONCLUSION

Job level has a moderate impact on time flexibility.

DISCUSSION AND FINDINGS

The findings from this study align with several prior studies on work-life balance. For instance:

- **Lazar (2010)** highlighted the broader benefits of work-life balance, such as better talent retention and operational efficiency, which the study confirms through employee perceptions of workplace culture and leadership support.
- **Holly & Mohnen (2012)** found that extended working hours negatively impact personal life.which aligns with this study's observation that many respondents feel overwhelmed by job demands.

CONCLUSION

The overall study confirms that work-life balance plays a critical role in employee satisfaction, productivity, overall workplace harmony.By addressing these concerns and organizations create a culture that values both professional success and personal fulfillment.

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RESEARCH ARTICLE

Formulation and Evaluation of Wheat Grass Topical Gel

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ABSTRACT

The current work aims to formulate and evaluate Triticum aestivum leaves extract as a topical herbal gel. Wheat grass gel was developed in the present work to treat skin conditions including psoriasis, eczema and anti-aging. Xanthan gum, guar gum, Carbopol 940 were utilised as gelling agents in the wheatgrass gel formulation. Three formulations of wheat grass topical gel were prepared and evaluated for physical appearance, skin irritation, spread ability, pH and extrudability. Using a hydrogen peroxide scavenging assay, the topical antioxidant activity of the wheat grass methanolic extract was assessed by Hydrogen peroxide scavenging assay. The gel formulations showed homogeneity and a green appearance. Spreadability tests revealed easy application with minimal shear force. The gels exhibited a viscosity ranging from 1120 to 3570 centipoise. Wheat grass meth anolic extract at 60µg/ml concentration exhibited IC_{50} value of 64.6and standard Quercetin exhibited at the same concentration IC_{50} value of87.09 thus indicating significant *in-vitro* antioxidant activity.

Keywords: Wheat grass, Topical gel, Quercetin, Anti-oxidant

INTRODUCTION

Gels are characterized by a network of interconnected molecules dispersed within a liquid solvent, forming a semi-solid structure, gels can be createdfrom a wide range of sources, including as synthetic polymers, biopolymers, nanoparticles, and even biological molecules like proteins and DNA [1,2].The formation of gels typically involves the process of gelation, where individual molecules or particles assemble into a three-dimensional network, trapping the solvent within its structure [3]. Gels are non-sticky, require less energy to formulate, stable and they have greater potential as a drug delivery system for topical application than ointments [4]. The majority of medications available as gels are used to treat pain and inflammation mostly as either non-narcotics like salicylates and corticosteroids like hydrocortisoneor narcotics like opioids. [5]. The greatest edible cereal-grass crop in the world is wheat (Triticum species), belonging to the Gramineae (Poaceae) family.[6] The leaves are long and narrow, with one or both surfaces being glabrous or hairy, and the stem is tufted, erect or semi-erect to prostrate, and typically hollow with thin walls [7-8].

Classification of gels

Gels can be categorized according to their physical characteristics, rheological characteristics, solvent type, and colloidal phases.[9]

Structure and Formation

Gels are produced through the process of gelation which can be initiated by temperature, pH, solvent composition or the addition of gelling agents, resulting in network structures that are linear, branched, or cross-linked. Transmission electron microscopy on super critically dried gels confirms that the networks are porous [10,11]. Entropic effects govern the elastic behavior of organic gels, and the network can undergo significant volumetric changes [12].

Properties

Gels have unusual mechanical properties, including elasticity, stiffness, and visco elastic behaviour. A gel is a composite made up of a liquid and a solid; the mechanical response of the gel is determined by the characteristics of each phase as well as how they interact.[13]Gels exhibit shear-thinning action, allowing them to flow more easily under tension but swiftly returning to their gel-like quality once stress is removed. Gels' mechanical properties can be modified by modifying parameters including gelling agent concentration, cross-linking, and solvent type.

Applications

- Cosmetics
- Bio technology
- Food industry
- Tissue engineering
- Environmental remediation
- Personal care products
- Art conservation

These applications highlight the versatility of gels across different industries, from healthcare to food, and from research to everyday consumer products[14]

Herbal gels

Herbal gel is a plant-based preparation. Gels are used topically for a variety of functions, including protecting, antiseptic, and antibacterial properties. Examples include *Berberis aristata, Azadirachtaindica, Curcuma longa and Rubia cordifolia.*[15]The aim of the study is to prepare and characterize Wheat grass topical gel for anti-aging, psoriasis, and to prove its antioxidant efficacy. Antioxidant activity is considered important for managing psoriasis because research indicates that psoriasis is associated with increased oxidative stress, meaning an imbalance between free

radicals, antioxidants and therefore, boosting antioxidant levels could potentially help alleviate symptoms by mitigating inflammation and skin damage

Estimation of antioxidant activity

Common tests used to measure antioxidant activity include DPPH (Diphenyl-1-picrylhydrazyl) radical scavenging assay, ABTS assay, Folin-Ciocalteu reagent etc., all rely on spectro photometric methods for quantifying the reduction of free radicals in a sample. The scavenging assay for hydrogen peroxide gauges the capacity of a substance to scavenge hydrogen peroxide (H_2O_2).The rate of H_2O_2 consumption is measured in an incubation system that contains H_2O_2 and a scavenger.

Oxidative stress in psoriasis

Studies show that psoriasis patients have elevated reactive oxygen species levels and reduced activity of antioxidant enzymes.

Potential benefits of antioxidants

By neutralizing free radicals, antioxidants can help in reducing inflammation, improves skin barrier functionand slow the progression of psoriatic lesions.

Dietary and topical antioxidants

Some research suggests that incorporating antioxidant-rich foods in the diet and applying topical antioxidant treatments could be beneficial for psoriasis patients. Wheat grass is utilised for anti-aging properties it has antioxidants to combat oxidative stress and neutralizes free radicals. These compounds help protecting skin cells from UV radiation and pollution, which contribute to premature aging. Wheatgrass is rich in chlorophyll, which helps in detoxification and enhances overall skin health. Topical application or Regular consumption of wheatgrass promotes youthful appearance and reduces wrinkles.

MATERIALS AND METHODS

Wheat grass was grown in the laboratory by purchasing high quality of sharbati wheat grain from local market. Carbopol-940, Guar gum and xanthan gum were acquired from Mumbai's Research Lab Fine Chem Industries. Every other chemical that were utilized were of analytical quality.

Wheat grass Cultivation

Required quantities of raw wheat grains were submerged in water over night and next day they were dried under sun in plastic trays, sand was sprinkled on them as a thin layer and covered to aid darkness to sprout faster and the other day, water was sprinkled again and covered, this process was repeated until sprouting was seen. Later the sprouting was watered and grown for a period of 8 days and harvested on 9th day.[16]

Preparation of wheat grass extract

The wheat grass was collected after eight days of sprouting and allowed to dry in the shade for four days in dark, well-ventilated rooms. The dried wheatgrass was ground up. The crushed wheatgrass was mixed with methanol, macerated for a week, and then filtered out in phases to achieve extraction. To get rid of the methanol, the extract was dried at 35 °C. The process of sequential extraction was also used. Crushed wheatgrass was exhausted in successive extraction by repeatedly adding little amounts of petroleum ether and filtration. Petroleum ether was eliminated by evaporating the filtrate, and any remaining material was exhausted by repeatedly adding acetone and then washing with water. [17]

Method for formulation of wheat grass gel:

Step 1: Preparation of gel base using various gelling agents.

The gel was formulated by weighing the necessary amount of gelling agents. The weighed amounts were taken in to a beaker and placed on a magnetic stirrer. The Carbopol 940 dispersion was forcefully mixed at 300rpm,the necessary quantity of methyl paraben was added as a preservative and distributed throughout the mixture. After covering the beaker with aluminum foil, it was allowed to mix approximately for fifteen minutes. Additionally, the mixture was homogenized for five minutes using a low-speed homogenizer. After the polymer was fully added and thoroughly mixed, 1% sodium hydroxide solution was added to bring the pH down to 7, at which gels started to form on their own. The required quantities of glycerine, colorants, and perfume (eucalyptus oil) were added to this gel. The gel was left to solidify at room temperature.[17]

Step 2: Preparation of Wheat grass powder co-solvent mixture
The required quantity of wheatgrass extract obtained from successive extractions was dissolved in a 1:1 co-solvent mixture of propylene glycol and alcohol

Step 3: Incorporation of wheat grass powder mixture into gel base.
The required amount of co-solvent mixture of wheatgrass extract was added to the gel bases and forcefully stirred to achieve a homogeneous mixture.

Evaluation of wheat grass topical gel:

- **Appearance of wheatgrass gel:** The appearance of the gel was observed visually against dark and bright background.
- **pH measurement:** A digital pH meter was used to measure the pH of 1% wheat grass gel.
- **Homogeneity**: The consistency of the contents is assessed visually.
- **Spread ability:** Gel was placed in between two slides**.** A weight of 100 gm was placed on the top of the two slides for 1 min. to provide a uniform film of the gel between the slides. After 1 min. the distance of spreaded gel was noted. Spread ability (S) was calculated by S = M.L/T, Where, **M** is the weight (g) tied to the upper glass slide, **L** is the length (cm) moved on the glass slide and T is the time.
- **Viscosity**: Viscosity of the prepared gels was measured using Brookfield viscometer (Brookfield Viscometer V6.5 RV) at 25°C ± 2°C at the rpm [18]**.**
- **Extrudability:** After the gels were filled into a collapsible tube, extrude ability was assessed. The tubes were filled with gel and sealed at the ends, their weights were noted. The tubes were clamped between two glass sides and a 500g weight was placed over the slides, the cap was taken off. To calculate the percentage of extruded gel, the collected gel was weighed.[19]

***In-vitro* anti-oxidant studies**

Assay for scavenging hydrogen peroxide radicals: The Ruch et al. 1989 method can be used to determine the test substance capacity to scavenge hydrogen peroxide. 40 mM hydrogen peroxide was prepared using 50 mM phosphate buffer (pH 7.4). Hydrogen peroxide concentration was determined using a spectrophotometer by measuring absorbance at 230 nm. Wheat grass extract (test) was mixed with distilled water and various concentrations(10–60 ug/ml) were prepared. After 10 minutes, the absorbance at 230 nm was measured using phosphate buffer as blank solution. Quercitin was used as a positive control. The calculation for the percentage of hydrogen peroxide scavenging is displayed below.

$$\%\, Scavenged\, H2O2 = Ai - At/Ai \times 100$$

Where At is the test absorbance and Ai is the control absorbance. The concentration of a medicine or molecule required to 50% inhibit a specific biological or biochemical process is known as the IC_{50} value, or half-maximal inhibitory concentration. Plotting the concentration on the x-axis and the hydrogen peroxide inhibition percentage on the y-axis allowed for the comparison of the standard and test IC_{50} values. IC_{50} can be calculated by fitting with the following equation

$Y = a \times X + b$

$IC_{50} = (0.5 - b)/a$

RESULTS AND DISCUSSION

The appearance of gel is green in colour and pH is observed from range of 6.8to 7.0 which confirms compatibility with skin. Viscosity of gel is in between range of 1120 centipoise to 3570 centipoise which results in a good consistency on application to the skin. Spread ability of gel is in range 2.0 to 2.3 which shows good penetration on skin. Extrudability of the gel is also observed in good range.

***In-vitro* anti-oxidant activity**

In-vitro anti-oxidant activity of wheatgrass extract was performed and the obtained values are mentioned under table.2 % Inhibition of test was compared with standard. The %Inhibition exhibited by the test is 64.6 at 60µg/ml where as the standard exhibited 87.09 at 60µg/ml. which indicates significant antioxidant activity of wheat grass gel.

CONCLUSION

Wheat grass topical gels (WG1, WG2, WG3) were prepared utilizing various polymers such as Carbopol 940, xanthan gum and guar gum. The gels were examined for homogeneity, viscosity, spreadability, texture, extrudability, pH, odor, appearance and the antioxidant qualities of the generated gels were also examined. All the formulations were greenish in colour and had a pH of 6-7 (skin pH), indicating that they were suitable for topical use. The viscosity ranged from 1100-3670 Cp, which is considered acceptable. The anti-oxidant activity of wheatgrass extract was investigated, and the IC_{50} values of wheatgrass extract and standard quercetin were found to be 34.3 and 45.6, respectively. Wheatgrass extract's IC_{50} results indicate that it has antioxidative properties.

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Table.1: Advantages and Disadvantages of Gels

ADVANTAGES	DISADVANTAGES
•**Controlled Release:** Gels can gently release active substances, such as medications or minerals, over time to provide long-term therapeutic or nutritional benefits. •**Ease of Application:** Gels have a smooth and spreadable consistency, making them simple to apply to surfaces or mix into formulations like creams or lotions. •**Versatility:** Gels may be adjusted to specific requirements by modifying their composition, making them appropriate for a variety of uses in food, cosmetics, and pharmaceutical sectors. •**Stability:** Gels can help formulations remain stable by preventing ingredient separation and ensuring homogeneity over time, resulting in a longer shelf life and higher product quality •**Selective Permeability:** Some gels have selective permeability, which allows some chemicals to pass while inhibiting others.	•**Drying Out**: Water-based gels can dry out over time, particularly if exposed to air or stored in insufficient containers, resulting in changes in texture, efficacy, and shelf life. •**Potential Residue**: Some gels may leave residue or tackiness after application, which might be undesirable in some formulas, such as personal care items or adhesives. •**Brittleness:** Some gel formulations, particularly those containing cross-linked polymer can become brittle or lose elasticity with time, decreasing their efficacy in applications requiring flexibility /durability. •**High Cost:** Developing and manufacturing specialty gels can be expensive, especially if they need unique components or procedures, limiting their widespread use in certain industries

Table.2: Formulation of Wheat Grass Topical Gel

Ingredients	WG1	WG2	WG3
Wheatgrass extract powder	0.48g	0.48g	0.48g
Co-solvent mixture (IPA:PG) (1:1)	2ml	2ml	2ml
Carbopol 940	0.1g	-	-
Xanthan gum	-	0.1g	-
Guar gum	-	-	0.1g

Glycerine	1.5ml	1.5ml	1.5ml
Methylparaben	0.05g	0.05g	0.05g
Eucalyptus oil	Q.S	Q.S	Q.S
Distilled water	10ml	10ml	10ml

Table.3 Evaluation of Wheat Grass Topical Gel

Concentration (µg/ml)	MEWG		Quercetin	
	% Inhibition	IC_{50} values	% Inhibition	IC_{50} values
10	5.38± 0.01		37.75 ± 0.05	
20	25.4 ± 0.03		44.70 ± 0.01	
30	29.3 ± 0.5	34.3	52.05 ± 0.03	45.6
40	33.5± 0.8		68.09 ± 0.06	
50	54.1 ±0.25		78.81 ± 0.11	
60	64.6 ± 0.45		87.09 ± 0.02	

Table 4: *In-Vitro* Anti-Oxidant Activity [% Inhibition Values of Mewg and Quercetin for Concentration of 10 to 60 (µg/Ml)]

Evaluation test	WG1	WG2	WG3
Appearance	Greenish appearance	Greenish appearance	Greenish appearance
pH	7.0 ±0.02	6.8 ±0.03	6.9 ±0.06
Homogeneity	+++	+++	++
Viscosity(cp)	1120 ± 5.2	3328 ± 4.3	3570± 2.5
Spreadability (cm)	2.3 ± 0.2	2.1 ± 0.5	2.0 ± 0.1
Extrudability	++	++	++

+++ indicates 90%, ++ indicates 80%, + indicates 70%

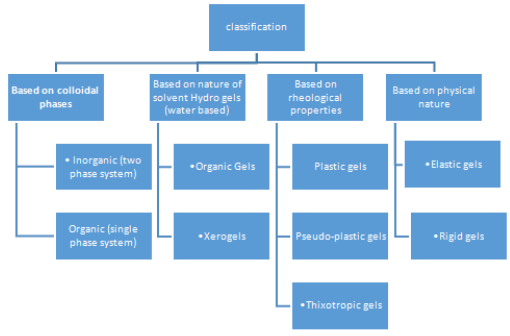


Figure 1. Classification of gels



Figure 2: Cultivation of *wheat grass*

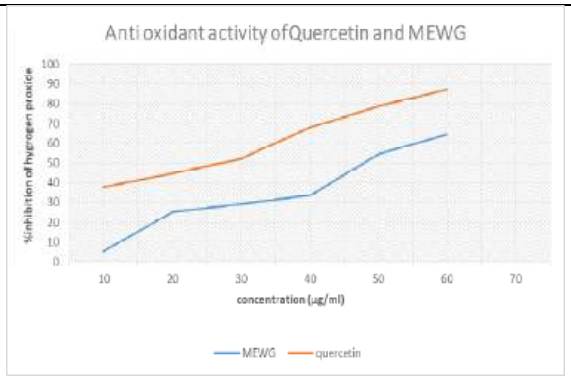


Figure 3. Anti-oxidant efficiency of Quercetin and Wheat grass extract

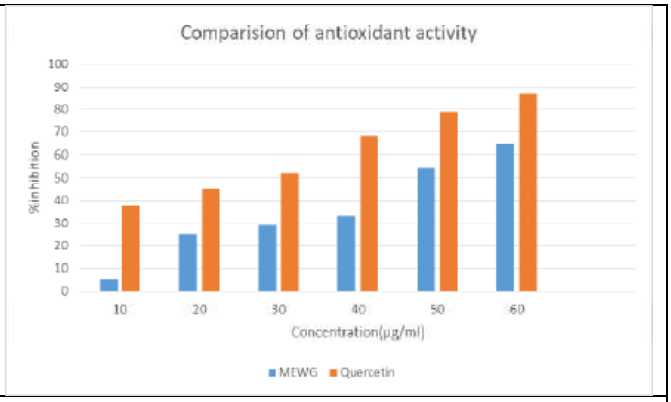


Figure.4 Comparision of anti-oxidant activity of MEWG and Quercitin

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RESEARCH ARTICLE

Exploring the Effectiveness of Multivariate EWMA and Hotelling T^2 Control Charts in Quality Control

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ABSTRACT

Maintaining public health requires efficient monitoring techniques for air quality, which is a crucial component of environmental health. This research focuses on the multivariate control charts, namely Multivariate Exponentially Weighted Moving Average (MEWMA) and Hotelling T^2 to the air pollutant data. The MEWMA control chart is effective in determining shifts in the mean vector of multivariate data. The Hotelling T^2 control chart is used to monitor changes in the dispersion and correlation structure of multivariate data. The data was split into two groups by the use of factor analysis. Next, the study employs Average Run Length (ARL) calculations to assess the performance of these control charts. The analysis reveals that the MEWMA control chart demonstrates superior detection capabilities for out-of-control data points within each variable group compared to the Hotelling T^2 control chart. Then the process capability index of both groups is more than 1, which indicates the process goes well in all the variable groups although some points are out of control. In this research study, the effectiveness of MEWMA and Hotelling T^2 control charts on air pollution data is determined. The findings provide valuable guidance for practitioners seeking robust methods to ensure timely detection of air quality variations and facilitate informed decision-making for pollution control and public health management.

Keywords: MEWMA, Hotelling T^2, Air data, multivariate control charts

INTRODUCTION

According to the recent report by the [19] India's capital, Delhi is the fourth largest pollutant city in the world. The Eight main components of air pollution are surface ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), and particulate matter (PM), which comprises PM 2.5 and PM 10, Ammonia (NH3), nitrogen oxides (NO_x). Of the eight, the main contributors to the major air pollution are CO, PM 2.5, and PM 10. In India, the vehicle sector is 20–35% of the PM2.5 pollution in the nation [11]. The utilization of industrial facilities, coal-fired power plants, and fuels made from biomass all contribute to the decline in air quality. All of these substances have the potential to induce several health issues, including stroke, neurological diseases, lung cancer, and heart disease. Therefore, managing the region's air quality requires careful attention [7]. According to earlier research [8], there was a rather strong relationship between PM 2.5, PM 10, and CO. However the analysis of the air quality is done on an individual basis. Even if there is a statistical association between the two, analyzing the concentration independently may result in a less accurate estimate. As a result, a statistical process control strategy was utilized in this work to analyze the air quality. Multivariate control chart [3] is a prominent process control technique that allows for the simultaneous control of two or more parameters. It is the application of several powerful tools to solve problems and enhance quality control in healthcare sectors by lowering variability. The multivariate control graph is one of these instruments that are most frequently employed in industries for statistical procedures, also used in healthcare, finance, etc. Few articles employ multivariate control charts, which used in a variety of fields, to determine which are effective for public healthcare. This study aims to fit the multivariate control charts to the air pollutant data. Several methods, including factor analysis, KMO, Bartletts, and correlation, are employed to categorize the parameters of air quality data. Two methods of multivariate control charts were selected for this data. The traditional Hotelling T^2 chart [5] is the most widely used control chart in worldwide to observe the process's mean vector. Every data set or value in this chart is entered separately, and the only thing that determines how each point relates to the others is the chart. Even though it is incredibly efficient, there are other tools available for multivariate analysis. There are situations when this chart can be improved upon by using another kind of multivariate control chart. MEWMA [1] is the extension of EWMA. Both control charts are used to identify the variability in the process and also described the assumptions of control charts in detail. The main goal of this paper is to evaluate each control chart's performance and identify which one is best at identifying process variability in air pollutant data.

Multivariate Control Charts

The dimensions of the outcomes of processes for several variables are used to create multivariate charts, and they are typically displayed by rational subgroups, which are related subgroups found in the literature [13]. There are situations where using single control charts for every factor independently makes sense when managing two or more quality attributes at once. However, employing this approach may result in incorrect findings if the combined probability of occurrence of Type I Errors (false alarms) and the relationship structure between the important p variables are not taken into consideration [18]. There are two stages involved in creating multivariate control charts. Obtaining an appropriate representation of the data is the first step (phase I), which is usually a retrospective analysis of the information to identify the control limits. Phase II – is to monitor the process. One of the variables used to measure control chart effectiveness is ARL. The average amount of samples under control is shown by ARL_0. The average number of samples outside of control is indicated by ARL_1 [6]. The MEWMA and Hotelling T^2 control charts are the most often used multivariate statistical control charts. These charts are responsive to even the smallest, most frequent variations in the process. In particular, the study aims to determine whether there is a statistically significant difference between the Hotelling T^2 chart and MEWMA's threshold of sensitivity when it comes to identifying minute variations in the mean vector. Every variable in this study will have its condition observed and managed. Afterwards, the ARL values were used to assess the performance of the MEWMA control chart and the Hotelling T^2 control chart. The best-performing multivariate control chart will be chosen.

MATERIALS AND METHODS

Hotelling T^2 Control Chart

In 1947, Harold Hotelling introduced a single chart for multivariate observations. He developed the procedure based on the statistical distance, t-statistic value and determined statistic value is called as Hotelling's T^2 statistic. It is used to recognize shifts in the mean of more than one interrelated variable. The data can be in subgroups or individual observations. It has a two phases. Phase-I is used to identify the outliers and mean shifts in the observations and Phase-II is used to determine the shifts present at the new observations. Let X be a randomly distributed with p-variate of size m, and N be the normal density function of X, represented by the notation Xi~Np(μ,Σ)where i = 1, 2, 3…m. As a result, the matrix (Equation1) is determined. The sample number is indicated by the notation m, and the quality features is indicated by the notation p.

$$X=\begin{bmatrix} X_{11} & X_{12}\cdots & X_{1p} \\ \vdots & \vdots & \vdots \\ X_{m1} & X_{m2}\ldots & X_{mp} \end{bmatrix} \quad (1)$$

i. The initial step is to find out the $\bar{X}$ as a sample mean and S as a sample covariance matrix
ii. The second step is to calculate the values of T^2. The value of T^2 is given by:
$T^2 = (x-\overline{x})S^{-1}(x-\overline{x})$ (2)
iii. The next step is Upper control limit (UCL) calculation:
UCL=$\frac{(m-1)^2}{m}\beta_{\alpha\frac{p}{2}(m-p-1)/2}$ (3)
iv. Multivariate charts are utilized to ascertain whether the process is under control upon sampling additional observations. The T^2 statistic for the retrospective T^2 control chart is defined by the sample mean vector $\bar{X}$ and sample covariance matrix S, which were obtained during the follow-up period.

Multivariate Exponentially Weighted Moving Average

Lowry introduced the Multivariate EWMA chart. An obvious progression of the EWMA is the MEWMA

$Z_j = RX_1 + (1-R)Z_{j-1}$ (4)

With the value $Z_0 = \mu = 0$ and R=diag ($r_{1\ldots}r_p$) for 0<r_j≤1, j=1, 2, 3…p. This chart has weighted value with particular case is denoted by r, while the number of observed quality characteristics is represented by p.

$$\begin{bmatrix} Z_{11} \\ \vdots \\ Z_{pi} \end{bmatrix} = \begin{bmatrix} r_1 & 0 & 0 \\ \vdots & \vdots & \vdots \\ 0 & 0 & r_p \end{bmatrix}\begin{bmatrix} \bar{x}_{1i} \\ \vdots \\ \bar{x}_{pi} \end{bmatrix}+\left(\begin{bmatrix} 1 & 0 & 0 \\ \vdots & \vdots & \vdots \\ 0 & 0 & 1 \end{bmatrix}-\begin{bmatrix} r_1 & 0 & 0 \\ \vdots & \vdots & \vdots \\ 0 & 0 & r_p \end{bmatrix}\right)\begin{bmatrix} Z_{1(i-1)} \\ \vdots \\ Z_{p(i-1} \end{bmatrix} \quad (5)$$

In the MEWMA control chart generated by the test statistics, if it is assumed that the multivariate xi with n = 1, 2, 3… is similarly independent and normally distributed, then Xi~Np(μ,Σ) represents the mean vector of the controlled process, and ∑ is the covariance matrix. The test statistics value

$Q_i^2=Z'\sum_{Zi}^{-1}Z_i$ (6)

If $Q_i^2=Z'\sum_{Zi}^{-1}Z_i$>H then it might be considered out of control. Since the value of Q_i^2 is always positive, then the value H is the upper limit and 0 is the lower limit of the control chart of MEWMA based ARL value. When p attributes have the same weight r, then the ARL is not only dependent on the centre parameter provided by the Mahalanobis distance. Because of this, the performance of this chart may be evaluated in relation to other charts.

Performance of Multivariate Control Charts

Statistical performance indicator is used to evaluate and compare various multivariate control chart types. The most popular statistical metric for evaluating the efficacy of a control chart and contrasting it with other chart types is the standard number of data collected until an unstable signal (ARL) is detected. The ARL parameter accounts for both Type I and Type II error probabilities. When we assume a process is uncontrollable when it is not, we make a Type I error. Type II errors occur when we are unable to identify the out of control positions. Consequently, it is standard procedure to evaluate the parameters of a control chart by looking at the ARL's performance. ARL values indicate

whether a process is under control or out of control. Since the majority of the variable has correlation, accurate identification of ARL values is not achievable. Nonetheless, there are a number of ways to obtain the right parameters for calculating the control chart's performance. The methodological aspects described below For this study, the secondary data were collected from the public sector Central Pollution Control Board (CPCB), which is the official portal of the Government of India. The data contains one month hourly based data of Chennai city, It contain air pollutant variables like surface ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), carbon monoxide (CO), and particulate matter (PM), which comprises PM 2.5 and PM 10, Ammonia (NH_3),nitrogen oxides (NO_x).

RESULTS AND DISCUSSION

The outcome of the analysis for every variable group will comprise the data processing result. Table 1 displays the descriptive statistics results for each variable. Fig 2 and 3 represents autocorrelation and normality test results. These two assumptions important to fit a control charts, because the presence of autocorrelation can make the chart into false alarm. From Fig 2 normality result are adequate for the formation of chart. According to Montgomery 2009, the small departure from normality doesn't affect the results of control charts. By using factor analysis, the factors can be grouped into two groups. Table 2 shows the result of factor analysis. This table demonstrates the values of total, variance percentage and cumulative percentage in order. Therefore the first group was consists of first four variables and the second group consists remaining four variables. Kaiser-Meyer-Olkin test is the measure of sampling adequacy; it shows the proportion of variance. Bartlett's test result describes the correlation matrix is identity or not. From the Table 3, Bartlett's test was significant and the value of KMO is a 0.6 which is adequate. The Table 4 shows the result of the Pearson correlations and Bartlett's test for each group. Strong correlations were found within each group of variables, according to the results of the Bartlett's test and Pearson correlation for each set of variables.

Table 5 shows the result of ARL for MEWMA and Hotelling T^2 control chart. As indicated in Table 5, the MEWMA chart's sensitivity in identifying small variations in the process's mean vector is compared with that of the Hotelling T^2 charts for the identical parameters. For the Group 1 λ=0.2 H=12.72 of MEWMA control chart is the best compared to Hotelling T^2. For the group 2, λ=0.1 H=12.72 of MEWMA control chart is better than Hotelling T^2. From the Fig 4 and 5, each and every outcome demonstrated that the MEWMA control chart is more sensitive in identifying even the smallest mean movements than the Hotelling T^2 control chart. As a result, the MEWMA control chart will be a more effective tool for data on air pollutants. The computation of the multivariate capability procedure is the final phase. The computation's outcome showed that Group-1 multivariate capability process was 1.378, whereas group 2's multivariate capability process was 1.006. Each and every multivariate capacity process value has a value greater than 1. This indicates that even while both control charts show good process capability and all processes are operating smoothly, it is still necessary to regularly monitor the process to ensure that it remains stable.

CONCLUSION

This research aims to detect effective control charts by comparing both multivariate control charts. For this research, data regarding air pollution in Chennai city for one month was chosen. It included information on an hourly basis. Most of the data are derived from eight pollutant variables. By the use of factor analysis, the two groups were formed. The first group contains PM 2.5, PM 10, NO_2, and NH_3 and the second group contains SO_2, CO, Ozone, and NO_x. When it's crucial to identify even the smallest changes in a process's characteristics, the MEWMA charts are an alternative to the Hotelling T^2 chart. These charts are more sensitive than the Hotelling T^2 chart to identify even a slight shift in the process mean vector, enabling quicker intervention in such circumstances. They also perform better in terms of ARL. Hence, both groups' process capability index is more than 1, indicating that while certain points are out of control, overall the process performs well across all variable groups. The findings of this investigation indicate that the MEWMA chart is a highly effective statistical instrument for overseeing air pollutants that possess numerous quality attributes. MEWMA control charts are more efficient in detecting variability than the Hotelling T^2 control

charts. The results offer significant direction to practitioners looking for reliable techniques to guarantee quick identification of changes in air quality and support informed decisions for managing public health and pollution.

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Table.1 Descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum
PM 2.5	22.50	10.24	00.65	66.00
PM 10	75.81	77.12	11.52	917.27
NO2	16.04	10.12	03.57	72.55
NH3	09.07	03.36	04.67	35.70
SO2	17.45	21.41	00.24	96.58
CO	07.00	02.21	00.24	01.77
Ozone	23.09	19.36	00.2	131.81
NOx	20.37	12.50	05.70	84.3

Table.2 Result of factor analysis

Component	Initial Eigen values		
	Total	% of Variance	Cumulative %
1	2.633	32.910	32.910
2	1.621	20.269	53.178
3	.966	12.080	65.258
4	.899	11.239	76.496
5	.733	9.167	85.663
6	.601	7.516	93.179
7	.489	6.116	99.295
8	.056	.705	100.000

Table.3 KMO and Bartlett's test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.599**
Bartlett's Test of Sphericity	Approx. Chi-Square	2290.997
	df	28
	Sig.	.000

Table.4 (i) Pearson correlation and Bartetts test for Group 1

	Correlations					
			(PM25ugm3)	**(PM10ugm3)**	**(NO2ugm3)**	**(NH3ugm3)**
GROUP-1	(PM25ugm3)	Pearson Correlation	1	0.153	0.189	0.084
		Sig. (2-tailed)		.000	.000	.023
		N	744	744	744	744
	(PM10ugm3)	Pearson Correlation	.153	1	.042	.041
		Sig. (2-tailed)	0.000		0.256	0.266
		N	744	744	744	744
	(NO2ugm3)	Pearson Correlation	0.189	0.042	1	0.394
		Sig. (2-tailed)	0.000	0.256		0.000
		N	744	744	744	744
	(NH3ugm3)	Pearson Correlation	0.084	0.041	0.394	1
		Sig. (2-tailed)	0.023	0.266	0.000	
		N	744	744	744	744
	Bartlett's Test of Sphericity	Approx. Chi-Square		174.167		
		df		6		
		Sig.		0.000		

Table.4 (ii) Pearson correlation and Bartetts test for Group 2

	Correlations					
			(SO_2ugm3)	(COmgm3)	(Ozoneugm3)	(NOxppb)
GROUP 2	(SO_2 ugm3)	Pearson Correlation	1	0.227	0.145	0.102
		Sig. (2-tailed)		.000	.000	.005
		N	744	744	744	744
	(CO mgm3)	Pearson Correlation	0.227	1	0.088	0.292
		Sig. (2-tailed)	.000		0.016	0.000
		N	744	744	744	744
	(Ozone ugm3)	Pearson Correlation	0.145	0.088	1	0.348
		Sig. (2-tailed)	0.000	0.016		0.000
		N	744	744	744	744
	(NOxppb)	Pearson Correlation	0.102	0.292	0.348	1
		Sig. (2-tailed)	0.005	0.000	0.000	
		N	744	744	744	744
	Bartlett's Test of Sphericity	Approx. Chi-Square		235.963		
		df		6		
		Sig.		.000		

Table.5 ARL value of MEWMA and Hotelling T^2 control chart:

	MEWMA					T^2
Group-1	Shifts	λ=0.1 H=11.784	λ=0.2 H=12.72	λ=0.4 H=12.75	λ=0.6 H=12.77	H=13.19
	1	12.21	11.55	20.81	21.06	21.22
	2	11.24	11.21	15.14	20.71	21.16
	3	10.20	11.20	10.44	20.34	20.56
	MEWMA					**T^2**
Group-2	Shifts	λ=0.1 H=12.72	λ=0.2 H=12.834	λ=0.4 H=13.465	λ=0.6 H=13.642	H=13.19
	1	13.27	14.85	20.33	20.06	21.45
	2	12.21	12.24	18.19	16.89.	20.75
	3	10.11	10.56	16.34	12.56	20.21

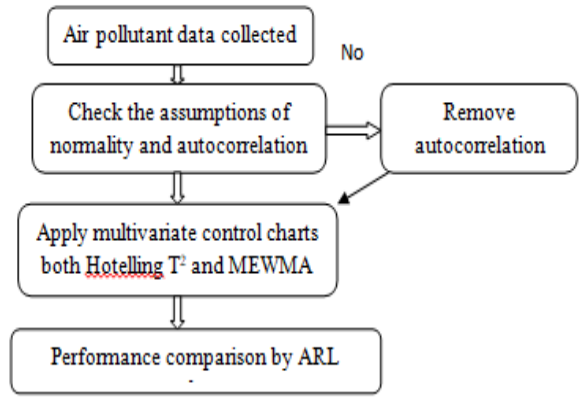


Figure.1 Flow chart

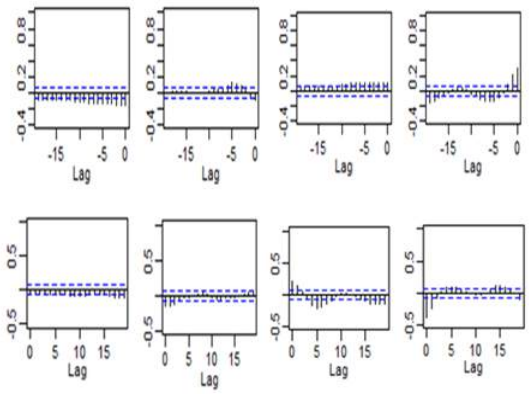


Figure. 2 Autocorrelation

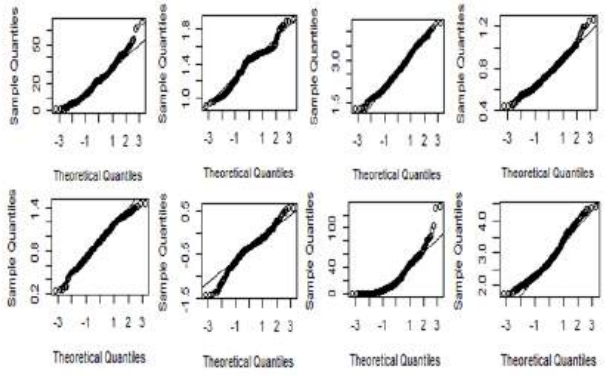
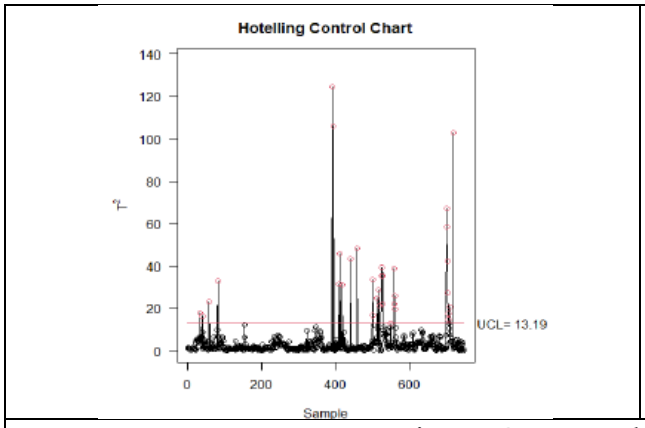


Figure.3 Normality Q-Q plot



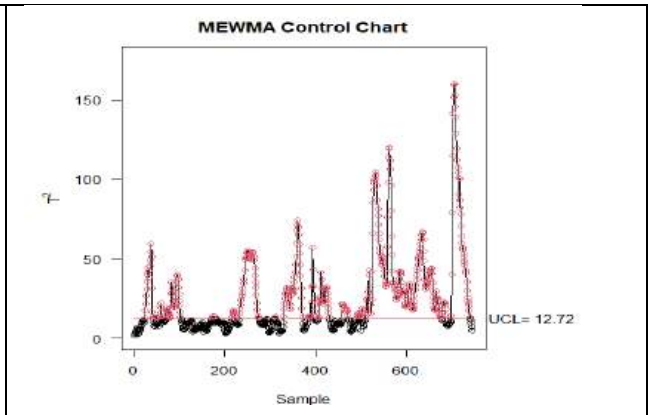
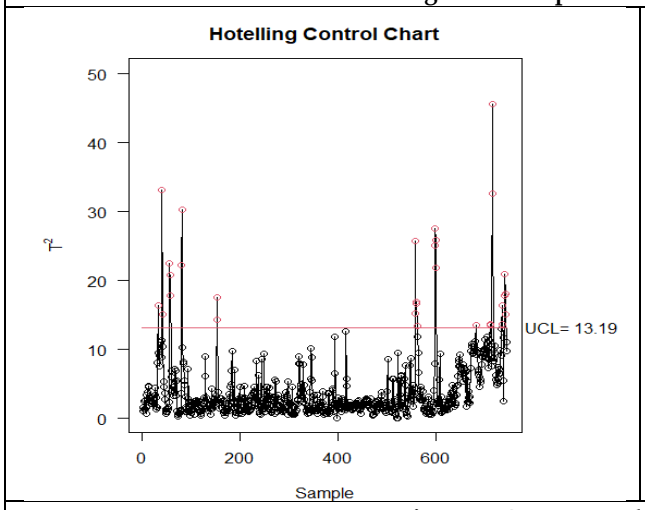


Figure 4 Group-1 multivariate control charts



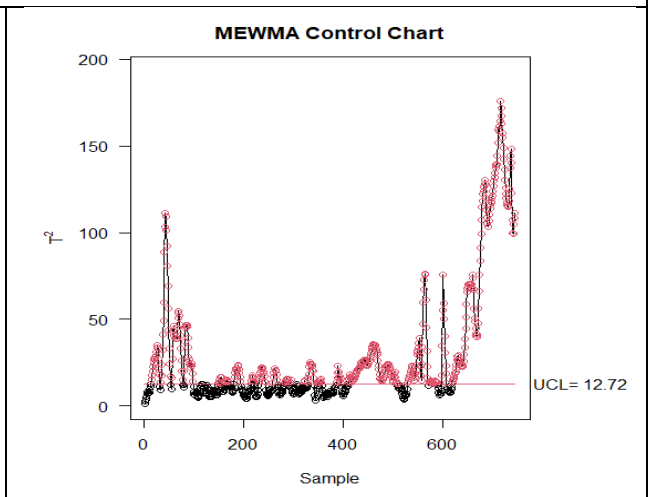


Figure 5: Group-2 multivariate control charts

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RESEARCH ARTICLE

Multimodal Sentiment Analysis: Comparision of State-of-the-Art Fusion Techniques

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ABSTRACT

In today's digital era, due to the advent of internet technology, humongous reviews and opinions are being shared regarding any products and services in forms of audio, video and text on the social media platforms. This necessitates the need for analyzing such vast number of untapped reviews. This evolving field of Multimodal Sentiment Analysis (MSA) interprets sentiments conveyed in forms of multimodal data like audios, images with captions, memes, videos, physiological signals and combination of them. Research in textual data sentiment analysis dominates, which limits the potential wealth of information in other modalities. This study explores multimodal sentiment analysis which spans across the field of artificial intelligence, natural language processing, deep learning, decision science and cognitive science. Multimodal fusion is at the center of multimodal sentiment analysis which fuses verbal and non-verbal cues for speaker intent inference. An extensive set of experiments is conducted for comparison of seven different multimodal fusion techniques. Experiments done on two popular datasets named CMU-MOSI, CMU-MOSEI. Diverse neural network architectures like attention-based architectures, memory-based architectures, and recurrent components-based architecture, etc. are implemented and compared for their efficacy for task of multimodal sentiment analysis.

Keywords: Sentiment Analysis, Affective Computing, Multimodal Fusion, Opinion Mining, Multimodal Sentiment Analysis

INTRODUCTION

Human language which is not only a mere word and it also extends to gestures, vocal nuances, and intonations. This makes an overall human communication a complex thing. This multimodal nature of human language poses a challenge for machines to effectively mimic the human communication. These language cues can be effortlessly interpreted by the humans but teaching machines this skill unlocks potential applications in field of affective computing, human-machine interaction. To understand the human language, verbal and nonverbal cues, which vary dynamically across contexts need to be processed effectively. Enabling machines to comprehend linguistic utterances within diverse nonverbal settings is crucial challenge. Modeling of intramodal dynamics (within a specific modality) and intermodal dynamics (across multiple modalities) is at center of research in field of multimodal affective computing. Intramodal dynamics involves interactions within a single modality, like words within a sentence. While crossmodal dynamics involve interactions between different modalities, exemplified by a smile and a loud voice accompanying a positive word. Recent trends lean towards more intricate models, incorporating attention, memory, and recurrent components for multimodal embedding learning. The current digital landscape is an exponential influx of text interlaced with diverse opinions and nuances. In this era of the World Wide Web, understanding and interpreting sentiments in multimodal context yield substantial power, especially for companies vested in gauging public sentiment for their products and services [1]. As sentiment play critical role in shaping decisions, brand perception and user interactions, there is intense surge for sentiment analysis in commercial and research interest [2]. However, the evolving nature of sentiment analysis has its own set of challenges, particularly in multimodal context [3,4]. Not only limited to English language, existing sentiment analysis frameworks capture sentiments embedded in diverse and also mix-mode languages [5]. Researchers have to traverse paths of knowledge transfer from resource-rich to resource-poor modalities in multimodal terrain [6,7].

Existing approaches, ranging from leveraging English lexical resources like SentiWordNet to employing machine translation systems for cross-modal analysis, confront bottlenecks in resource scarcity and fidelity in translation [8]. Though there is remarkable progress in constructing multimodal sentiment analysis frameworks and tools, the lack of resources is a crucial challenge [9]. Another study by [10] delves into the realm of multimodal sentiment analysis, embarking on a comprehensive journey through state-of-the-art fusion techniques. Through meticulous experimentation and benchmarking on common datasets, we evaluate and compare seven techniques, shedding light on their efficacy and shortcomings. By providing a comprehensive evaluation, we aim to illuminate the true essence and practical utility of these approaches, elucidating their tangible contributions beyond reported results. Existing reviews in the field provide insightful categorization of modality fusion strategies and identify overarching challenges. This study specifically focuses on empirical evaluations across different multimodal fusion approaches for multimodal sentiment analysis. It bridges the gap by conducting a detailed empirical study across various cutting-edge fusion techniques used in multimodal sentiment analysis. We replicate and analyse the latest seven alternative fusion approaches on two well-known datasets for multimodal sentiment and emotion research. The remaining sections of this paper are organised as follows. The detailed process flow for Multimodal Sentiment Analysis is presented first. This is followed by a brief overview of the datasets used for implementation. Next, different fusion techniques using multiple modalities are discussed. Various evaluation metrics are then outlined. Finally, result analysis is presented, followed by the conclusion.

MSA PROCESS FLOW

MSA analyses many modalities, including video , images with captions, images ,text and audio to acquire a better interpretation opinions and emotions conveyed in a given situation. Fig.1 represents step by step process flow for MSA. The in-depth breakdown of the micro steps for each phase:

- **Data Acquisition:** Source diverse data types from various platforms (social media, repositories, multimedia sources) using APIs, web scraping, or accessing existing datasets. Extract metadata (timestamps, user details, descriptive tags) from images or videos to enrich the dataset.

- **Modality Separation:** Segregate collected information into distinct categories: Isolate textual content from the dataset. Extract images and visual content separately. Separate audio and video segments for subsequent analysis.
- **Pre-processing:** Treat each modality specifically: Textual data undergoes tokenization, stop word removal, and character handling. Images are resized or filtered. Audio/video content might be converted to text through speech-to-text algorithms or undergo feature extraction from audio signals.
- **Feature Extraction:** Derive specific features from each modality: Textual features (TF-IDF, word embeddings, BERT embeddings). Image features (pre-trained CNN models, histograms of oriented gradients - HOG). Audio/video features (MFCCs, pre-trained models for video frames).
- **Multimodal Fusion:** Extracted features from different modalities are then fused using various fusion techniques like early or late fusion, graph-based fusion, self-attention mechanisms, or multimodal neural networks.
- **Classification:** Appropriate classifiers are used to classify sentiment using fused features. Model is trained on integrated multimodal features. Accuracy (Binary and 5-class), F1-score, MAE and Corr are evaluation matrices which are used to validate and assess model performance to gauge sentiment efficacy.

DATASETS USED

We conduct empirical assessments on various fusion methods for multimodal sentiment analysis using two popular datasets, CMU Multimodal Opinion-level Sentiment Intensity (CMU-MOSI) [11] and CMU Multimodal Opinion Sentiment and Emotion Intensity (CMU-MOSEI) [12]. Step by step process for custom dataset generation is depicted in Fig.2.

CMU-MOSI

The CMU-MOSI [11] dataset, compiled in 2016, encompasses 93 videos sourced from YouTube. These videos, covering a variety of topics and genres, underwent meticulous annotation by 89 expert annotators. Across the 93 videos, a total of 2,199 unique segments were labeled for sentiments and emotions in English. The dataset includes multimodal features extracted from audio (including pitch and intensity), video (facial expressions and gestures), and textual elements (analyses of sentiment). Alignment techniques ensured synchronization of these modalities with the corresponding timestamps in the videos.

CMU-MOSEI

The CMU-MOSEI [12] dataset, compiled in 2018, comprises 3,228 videos sourced from YouTube, featuring diverse topics and discussions. These videos engaged 22,777 unique segments, annotated by 1,000 expert annotators, predominantly in English. Wide variety of topics are covered by MOSEI which includes debates (2.9%), consulting (1.8%) and majorly covers reviews (16.2%). Annotations on sentiments were rated on a scale from -3 to +3. The dataset offers multimodal features extracted from audio, video, and text modalities. These modalities underwent alignment techniques to synchronize with timestamps.

MULTIMODAL FUSION MODELS

In this section, we evaluated and outlined seven different multimodal fusion architectures on which comparative study done. We have implemented a diverse set of graph networks based, attention mechanisms based, memory networks based and tensor fusion networks-based models using unified PyTorch framework. Fusion models include early fusion (ef_lstm) [13], memory fusion (mfn) [14], graph network fusion graph_mfn [12], mfm [15], bert_mag [16], attention -based fusion (mult)[17] and mmim[18]. The models for this study were chosen based on their representative diversity across various fusion paradigms typically utilised in MSA.All these models have their implementations on GitHub by their respective authors. From scratch, we replicated all the models.

EF-LSTM

EF_LSTM [13] integrates knowledge from several modalities using an Early Fusion technique. It has assessed a trimodal model then bimodal and finally unimodal model. The trimodal model achieves best performance. This method emphasizes on a 6-class emotional classification based on regression. Features from three modalities—linguistic, visual, and acoustic—are concatenated at the input level to produce an input vector for a Deep Neural Network (DNN). Operating by combining linguistic, visual, and audio elements at each timestamp, EF-LSTM generates a multimodal representation at the sentence level. The last hidden state finishes in the output sentiment by sequential processing across two fully-connected layers.

MFN

Operating on multi view sequential learning, the Memory Fusion Network (MFN) [14] integrates cross-view interactions with view-specific ones. It summarises these interactions throughout time using a Multi-view Gated Memory. MFN derives expected feature values by computing predicted visual and audio characteristics within the word utterance time interval. Three unimodal LSTMs are used to update the memory cells concurrently. The last memory cell generates multimodal sentence representation concurrently with unimodal LSTMs' last hidden states. Two fully-connected layers sequential processing this representation generates the output emotion.

Graph MFN

With dynamic fusion structures to improve modality interaction and interpretability, the Graph Memory Fusion Network (Graph-MFN) [12] marks a development over MFN. Set of parallel LSTMs representing certain modality makes up multimodal fusion network. To highlight cross-modal dynamics, coefficients are assigned by the dynamic fusion graph component. Furthermore, stored in the Multiview Gated Memory component are multimodal fusion process output. Graph-MFN improves interpretability in comparison to its predecessor, MFN by dynamically changing fusion structures to enable modal interaction.

MFM

Powerful and strong, the Multimodal Factorisation Model (MFM) [15] is excellent in learning both multimodal-discriminative and modality-specific generative components. It reconstructs missing modalities by combining these elements, therefore offsetting lost information by means of independent components. Over multimodal datasets, the model's discriminative factor produces either competitive or state-of- the-art outcomes. Especially, the modality-specific generating factors allow data production based on factorized variables. This enables missing modalities and richer understanding of the complex relationships inside multimodal learning systems.

Bert Mag

Especially in relation to aligned data, the Multimodal Adaptation Gate for Bert (MAG-BERT) [16] represents a development over RAVEN [21]. It modifies BERT and XLNet to accommodate the presence of vision and sound modalities by inserting a Multimodal Adaptation Gate (MAG) at different layers within the BERT core. MAG use this representation to dynamically update lexical representations in the pre-trained transformer model. It views nonverbal behaviour as a vector with trajectory and amplitude. This enhancement increases the alignment and integration of multimodal information inside the BERT framework. It boosts its adaptability and performance with aligned data.

Mult

By use of directive paired cross-modal attention, the Multimodal Transformer (MulT) [17] increases the capacity of multimodal transformer design. By means of this special attention mechanism, information from one modality can be translated to another. It resolves intrinsic difficulties including non-aligned data resulting from different sampling rates and handling long-range relationships between modalities. MulT does this by using directional pairwise cross-modally attention. It enables interactions between multimodal sequences spanning several time steps. This novel method improves the capacity of the model to detect complex interactions and dependencies inside multimodal data by facilitating the latent adaption of information streams between modalities.

MMIM

Within unimodal input pairs and between the resulting multimodal fusion and individual unimodal inputs, the Multimodal Information Maximizing (MMIM) [18] method hierarchically maximizes Mutual Information (MI). Emphasizing MI in both inter-modality and fusion phases helps MMIM to guarantee that task-related information is maintained all along the multimodal fusion process. This approach intends to maximize the information flow among several modalities while preserving and improving task-related knowledge during the fusion of multimodal data.

EVALUATION METRICS

To evaluate effectiveness on MOSI and MOSEI, a set of evaluation metrics commonly used in previous studies [19,20] were employed. These include binary accuracy (acc_2), F1 score (F1_score), multiclass accuracy for five classes (acc_5), Mean Absolute Error (MAE), Correlation (Corr). Binary Accuracy (acc_2) measures the percentage of correctly classified samples in a binary classification setting. F1_Score is the harmonic mean of precision and recall, balancing false positives and false negatives. acc_5 represents the percentage of correctly predicted samples among the 5 predicted classes. MAE measures the average absolute difference between predicted and actual sentiment scores. Corr is the relationship between model predictions and regression ground truth. Higher values indicate superior performance across all metrics except for MAE. For MAE, lower the values better the performance.

RESULT ANALYSIS AND FUTURE DIRECTIONS

In dissecting the outcomes of our comprehensive evaluation, we scrutinized the performance of seven cutting-edge fusion models in multimodal sentiment analysis across the MOSI and MOSEI datasets. Performance metrics for MOSI dataset is shown in Table II and performance metrics for MOSEI dataset is shown in Table III. The tabulated results present the performance metrics for various models evaluated on the MOSI and MOSEI datasets. Each metric provides insight into the efficacy of various fusion strategies in multimodal sentiment analysis. Moreover, the comparison with original results, represented in a bar chart, highlights any deviations or improvements observed in our evaluation compared to the original findings. Fig. 3 represents comparative analysis on MOSI dataset with original implementation values. MOSEI dataset comparative analysis ins shown in Fig.4. Fig.5 shows MOSI and MOSEI dataset comparative analysis. It contributes to the ongoing research in this domain, offering valuable insights into the performance variations and strengths of these state-of-the-art techniques on diverse multimodal datasets. This empirical evaluation sheds light on the efficacy of these fusion models in understanding and analyzing multimodal. This comparative investigation establishes the groundwork for future progress in the field of multimodal sentiment analysis. It also contributes for better understanding of human expressions across different modalities in digital communication. For future model comparisons, it is essential to document computational efficiency, training time, inference speed, and hardware requirements to assess performance trade-offs and scalability across different architectures. Bias analysis can also be conducted on more diverse, real-world datasets to assess generalizability of the models.

CONCLUSION

In our extensive comparison of cutting-edge multimodal human language analysis methods, we explored the effectiveness and efficiency of these models across two pivotal multimodal affect recognition datasets. Our thorough investigation uncovered crucial elements within multimodal language models, revealing insights into their performance intricacies. We found that attention mechanism approaches outperformed others in sentiment analysis and emotion recognition tasks, despite their higher computational requirements. Components adapt at capturing crossmodal interactions, integrating context, and leveraging linguistic modalities significantly enhanced performance. Looking ahead, we aim to delve into conversational video sentiment analysis, capitalizing on the benefits of utterance context in understanding human language nuances. Exploring sentiment in dynamic conversational settings presents an exciting avenue for future research.

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Table 1: Dataset Analysis

Dataset	CMU-MOSI	CMU-MOSEI
Year	2016	2018
Modalities	Video, Audio, Text	Video, Audio, Text
Sentiment Type	Sentiment Intensity (1 to 5 scale)	Emotion Intensity (8 categories: -3 to +3)
Content	YouTube video-blogs expressing diverse opinions	Videos discussing diverse topics
Duration	93 videos	3228 videos, 22,777 utterances
Speakers	41 female speakers, rest were male	1000 plus speakers (57% male, 43% female)
Speaker Ages	Ranged from 20 to 30 years	-
Language	English	English
Annotations	Sentiment intensity annotations for segments	Eight sentiment categories: -3 to +3

Table 2: Performance metrics for MOSI Dataset

Model Name	acc_2	F1_score	acc_5	MAE	Corr
ef_lstm	70.25	70.35	25.45	1.065	0.744
mfn	78.28	78.26	39.07	0.939	0.669
graph_mfn	76.02	76.04	36.96	0.910	0.652
mfm	77.04	77.08	40.74	0.970	0.641
bert_mag	83.02	82.94	51.6	0.739	0.782
Mult	79.8	79.8	42.2	0.924	0.676
MMIM	81.49	81.48	50.36	0.744	0.778

Table 3: Performance metrics for MOSEI Dataset

Model Name	acc_2	F1 Score	acc_5	MAE	Corr
ef_lstm	82.28	81.87	50.96	0.592	0.691
mfn	81.56	81.76	52.8	0.573	0.715
graph_mfn	80.18	80.52	52.88	0.564	0.727
mfm	81.18	81.61	51.66	0.575	0.725
bert_mag	80.93	81.46	54.7	0.541	0.760
Mult	80.2	80.76	53.89	0.563	0.733
MMIM	83.4	82.42	53.28	0.526	0.772

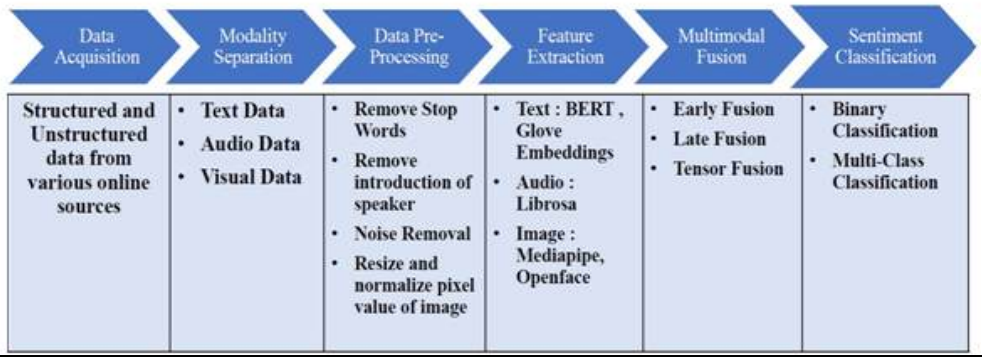


Figure 1: Multimodal Sentiment Analysis Process Flow



Figure 2: Dataset Generation Process

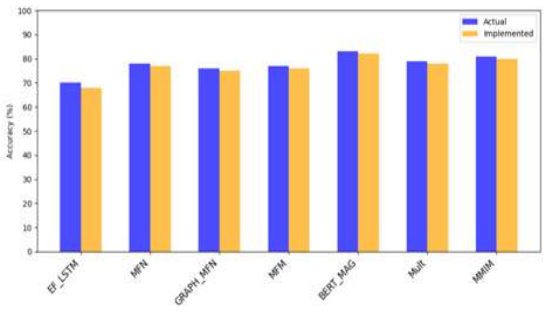


Figure. 3 Comparative Analysis with Original Results on MOSI Dataset

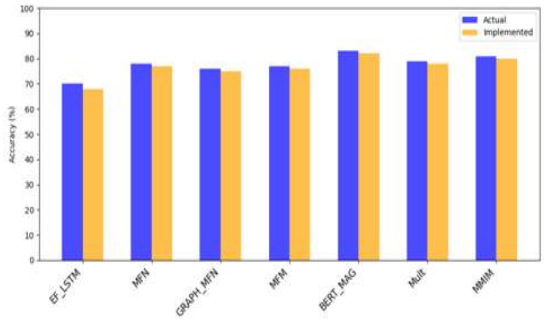


Figure.4 Comparative Analysis of Actual and Implemented Results on the MOSEI Dataset

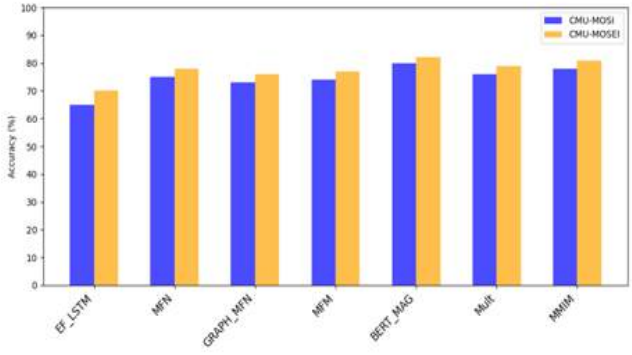


Figure. 5 Comparative Analysis of Implemented Results on the MOSI and MOSEI Dataset

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RESEARCH ARTICLE

Comparative Analysis of Fully Fuzzy Linear Fractional Programming by Graphical Method, Crammers Rule and Denominator Objective Restriction Method

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ABSTRACT

For dealing with many types of uncertainties, various methods have been introduced in linear fractional programming method. To find the optimality of an objective function, we have approached a new problem which is known as fully fuzzy linear fractional programming problem. In this paper a comparative analysis has been done by solving fully fuzzy fractional programming problem with Graphical method, Crammer's rule and denominator objective restriction method for determining the optimal results. In such type of problems, the given objective function is in the form of fuzzy fractional programming which is later converted into three crisp linear fractional problems. The denominator objective restriction method and graphical method are the standard methods for finding the accuracy of the optimal values of fully fuzzy linear fractional programming. Therefore, here we have also used crammer's rule for confirming the accuracy of the optimum result.

Keywords: Linear fractional programming, graphical method, denominator objective restriction method, fully fuzzy linear fractional programming, crammer's rule, triangular fuzzy numbers, membership function, inequalities, optimization, linear programming, optimal solution.

INTRODUCTION

Basically linear fractional programming problem is an important sub part of mathematical optimization. A linear fractional programming problem is defined as the ratio of two linear functions subject to linear constraints along with non-negative restrictions. Using concept of simultaneous equations technique for solution of linear fractional programming problem is quite an interesting way for finding the optimum result, such as firstly convert the objective function of LFP into standard linear programming problem then use the system of simultaneous equations and finally by using echelon form find out extreme points and the maximised or minimised values. Since there are various methods for finding the optimum solutions of LFP in this paper we have used crammer's rule and this technique has been proved quite interesting and easy to understand for finding the optimum results. Graphical Method, Crammer's Rule by matrix method and Denominator Objective Restriction Method is used for attaining fuzzy optimal solution of fully fuzzy linear fractional programming problem (FFLFP). For obtaining optimal outputs, problem is divided into three parts, which is called: crisp linear fractional programming problem, with all conditions of bounded variable constraint. Whereas these three crisp fractional problems are solved differently which gives fuzzy optimum result/ values. In other words, we can say this method totally depends on those three crisp problems and also has easy structure for solving problems. Linear fractional programming plays a remarkable role in real life areas, such as:

- Production Planning.
- Financial Sector.
- Health Care. Etc

And by the above statements good use of LFP in real life applications was very clear therefore. There were many methods developed and still exits, for solving these fractional problems but not practically applicable because of their certain limitations in determining the optimal results of fully fuzzy linear fractional programming problems with all the fuzzy parameters. Hence, graphical method, crammer's method and denominator objective restriction method has been proved better method which can be easily applicable for solving the traditional linear fractional programming **problem** and it can efficiently solve the fully fuzzy linear fractional programming problem.

Definition A: Fuzzy Set.

Let X is the universe of discourse, it's elements are represented by x. Then the fuzzy set A is stated as the ordered pair: $A = \{x, \mu_A(x) | \, x \, \epsilon \, X\}$

Definition B: Triangular Fuzzy Number.

The triplet (m_1, m_2, m_3) is called as triangular fuzzy number, and in this triplet "m_1" is the smallest value, "m_2" is the most probable value and "m_3" is the largest possible value in any of the fuzzy event.

NUMERICAL EXAMPLE AND RESULTS

Example

Production Planning: Let a Ball Bearing company produces two kinds of products A and B which gives the profit of (2, 1, 1) and (4, 2, 2) rupees with the fixed cost (1, 1, 1) rupees per unit respectively. Although the cost of single unit is (5, 1, 1) and (2, 1, 1) rupees respectively, and it is considered that the confirmed (fixed) cost is (1, 1, 1) rupees added to the cost function due to the certain conditions in the process of production. It is considered that product A and product B is about (1, 1, 1) units per pound and (5, 2, 2) units per pound respectively, the raw material is restricted to (5, 4, 4) pounds, Man- hours per unit required for product A is (5, 2, 2) hours per unit and for product B is (2, 1, 1) hours per unit but, the total Man- hours (10, 2, 2)hours are available daily and time required for product A is (2, 1, 1) min per unit and for product B is (4, 1, 1) minutes per unit but, total time required is (8, 1, 1) minutes per unit. To maximize the total profit, find out how many products A and products B must be created or produced?

$$maximize(Z_1, Z_2, Z_3) = \frac{(2,1,1)\tilde{x}_1 \oplus (4,2,2)\tilde{x}_2 \oplus (1,1,1)}{(5,1,1)\tilde{x}_1 \oplus (2,1,1)\tilde{x}_2 \oplus (1,1,1)}$$

Subject to constraints:
$(1,1,1)\tilde{x}_1 \oplus (5,2,2)\tilde{x}_2 \leq (5,4,4)$
$(5,2,2)\tilde{x}_1 \oplus (2,1,1)\tilde{x}_2 \leq (10,2,2)$
$(2,1,1)\tilde{x}_1 \oplus (4,1,1)\tilde{x}_2 \leq (8,1,1)$
$x_1 \geq 0, \quad x_2 \geq 0$
Solution: Convert the given LFP problem into three crisp fractional programming problem:

UPPER LEVEL PROBLEM

$$Maximize\ Z_1 = \frac{x_1 + 2x_2 + 1}{x_1 + x_2 + 1}$$

Subject to: $x_1 + 2x_2 \leq 4$
$2x_1 + x_2 \leq 2$
$x_1 + x_2 \leq 1$
$x_1 \geq 0, \quad x_2 \geq 0$

MIDDLE LEVEL PROBLEM

$$Maximize\ Z_2 = \frac{y_1 + 2y_2 + 1}{y_1 + y_2 + 1}$$

Subject to: $y_1 + 2y_2 \leq 4$
$2y_1 + y_2 \leq 2$
$y_1 + y_2 \leq 1$
$y_1 \geq 0, \quad y_2 \geq 0$

LOWER LEVEL PROBLEM

$$Maximize\ Z_3 = \frac{2t_1 + 4t_2 + 1}{2t_1 + 2t_2 + 1}$$

Subject to: $t_1 + 5t_2 \leq 5$
$5t_1 + 2t_2 \leq 10$
$2t_1 + 4t_2 \leq 8$
$t_1 \geq 0, \quad t_2 \geq 0$

By Graphical Method
MIDDLE LEVEL PROBLEM

$$Maximize\ Z_2 = \frac{y_1 + 2y_2 + 1}{y_1 + y_2 + 1}$$

Subject to: $y_1 + 2y_2 \leq 4$
$2y_1 + y_2 \leq 2$
$y_1 + y_2 \leq 1$
$y_1 \geq 0, \quad y_2 \geq 0$
Focus point is calculated by solving the equations of $L(y)$ and$S(y)$ separately,
$L(y) = y_1 + 2y_2 + 1$
$S(y) = y_1 + y_2 + 1$
Hence for$L(y)$ we get (0, -1/2) and (-1, 0) similarly for $S(y)$ we get (0, -1) and (-1, 0)
By solving the constraints, we get extreme points
$y_1 + 2y_2 = 4$, gives (0, 2) and (4, 0)
$2y_1 + y_2 = 2$, gives (0, 2) and (1, 0)
$y_1 + y_2 = 1$, gives (0, 1) and (1, 0)
Now the graph will be plotted as follows
The feasible region is ABC with A (0, 0), B (1, 0),C (0, 1) and $Z_{max} = 1.5$ at C.

UPPER LEVEL PROBLEM

$Maximize\ Z_1 = \frac{x_1 + 2x_2 + 1}{x_1 + x_2 + 1}$

Subject to:$x_1 + 2x_2 \leq 4$

$2x_1 + x_2 \leq 2$

$x_1 + x_2 \leq 1$

$x_1 \geq 0, \quad x_2 \geq 0$

Focus point is calculated by solving the equations of $L(x)$ and$S(x)$ separately,

$L(x) = x_1 + 2x_2 + 1$

$S(x) = x_1 + x_2 + 1$

Hence for$L(x)$ we get (0, -1/2) and (-1, 0) similarly for $S(x)$ we get (0, -1) and (-1, 0)

By solving the constraints, we get extreme points

$x_1 + 2x_2 = 4$, gives (0, 2) and (4, 0)

$2x_1 + x_2 = 2$, gives (0, 2) and (1, 0)

$x_1 + x_2 = 1$, gives (0, 1) and (1, 0)

Now the graph will be plotted as follows

The feasible region is ABC with A (0, 0), B (1, 0), C (0, 1) and $Z_{max} = 1.5$ at C.

LOWER LEVEL PROBLEM

$Maximize\ Z_3 = \frac{2t_1 + 4t_2 + 1}{2t_1 + 2t_2 + 1}$

Subject to: $t_1 + 5t_2 \leq 5$

$5t_1 + 2t_2 \leq 10$

$2t_1 + t_2 \leq 8$

$t_1 \geq 0, \quad t_2 \geq 0$

Focus point is calculated by solving the equations of $L(t)$ and$S(t)$ separately,

$L(x) = 2t_1 + 4t_2 + 1$

$S(x) = 2t_1 + 2t_2 + 1$

Hence for$L(t)$ we get (0, -1/4) and (-1/2, 0) similarly for $S(t)$ we get (0, -1/2) and (-1/2, 0)

By solving the constraints, we get extreme points

$t_1 + 5t_2 = 5$, gives (0, 1) and (5, 0)

$5t_1 + 2t_2 = 10$, gives (0, 5) and (2, 0)

$2t_1 + t_2 = 8$, gives (0, 2) and (4, 0)

Now the graph will be plotted as follows

The feasible region is ABCD with A (0, 0), B (2, 0), C (1.7, 0.6)and D(0, 1)and $Z_{max} = 1.2$ at C.

By Matrix Method (Crammer's Rule)

MIDDLE LEVEL PROBLEM

$Maximize\ Z_2 = \frac{y_1+2y_2+1}{y_1+y_2+1}$……(A)

Subject to:$y_1 + 2y_2 \leq 4$……(1)

$2y_1 + y_2 \leq 2$…….(2)

$y_1 + y_2 \leq 1$……..(3)

$y_1 \geq 0, \quad y_2 \geq 0$

Using equation (1) and (2) $\begin{bmatrix} 1 & 2 \\ 2 & 1 \end{bmatrix} \vdots \begin{matrix} 4 \\ 2 \end{matrix}$ D= $\begin{vmatrix} 1 & 2 \\ 2 & 1 \end{vmatrix} = -3$

$D_{y_1} = \begin{vmatrix} 4 & 2 \\ 2 & 1 \end{vmatrix} = 0 \quad ; \quad y_1 = \frac{D_{y_1}}{D} = 0 D_{y_2} = \begin{vmatrix} 1 & 4 \\ 2 & 2 \end{vmatrix} = 6 \quad ; \quad y_2 = \frac{D_{y_2}}{D} = 2$

$Z_{max} = 1.5$

Using equation (1) and (3) $\begin{bmatrix} 1 & 2 \\ 1 & 1 \end{bmatrix} \vdots \begin{matrix} 4 \\ 1 \end{matrix}$ D= $\begin{vmatrix} 1 & 2 \\ 1 & 1 \end{vmatrix} = -1$

$D_{y_1} = \begin{vmatrix} 4 & 2 \\ 1 & 1 \end{vmatrix} = 2 \quad ; \quad y_1 = \frac{D_{y_1}}{D} = -2 D_{y_2} = \begin{vmatrix} 1 & 4 \\ 1 & 1 \end{vmatrix} = -3 \quad ; \quad y_2 = \frac{D_{y_2}}{D} = 3$

$Z_{max} = 2.5$, since the extreme points cannot be negative, therefore the above solution cannot be optimum.

Using equation (2) and (3) $\begin{bmatrix}2 & 1 \vdots 2\\ 1 & 1 \vdots 1\end{bmatrix}$D= $\begin{vmatrix}2 & 1\\ 1 & 1\end{vmatrix} = 1$

$D_{y_1} = \begin{vmatrix}2 & 1\\ 1 & 1\end{vmatrix} = 1$; $y_1 = \frac{D_{y_1}}{D} = 1 D_{y_2} = \begin{vmatrix}2 & 2\\ 1 & 1\end{vmatrix} = 0$; $y_2 = \frac{D_{y_2}}{D} = 0$

$Z_{max} = 1$

From all the optimum results maximum value is $Z_{max} = 1.5$ in Middle Level Problem.

UPPER LEVEL PROBLEM

$Maximize\ Z_1 = \frac{x_1+2x_2+1}{x_1+x_2+1}$ ……(B)

Subject to:$x_1 + 2x_2 \leq 4$……..(1)

$2x_1 + x_2 \leq 2$……...(2)

$x_1 + x_2 \leq 1$……...(3)

$x_1 \geq 0, \quad x_2 \geq 0$

Using equation (1) and (2) $\begin{bmatrix}1 & 2 \vdots 4\\ 2 & 1 \vdots 2\end{bmatrix}$D= $\begin{vmatrix}1 & 2\\ 2 & 1\end{vmatrix} = -3$

$D_{x_1} = \begin{vmatrix}4 & 2\\ 2 & 1\end{vmatrix} = 0$; $x_1 = \frac{D_{x_1}}{D} = 0 D_{x_2} = \begin{vmatrix}1 & 4\\ 2 & 2\end{vmatrix} = 6$; $x_2 = \frac{D_{x_2}}{D} = 2$

$Z_{max} = 1.5$

Using equation (1) and (3) $\begin{bmatrix}1 & 2 \vdots 4\\ 1 & 1 \vdots 1\end{bmatrix}$D= $\begin{vmatrix}1 & 2\\ 1 & 1\end{vmatrix} = -1$

$D_{x_1} = \begin{vmatrix}4 & 2\\ 1 & 1\end{vmatrix} = 2$; $x_1 = \frac{D_{x_1}}{D} = -2 D_{x_2} = \begin{vmatrix}1 & 4\\ 1 & 1\end{vmatrix} = -3$; $x_2 = \frac{D_{x_2}}{D} = 3$

$Z_{max} = 2.5$, since the extreme points cannot be negative, therefore the above solution cannot be optimum.

Using equation (2) and (3) $\begin{bmatrix}2 & 1 \vdots 2\\ 1 & 1 \vdots 1\end{bmatrix}$D= $\begin{vmatrix}2 & 1\\ 1 & 1\end{vmatrix} = 1$

$D_{x_1} = \begin{vmatrix}2 & 1\\ 1 & 1\end{vmatrix} = 1$; $x_1 = \frac{D_{x_1}}{D} = 1 D_{x_2} = \begin{vmatrix}2 & 2\\ 1 & 1\end{vmatrix} = 0$; $x_2 = \frac{D_{x_2}}{D} = 0$

$Z_{max} = 1$

From all the optimum results maximum value is $Z_{max} = 1.5$ inUpper Level Problem.

LOWER LEVEL PROBLEM

$Maximize\ Z_3 = \frac{2t_1+4t_2+1}{2t_1+2t_2+1}$ ……(C)

Subject to: $t_1 + 5t_2 \leq 5$……(1)

$5t_1 + 2t_2 \leq 10$……(2)

$2t_1 + t_2 \leq 8$……(3)

$t_1 \geq 0, \quad t_2 \geq 0$

Using equation (1) and (2) $\begin{bmatrix}1 & 5 \vdots 5\\ 5 & 2 \vdots 10\end{bmatrix}$D= $\begin{vmatrix}1 & 5\\ 5 & 2\end{vmatrix} = -23$

$D_{t_1} = \begin{vmatrix}5 & 5\\ 10 & 2\end{vmatrix} = -40$; $t_1 = \frac{D_{t_1}}{D} = 1.7 D_{t_2} = \begin{vmatrix}1 & 5\\ 5 & 10\end{vmatrix} = -15$; $t_2 = \frac{D_{t_2}}{D} = 0.6$

$Z_{max} = 1.2$

Using equation (1) and (3) $\begin{bmatrix}1 & 5 \vdots 5\\ 2 & 4 \vdots 8\end{bmatrix}$D= $\begin{vmatrix}1 & 5\\ 2 & 4\end{vmatrix} = -6$

$D_{t_1} = \begin{vmatrix}5 & 5\\ 8 & 4\end{vmatrix} = -20$; $t_1 = \frac{D_{t_1}}{D} = 3.3 D_{t_2} = \begin{vmatrix}1 & 5\\ 2 & 8\end{vmatrix} = -2$; $t_2 = \frac{D_{t_2}}{D} = 0.3$

$Z_{max} = 1.07$

Using equation (2) and (3) $\begin{bmatrix}5 & 2 \vdots 10\\ 2 & 4 \vdots 8\end{bmatrix}$D= $\begin{vmatrix}5 & 2\\ 2 & 4\end{vmatrix} = 16$

$D_{t_1} = \begin{vmatrix}10 & 2\\ 8 & 4\end{vmatrix} = 24$; $y_1 = \frac{D_{t_1}}{D} = 1.5 D_{t_2} = \begin{vmatrix}5 & 10\\ 2 & 8\end{vmatrix} = 20$; $t_2 = \frac{D_{t_2}}{D} = 1.2$

$Z_{max} = 1.2$

From all the optimum results maximum value is $Z_{max} = 1.2$ in Lower Level Problem.

By Denominator Objective Restriction Method

MIDDLE LEVEL PROBLEM

$Maximize\ Z_2 = \frac{y_1+2y_2+1}{y_1+y_2+1}$.....(A)

Subject to: $y_1 + 2y_2 \leq 4$.....(1)

$2y_1 + y_2 \leq 2$.....(2)

$y_1 + y_2 \leq 1$.....(3)

$y_1 \geq 0, \quad y_2 \geq 0$

C_j			1	2	0	0	0	Min
C_B	B_V	X_B	y_1	y_2	S_1	S_2	S_3	Ratio
0	S_1	4	1	2	1	0	0	2
0	S_2	2	2	1	0	1	0	2
0	S_3	1	1	1	0	0	1	1
$Z_j - C_j$			-1	-2	0	0	0	

C_j			1	2	0	0	0	Min
C_B	B_V	X_B	y_1	y_2	S_1	S_2	S_3	Ratio
0	S_1	2	-1	0	1	0	-2	
0	S_2	1	1	0	0	1	-1	
2	x_2	1	1	1	0	0	1	
$Z_j - C_j$			1	0	0	0	2	

Now

C_j			1	1	0	0	0	Min
C_B	B_V	X_B	y_1	y_2	S_1	S_2	S_3	Ratio
0	S_1	4	1	2	1	0	0	2
0	S_2	2	2	1	0	1	0	2
0	S_3	1	1	1	0	0	1	1
$Z_j - C_j$			-1	-1	0	0	0	

C_j			1	1	0	0	0	Min
C_B	B_V	X_B	y_1	y_2	S_1	S_2	S_3	Ratio
0	S_1	2	-1	0	1	0	-2	
0	S_2	1	1	0	0	1	-1	
2	x_2	1	1	1	0	0	1	
$Z_j - C_j$			1	1	0	0	2	

In both the cases $(y_1, y_2) = (0,1)$maximum value is $Z_{max} = 1.5$ in Middle Level Problem.

UPPER LEVEL PROBLEM

$Maximize\ Z_1 = \frac{x_1+2x_2+1}{x_1+x_2+1}$ .....(B)

Subject to:$x_1 + 2x_2 \leq 4$.....(1)

$2x_1 + x_2 \leq 2$.....(2)

$x_1 + x_2 \leq 1$.....(3)

$x_1 \geq 0, \quad x_2 \geq 0$

C_j			1	2	0	0	0	Min
C_B	B_V	X_B	x_1	x_2	S_1	S_2	S_3	Ratio
0	S_1	4	1	2	1	0	0	2
0	S_2	2	2	1	0	1	0	2
0	S_3	1	1	1	0	0	1	1
$Z_j - C_j$			-1	-2	0	0	0	

C_j			1	2	0	0	0	Min
C_B	B_V	X_B	x_1	x_2	S_1	S_2	S_3	Ratio
0	S_1	2	-1	0	1	0	-2	
0	S_2	1	1	0	0	1	-1	
2	x_2	1	1	1	0	0	1	
$Z_j - C_j$			1	0	0	0	2	

C_j			1	1	0	0	0	Min
C_B	B_V	X_B	x_1	x_2	S_1	S_2	S_3	Ratio
0	S_1	4	1	2	1	0	0	2
0	S_2	2	2	1	0	1	0	2
0	S_3	1	1	1	0	0	1	1
$Z_j - C_j$			-1	-1	0	0	0	

C_j			1	1	0	0	0	Min
C_B	B_V	X_B	x_1	x_2	S_1	S_2	S_3	Ratio
0	S_1	2	-1	0	1	0	-2	
0	S_2	1	1	0	0	1	-1	
2	x_2	1	1	1	0	0	1	
$Z_j - C_j$			1	1	0	0	2	

In both the cases $(x_1, x_2) = (0,1)$maximum value is $Z_{max} = 1.5$ in Upper Level Problem.

LOWER LEVEL PROBLEM

$Maximize\ Z_3 = \frac{2t_1+4t_2+1}{2t_1+2t_2+1}$ ……(C)

Subject to: $t_1 + 5t_2 \leq 5$……(1)

$5t_1 + 2t_2 \leq 10$……(2)

$2t_1 + 4t_2 \leq 8$……(3)

$t_1 \geq 0, \quad t_2 \geq 0$

C_j			2	4	0	0	0	Min
C_B	B_V	X_B	t_1	t_2	S_1	S_2	S_3	Ratio
0	S_1	5	1	5	1	0	0	2
0	S_2	10	5	2	0	1	0	2
0	S_3	8	2	4	0	0	1	1
$Z_j - C_j$			-2	-4	0	0	0	

And so on hence we get,

In both the cases $(t_1, t_2) = (1.7,0.6)$maximum value is $Z_{max} = 1.2$ in Lower Level Problem

CONCLUSION

This paper has used graphical method, denominator objective restriction method and crammers method to find the maximum or minimum value of fully fuzzy fuzzy fractional programming problem. It has also been observed that after comparison with the results of other method, the obtained results are similar. It is found that the proposed method is quite simple and easy to implement, comparative to other algorithms.

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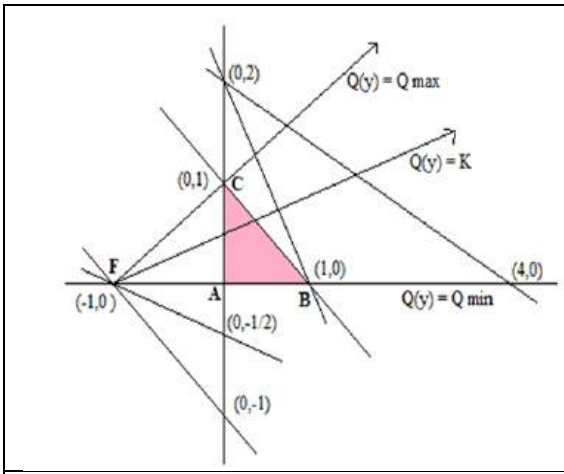


Fig:1

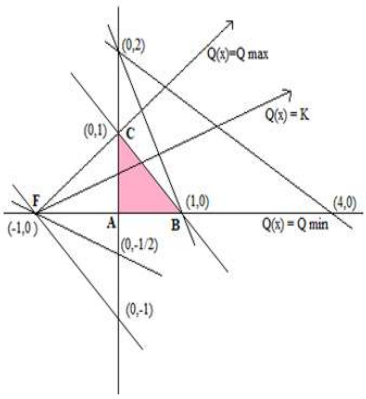


Fig:2

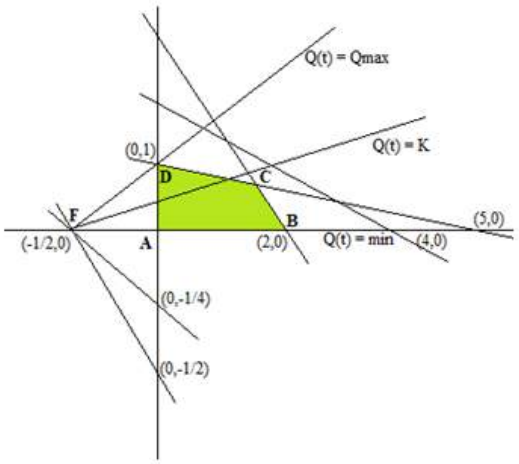


Fig:3

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RESEARCH ARTICLE

A Study on Performance Appraisal System at ABC Private Limited

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ABSTRACT

The study on a "Performance Appraisal System" at ABC Private Limited, investigates on how the appraisal system is effective and how the appraisal influences the employee performance, motivation and job satisfaction. Nowadays, businesses are adopting data-driven strategies to refine their operations. The research analyzes various appraisal techniques which involves both traditional and modern methods such as 360-degree feedback and objective-based evaluations. The research methodology involves both qualitative and quantitative data which are collected from a diverse group within the organization. It also highlights the significance of fairness, transparency and constructive feedback provided from the performance appraisal system helps the employees to become high-performers and motivated professionals.

Keywords: Performance appraisal system, Employee performance, Motivation, Job satisfaction, Constructive feedback.

INTRODUCTION

In today's dynamic world, Organizations are constantly evolving to meet the growing demands of a competitive business environment. Performance appraisal system plays a crucial role in an organization, which helps in managing and evaluating employee's performance and also aligns the individual goals with the organizational objectives. The Performance appraisal is a component of performance management which deals with managing the workforce. It is a formalized process through which the employee's work performance is evaluated and the rewards or recognitions are provided based on the evaluation. The performance appraisal helps the organizations to identify the strengths and the areas for improvement of their employees and also helps to set future goals based on the past

trends. These appraisals are conducted annually or semi-annually which involves both qualitative and quantitative measures of the work performance of the employees. A well-designed appraisal system promotes fairness, transparency, provides a clear criteria and reduces biases. Adopting to an appraisal system helps to customize the needs of both the employer and employee which is the key to maintain an effective workforce in the organization.

PERFROMANCE APPRAISAL SYSTEM:

MEANING

The term "Performance Appraisal" refers to the regular review of an employee's job performance and his/her overall contribution to a company. It is also known as Annual Review, Employee Appraisal, Performance Review, Performance Evaluation. It is a systematic and formal process used by organizations to evaluate and measure the performance of their employees based on several performance appraisal factors. The process typically involves:

- Setting performance standards.
- Collecting and analyzing information on individual employee performance.
- Providing feedback and addressing poor performance if necessary.

DEFINITION

According to Randall S. Schuler, "Performance appraisal is referred as a formal, structured system used to measure and evaluate an employee's job-related behavior and outcomes. The goal is to identify how and why an employee is currently performing, and how they can perform more effectively in the future, ultimately benefiting the employee, the organization, and society".

AIM OF THE STUDY

This study aims to evaluate the effectiveness of the current appraisal system within an organization. It seeks to identify the factors influencing employee performance, motivation and job satisfaction. The research aims to provide recommendations for optimizing the appraisal system to enhance the overall organizational growth and employee development.

NEED OF THE STUDY

In today's changing environment, organizations may need an effective performance appraisal system to assess and improve the performance of the employees. This study explores the importance of the system in enhancing the productivity, fostering growth, and aligning individual goals with the organizational objective to ensure long-term success.

By evaluating existing performance appraisal systems, the study provides insights into the best practices and recommendations for improving the systems, ensuring that they align with the current organizational trends and requirements.

SCOPE OF THE STUDY

- The study examines various evaluation processes and methods that are used to assess employee performance, analyzing their evaluation and applications.
- It explores the impact of performance appraisal on employee motivation, job satisfaction, productivity and overall organizational performance.
- It identifies the challenges faced in implementing the appraisal and highlights the areas for improvement.
- It highlights the role of performance appraisals in employee development, productivity enhancement and aligning individual goals with organizational objectives.

OBJECTIVES OF THE STUDY:

- To identify the individual factors influencing employee performance as measured by the performance appraisal system.
- To assess the impact of performance appraisal on employee motivation and job satisfaction.
- To evaluate the alignment of performance appraisal methods with the organizational goals and objectives.

- To provide recommendations for enhancing the effectiveness of performance appraisal systems.

CHARACTERISTICS OF PEFROAMCE APPRAISAL SYSTEM

Clear Objective

The system should include a well-defined goal such as providing clear criteria, identifying the training needs, making informed-decisions.

Standardization

It ensures that the appraisal system evaluates the employee's performance consistently across all employees within the organization.

Comprehensive

It should assess various aspects of work performance of the employees such as skills, knowledge, behavior, goals achieved and overall contribution to the organization.

Feedback Mechanism

The appraisal should provide a regular and constructive feedback to the employees about their strengths and the areas for improvement.

Documentation

The detailed records of the previous appraisals held such as the criteria used, feedback provided, performance ratings and the decisions that are made should be recorded.

Legal & Ethical Considerations

The appraisal system should comply with both the labor laws and ethical standards ensuring that the decisions made are not discriminated against any employees.

INDIVIDUAL FACTORS INFLUENCING PERFORMANCE APPRAISAL SYSTEM:

Individual factors that affect the performance appraisal system includes individual's behavior or characteristics that influences on how an employee is assessed. Understanding these factors are essential for ensuring accuracy and fair evaluation results. Some of the individual factors include:

- Punctuality.
- Accountability.
- Time management.
- Quality and Quantity of work.
- Teamwork.
- Leadership capabilities.
- Communication abilities.
- Skills and Job expertise.

IMPACT OF PERFORMANCE APPRAISAL SYSTEM ON MOTIVATION AND JOB SATISFACTION:

The appraisal system is used to assess and guide the employees. When the system is well-designed and implemented properly, it can help the employees by boosting morale, enhancing job satisfaction and employee motivation. If not then it may lead to stress, anxiety and dissatisfaction. Understanding both the positive and negative impacts are essential for improving the workforce performance.

Positive Impacts

Clear career path and growth opportunity

By appraisal, employee can identify the strength and areas for improvement and some appraisal methods also provide more insights about the career or growth opportunity.

Improves communication
Open dialogue conversation between the employer and employee may foster trust and better relationship between them.

Promotes motivation and satisfaction
When the feedback is provided on a regular basis, it helps the employees to grow their skills and knowledge which increases motivation and job satisfaction.

Negative Impacts
Stress or anxiety
Employee may feel stress or anxiety due to the consequences of poor appraisal which may lead to lower their motivation and fells dissatisfied.

Biased and unclear evaluation criteria
When the criteria are vague or not clear, the employees may feel demotivated or not fairly judged.

Unrealistic goals
When the goals are too high or not aligned with the role may lead to dissatisfaction and lowers the employee motivation.

Feedback
When the feedback provided is nor regular and constructive, employees may feel confused leads to discouraged or disengaged.

METHODS OF PERFORMANCE APPRAISAL SYSTEM
Performance appraisal system plays a crucial role in decisions regarding promotion, demotion, suspension, training etc., Traditional methods of performance appraisal are more basic methods of appraisal which focuses on the evaluation of the employee's past actions and behavior. These methods may be subjectivity and tend to biases in the evaluation of the employee. Whereas Modern methods of performance appraisal are most advanced techniques that not only assess the past performance of the employee, it also considers the future potential, competencies and development needs of the employees. These methods are data-driven, employee-focused and less prone to biases. Modern methods also include the self-assessment of the employees and peer reviews for providing continuous feedback for the employees.

TRADITIONAL METHODS
Graphic Rating Scale (GRS)
Critical Incident Method
Essay Method
Ranking Method
Forced Distribution Method

MODERN METHODS
360-Degree Feedback
Management by Objective (MBO)
Behaviorally Anchored Rating Scale
Self-Assessment
Continuous feedback

REVIEW OF LITERATURE

- **Dr. M Dhanabhakyam and Fahad KP (2025)**
  This study analyzes the impact of performance appraisal system on employee morale in private sector banks in Kerala, the results shows that effective appraisals boosts job satisfaction and commitment. Conducted with 244 employees, it reveals that rating strategies influence morale.

- **Alwizan Mohd Ron, Ahmad Shahrul Nizam Isha (2025)**
  This study explores the role of ethical leadership in performance appraisal system which focuses on ESG criteria and highlights the gaps on state-owned agencies in Sabah. It examines how the ethical leadership affects organizational performance and ESG sustainability, this study advice for further research to enhance appraisal system and their impact on the ESG initiatives.
- **Christopher Ogola (2025)**
  The researcher investigates the role of goal theory in performance appraisal and finding that there is a positive relationship between the appraisals and employee performance. It also highlights the factors such as sector, organizational size and sample type that influence the relationship.
- **Zewdu, Teshome (2024)**
  It investigates perception of employees on the performance appraisal system at Adanech Argaw Timer and Plank Manufacturing Company. It reveals that the employees feel dissatisfied due to its subjectivity and non-participatory nature. The appraisal system also has some issues such as errors, biases and evaluator incompetency. It recommends to adopt to a best industry practices, standardizing tools and overall system for the development of the employee in the organization.

RESEARCH METHODOLOGY

Research methodology refers to the system approach used by researcher to collect, analyze and interpret data in order to answer a research question or to solve a problem. It involves the techniques, processes and the tools used to gather data, the methods used to analyze it.

RESEARCH DESIGN

A research design is the overall plan or structure that outlines the methodology, data collection techniques, sampling techniques and data analysis methods to be used in a study. For the performance appraisal system, **Descriptive research design** is used which focuses on understanding the effectiveness, challenges and employee perception related to the appraisal within an organization.

RESEARCH APPROACH

1. **Qualitative:** It involves exploring the perception of both employees and managers regarding the performance appraisal system through interview.
2. **Quantitative:** It focuses on collecting numerical data from a structured questionnaire to access the effectiveness and fairness of the system.

Data Collection Methods

i. **Primary data:** The data was collected through a structured questionnaire which was directly collected from the employees in the organization.
ii. **Secondary Data:** The data was collected from the existing reports and documents within the organization. It offers a deeper understanding of the concept of performance appraisal system. It includes:
   - Internal Reports.
   - Company Policies and Guidelines.
   - Existing Literature.

Sampling Technique

This study involves **Stratified random sampling** technique to ensure that participants from diverse roles, departments and experience levels were included.

Sample Size

The study was conducted with a sample size of **96** participants including both the employees and managers within the organization and the targeted population size was **243**.

Sampling Area

The data was collected from different departments at **"ABC PRIVATE LIMITED"** to ensure that a comprehensive analysis of the performance appraisal system was held.

STATISTICAL TOOL USED

It refers to the techniques that are used to collect, analyze, interpret and present data to identify the patterns, relationship and trends. These tools helps to draw conclusion and make decisions based on the data that are provided by the respondents. The statistical tool used in the study are:

- Chi-Square test.
- Karl Pearson's coefficient of correlation.
- F – test.
- Regression.
- Mann-Whitney U – test.

CHI-SQUARE TEST

Null Hypothesis (H_0): There is no association between the experience of the respondents and the appraisal system which helps in identifying and addressing performance gaps effectively.

PARTICULARS/ EXPERIENCE	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE	TOTAL
LESS THAN 1 YEAR	5	2	3	1	0	**11**
1 - 5 YEARS	15	13	2		0	**31**
5 - 10 YEARS	9	15	4	3	2	**33**
MORE THAN 10 YEARS	6	9	2	2	2	**21**
TOTAL	**35**	**39**	**11**	**7**	**4**	**96**

EXPECTED FREQUENCY:

E = $\frac{RTxCT}{GT}$

E = Expected Frequency

RT = Row Total

CT = Column Total

GT = Grand Total

PARTICULARS/ EXPERIENCE	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE	TOTAL
LESS THAN 1 YEAR	4	4.5	1.3	0.8	0.5	**11**
1 - 5 YEARS	1.3	12.6	3.6	2.3	1.3	**31**
5 - 10 YEARS	12	13.4	3.8	2.4	1.4	**33**
MORE THAN 10 YEARS	7.7	8.5	2.4	1.5	0.9	**21**
TOTAL	**35**	**39**	**11**	**7**	**4**	**96**

CHI- SQUARE FORMULA: $\chi^2 = \frac{\Sigma(O_i - E_i)^2}{E_i}$

Where, O_i=Observed value (actual value)&E_i = Expected value

OBSERVED FREQUENCY (O_i)	**EXPECTED FREQUENCY (E_i)**	$O_i - E_i$	$(O_i - E_i)^2$	$\frac{(O_i - E_i)^2}{E_i}$
5	4	1	1	0.25
15	11.3	3.7	13.69	1.2
9	12	-3	9	0.75
6	7.7	-1.7	2.89	0.4
2	4.5	-1.2	6.25	1.4
13	12.6	0.4	0.16	0.01
15	13.4	1.6	2.56	0.2
9	8.5	0.5	0.25	0.03
3	1.3	1.7	2.89	2.2
2	3.6	-1.6	2.56	0.7
4	3.8	0.2	0.04	0.01
2	2.4	-0.4	0.16	0.07
1	0.8	0.2	0.04	0.05
1	2.3	-1.3	1.69	0.7
3	2.4	0.6	0.36	0.15
2	1.5	0.5	0.25	0.17
0	0.5	-0.5	0.25	0.5
0	1.3	-1.3	1.69	1.3
2	1.4	0.6	0.36	0.3
2	0.9	1.1	1.21	1.3
				$\sum\frac{(O_i-E_i)^2}{E_i}$ **= 11.69**

$$\chi^2 = \frac{\Sigma(O_i - E_i)^2}{E_i}$$

χ^2 =11.69 (Calculated Value)

Degrees of freedom, df = (C-1) (R-1)

= (5-1) (4-1)

df = 12

At a significance level of α = 0.05 and degrees of freedom df = 12, the critical value for the Chi-Square distribution is approximately 21.026.

Calculated value < Tabulated value (11.69 < 21.026)

Therefore, Null hypothesis (H_0) is accepted.

CONCLUSION

The Calculated value is 11.69 which is lesser than the tabulated value (21.026), so the null hypothesis (H_0) is accepted. Hence, there is no association between the experience of the respondents and the appraisal system which helps in identifying and addressing performance gaps effectively.

CORRELATION

Null Hypothesis (H_0): There is no significant relationship between the performance ratings conducted periodically and the performance rating is helpful for managers to provide employee counselling.

Performance ratings conducted periodically	56	32	4	2	2
Performance rating is helpful for managers to provide employee counselling	38	45	6	5	2

FORMULA

$\mathbf{r} = \frac{N(\sum XY) - (\sum X)(\sum Y)}{\sqrt{N\Sigma X^2 - (\Sigma X)^2} - \sqrt{N\Sigma Y^2 - (\Sigma Y)^2}}$

Where, **r** = Coefficient of Correlation

N= Number of pair of observations

X and **Y** =Individual data values for the two variables

$\sum X$= Sum of the X values

$\sum Y$= Sum of the Y values

ΣX^2= Sum of the squared x values

ΣY^2= Sum of the squared Y values

$\sum XY$= Sum of the product of the X and Y values

X	**Y**	**X²**	**Y²**	**XY**
56	38	3136	1444	2128
32	45	1024	2025	1440
4	6	16	36	24
2	5	4	25	10
2	2	4	4	4
∑X = 96	**∑Y = 96**	**∑X² = 4184**	**∑Y² = 3534**	**∑XY = 3606**

$\mathbf{r} = \frac{N(\sum XY) - (\sum X)(\sum Y)}{\sqrt{N\Sigma X^2 - (\Sigma X)^2} - \sqrt{N\Sigma Y^2 - (\Sigma Y)^2}}$

$r = \frac{5(3606) - (96)(96)}{\sqrt{5(4184) - (96)^2}\sqrt{5(3534) - (96)^2}}$

$= \frac{8814}{9948.07}$

r = 0.886

CONCLUSION

The coefficient of correlation (r) is 0.886. Since the fairly high degree of positive correlation is between +0.75 and +0.9. Therefore, there is a fairly high degree of positive correlation between the performance ratings conducted periodically and the performance rating is helpful for managers to provide employee counselling.

F – TEST

Null Hypothesis (H_0): There is no significant relationship between the performance goals set are challenging to attain and the age of the respondents.

Performance goals set are challenging to attain	43	53	0	0	0
Age	9	29	36	17	5

FORMULA

$\mathbf{F} = \frac{S_1^2}{S_2^2}$

$\mathbf{S_1^2} = \frac{\sum X^2}{N_1 - 1}$, $\mathbf{S_2^2} = \frac{\sum Y^2}{N_2 - 1}$

Where, S_1^2 and S_2^2 = Sample Variances

$\sum X^2$ = Sum of X values

$\sum Y^2$ = Sum of Y values

N_1 and N_2 = Number of observations of group 1 and 2.

X	X^2	Y	Y^2
43	1849	9	81
53	2809	29	841
0	0	36	1296
0	0	17	289
0	0	5	25
$\sum X = 96$	**$\sum X^2 = 4658$**	**$\sum Y = 96$**	**$\sum Y^2 = 2532$**

$\bar{X} = \frac{96}{2} = 48$, $\bar{Y} = \frac{96}{5} = 19.2$

$S_1^2 = \frac{\sum X^2}{N_1 - 1} = 4658$

$S_2^2 = \frac{\sum Y^2}{N_2 - 1}$

$= \frac{2532}{4}$

$S_2^2 = 633$

$F = \frac{S_1^2}{S_2^2}$

$= \frac{4658}{633}$

F = 7.36 (Calculated Value)

Degrees of freedom (df)

Degrees of freedom for the numerator, $df_1 = N_1 - 1$

$= 2 - 1$

$df_1 = 1$

Degrees of freedom for the denominator, $df_2 = N_2 - 1$

$= 5 - 1$

$df_2 = 4$

The critical value of the F-test for the two-tailed with degrees of freedom (1, 4) and significance level of $\alpha = 0.05$. The table value for the F-test is $t_{0.05} = 7.71$

Calculated value < Tabulated value (7.36 < 7.71)

Therefore, Null hypothesis (H_0) is accepted.

CONCLUSION

The calculated value is 7.36 which is lesser than the tabulated value (7.71). Therefore, null hypothesis (H_0) is accepted. Hence, there is no significant relationship between the performance goals set are challenging to attain and the age of the respondents.

REGRESSION

Null Hypothesis (H_0): There is no significant relationship between the performance ratings conducted periodically and the performance appraisal system encourages constructive feedback from both managers / HOD's and peers.

The performance ratings conducted periodically	56	32	4	2	2
The performance appraisal system encourages constructive feedback from both managers / HOD's and peers	47	31	13	3	2

FORMULA

Y = a + bX

$b = \frac{N \sum XY - (\sum X)(\sum Y)}{N \sum X^2 - (\sum X)^2}$

Where, b = Slope of the line

a = Y-intercept of the line

X = Values of the first data set

Y = Values of the second data set

X	Y	X^2	Y^2	XY
56	47	3136	2209	2632
32	31	1024	961	992
4	13	16	169	52
2	3	4	9	6
2	2	4	4	4
∑X = 96	**∑Y = 96**	**∑X² = 4184**	**∑Y² = 3352**	**∑XY = 3686**

Regression co-efficient of X on Y:

$b = \frac{N (\sum XY) - (\sum X)(\sum Y)}{N \sum Y^2 - (\sum Y)^2}$

$= \frac{5 (3686) - (96)(96)}{5 (3352) - (96)^2}$

$= \frac{9214}{7544}$

b_{XY}= 1.221

Regression equation of X on Y:

$X - \bar{X} = b_{XY} (Y - \bar{Y})$

X – 19.2 = 1.221 (Y – 19.2)

X = 1.221 Y – 4.243

Regression co-efficient of Y on X:

$b = \frac{N (\sum XY) - (\sum X)(\sum Y)}{N \sum X^2 - (\sum X)^2}$

$= \frac{5 (3686) - (96)(96)}{5 (4184) - (96)^2}$

$= \frac{9214}{11704}$

b_{YX} = 0.787

Regression equation of Y on X:

$Y - \bar{Y} = b_{XY} (X - \bar{X})$

Y – 19.2 = 0.787 (X – 19.2)

Y = 0.787 X – 4.09

Degree of Association = $\sqrt{bxy} \cdot \sqrt{byx}$

$= \sqrt{1.221}\sqrt{0.787}$

Degree of Association = 0.980

CONCLUSION

The coefficient of regression is 0.980. Therefore, there is a very high degree of positive association between the variables. Hence, the performance ratings are conducted periodically to ensure consistent evaluation and improvement. The appraisal system encourages constructive feedback from both the managers/HOD's and peers, fostering a comprehensive assessment of employee performance.

MANN-WHITNEY U – TEST

Null Hypothesis (H_0): There is no significant difference between the performance appraisal system encouraging constructive feedback from both managers / HOD's and peers Vs The feedback provided during the appraisal is effective and leads to improvement.

The performance appraisal system encourages constructive feedback from both managers / HOD's and peers	47	31	13	3	2
The feedback provided during the appraisal is effective and leads to improvement	31	57	5	3	-

Formula

$U = \min \{U_1, U_2\}$

$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$, $U_2 = R_2 - \frac{n_2(n_2+1)}{2}$

R = Ranks of the group

N = Number of observations

X	**R_1**	**Y**	**R_2**
47	8	31	6.5
31	6.5	57	9
13	5	5	4
3	2.5	3	2.5
2	1	-	-
$\sum X = 96$	**$\sum R_1 = 23$**	**$\sum X = 96$**	**$\sum R_2 = 22$**

$n_1 = 5, n_2 = 4$

$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$

$= 23 - 15$

$U_1 = 8$

$U_2 = R_2 - \frac{n_2(n_2+1)}{2}$

$= 22 - 10$

$U_2 = 12$

$U = \min \{U_1, U_2\} = \min \{8,12\}$

$U = 8$

$n_1 = 5, n_2 = 4$

Table Value = 1

Calculated Value > Tabulated Value (8 > 1)

CONCLUSION

The Calculated value is 8 which is greater than the Tabulated Value (1), therefore null hypothesis (H_0) is accepted. Hence, there is no significant difference between the performance appraisal system encouraging constructive feedback from both managers / HOD's and peers Vs The feedback provided during the appraisal is effective and leads to improvement.

LIMITATIONS OF THE STUDY

- The Study involves a small group of employees or a specific organization, which may not fully represent a boarder perspective of industry trends.
- Subjectivity in employee feedback results in biased assessments which will affect the fairness and precision of the appraisal.
- Due to the time constraint it was not possible to fully explore the long-term impacts or to gather sufficient data to make conclusions.
- The study is restricted by limited access to internal records of the organization.
- The traditional appraisal system often relies on the top-down feedback method which results in a limited view on the employee's performance.

FINDINGS

The major findings of the study include:

- The majority of respondents around 51% have agreed that the performance appraisal system is fair and unbiased. Also 49% of the respondents have agreed that the performance evaluations are conducted consistently across all employees.
- A significant number of respondents (48%) have strongly agreed that the appraisal system helps in identifying and addressing performance gaps effectively.
- Majority of 58% of the respondents have strongly agreed that the performance ratings are conducted periodically.
- The majority of 49% of the respondents have strongly agreed that the appraisal system encourages constructive feedback from both managers/HOD's and peers.
- A significant number of respondents around 59% have agreed that the feedback provided during the appraisal was effective and leads to improvement.
- Around 43% of the respondents have agreed that they are satisfied with the overall appraisal system of their company.

SUGGESSTIONS

- Conduct regular training sessions for the managers that helps them to deliver the feedback to their employees in a manner that is clear, unbiased and respectful.
- Considering the employee's self-assessment during the appraisal process.
- Adopting to a performance management software to automate the appraisal process.
- Shifting to a competitive achievement ranking system and intangible contributions.
- Provide equal importance for both traditional and modern methods of appraisal.

CONCLUSION

Performance appraisal system is an essential tool for monitoring employee's work performance and providing effective feedbacks about their performances. It helps to recognize talents and also provide training and development programs for the underperformer. However, the study finds certain challenges such as subjectivity, lack of consistency and more delayed feedback which reduces the effectiveness of the appraisal system. To overcome these challenges, it is better to adopt to a performance management software which helps to enhance the appraisal process. The software offers various features such as real-time feedback, automated evaluation, tracking performance, goal alignment etc., These software helps to increase the accuracy and consistency and also ensures the fairness and transparency in the performance appraisal process. By integrating technology into the formal performance appraisal system, businesses can support the employee's growth which leads to improve employee performance and overall organizational success.

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RESEARCH ARTICLE

Innovation and Initiatives in Energy Conservation and Management

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ABSTRACT

The efficient use of energy can be widely referred to as energy conservation. Energy conservation refers to the reduction or abolition of wasteful or undesirable energy use. It is possible to complete a task by using less energy or none at all. Energy efficiency has a significant potential to promote economic growth and lower greenhouse gas emissions (GHGs) globally. India started implementing energy-saving measures more than 20 years ago, and since then, It has produced a precise framework of policies to encourage energy conservation. All individuals can save energy by minimizing the time they spend using fans, lights, heaters, and other electrical devices in their daily lives. The National Energy Savings Campaign can greatly benefit from this easy and efficient method of energy conservation. It should go without saying that employing renewable energy sources, such as biomass, wind, and solar, would boost the economy and lower greenhouse gas emissions. In 2019, India's economy was the fifth largest in the world; by 2025, it aims to rank third. India will keep moving forward to reach a USD 5 trillion economy by 2025 while also making sure environmental repercussions are kept to a minimum.

Keywords: Energy conservation, GDP, Climate Change, Demand side management, Smart automation

INTRODUCTION

The coal, oil, and natural gas power industries are responsible for one-third of the world's greenhouse gas emissions. It is crucial to provide cleaner and more dependable electricity in order to improve people's quality of life [1]. India's present attempts at economic expansion are contributing to an increase in its energy requirements. An essential precondition for a nation's economic growth is the availability of ever-increasing energy [2]. The National Energy Plan [NEP] was developed by the Ministry of Power (MoP) to supply energy throughout the country [3].It includes a thorough ten-year action plan. In order to ensure that citizens are granted power in an economical and effective manner, it has also developed a second strategy. According to the World Resource Institute Report 2017 [4, 5], India ranks fourth globally in terms of carbon emissions, behind the US (14.36%), China (26.83%), and the EU (9.66%). Nearly 6.65% of the world's carbon emissions come from India. Climate change has the potential to alter the planet's natural equilibrium. Intended Nationally Determined Contributions (INDCs) have been made to the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC).By keeping the increase in global temperature to well below 2 °C, the latter has sought to achieve success [6, 7]. Global electricity demand is expected to peak around 2030, according to the World Energy Council [8]. India imports expensive fossil fuels and is one of the biggest users of coal worldwide [8]. India has pledged to participate in a number of global programs designed to reduce the emission intensity of the GDP (Gross Domestic Product). India has made considerable efforts to carry out the cuts it has committed to, despite the fact that they are not legally required, while considering the overall impact on the Indian economy. To reach the targeted level of emissions intensity reduction, India will have to employ energy efficiency (EE) and renewable energy sources [9].India has accomplished a lot in the last few years. Thanks to the nation's extensive efforts, electricity is now available to over 700 million people. India has increased support for renewable energy industries, particularly solar PV, and energy awareness campaigns like the Ujala initiative in Gujarat that encourage the use of LEDs instead of high power rated bulbs. India, which has 1.4 billion people, is one of the fastest-growing major economies in the world. The future of the world's energy markets lies in India. In recent years, the Indian government has made great strides in expanding access to cooking and clean energy.

It has also deployed a large amount of renewable electricity, especially solar energy, and successfully implemented several energy market reforms [10]. India's increasing energy needs lead to increased supply and demand volatility. On the supply side, more electricity is being produced using renewable resources like solar photovoltaics and wind. Almost 31% of Indians live in cities, which is related to demand in terms of the living conditions of all demographic groups. According to projections, this figure will rise to 40% in 2030 and 50% in 2050. Buildings' share of air conditioning loads will more than double, which will greatly raise daily electricity consumption at its peak [11]. Environmental contamination is currently a major worldwide concern. The damaging emissions from internal combustion engines are one of the primary causes of air pollution. Globally, there is a strong push to promote electric vehicles (EVs) in an effort to mitigate the effects of emissions from fossil fuels and solve environmental issues. Electric-powered trains can cut emissions, enhance fuel safety, and minimize urban air pollution, making them a viable alternative for transportation. People are being encouraged by the government to use electric automobiles. According to the future prediction evaluation projected, EV charging will account for 5 to 7 percent of the total electricity demand by 2030. Demographics, the importance of the manufacturing sector, future GDP growth rates, and the electrification of services like cooking and transportation by trains, electric cars, etc are some of the factors that affect the demand for electricity. India now has 395 GW of installed electricity producing capacity, and the country will need 1275.534 TWh in 2020–2021. By 2030, the total amount of electricity consumed had increased to 2074 TWh (low GDP growth, high efficiency), 2785 TWh (high GDP growth, low efficiency), and 2338 TWh (at 6.2 percent CAGR)[12,13]. In 2019–20 and 2020–21, India's real electrical energy requirements were 12,91,010 MU and 12,75,534 MU, respectively. According to study and econometric projections, the world's total daily power consumption would be close to 6510 million units by 2030.India has set a goal to reduce its emission intensities by 33–55% by 2030. It also plans to use renewable energy sources to meet half of its energy needs by that year and drastically cut its carbon emissions. By 2030, India's non-fossil energy capacity is predicted to increase to 500 GW,

more than doubling the nation's current grid power capacity. By 2030, 60% of India's power generation capacity would be free of fossil fuels if the target were met. In 2022, only roughly 27% of India's energy needs will be satisfied by renewable sources; by 2030, that number will rise to 50%. India needs a robust policy for energy conservation and the use of renewable energy sources in order to accomplish the aforementioned objective. Energy efficiency is one of the most crucial strategies for achieving the emission reduction targets. This study has looked at how energy conservation contributes to energy security [14], [15].

INDIA POWER SECTOR AT GLANCE

In the fiscal year 2020–21, 11,41,941 million units of electricity were consumed in India, which currently has 395 GW of installed power generation capacity. With an installed power capacity of 395.07 GW, India is the world's second-largest consumer and third-largest producer of electricity as of January 2022. Additional encouragement will come from per-capita usage, population growth, and increased electrification. In 2022, power consumption is anticipated to reach 1,894.7 TWH [16]. India has a large amount of power-generating capacity, but its infrastructure for the supply, transmission, and distribution of fuel is insufficient. In India, the average thermal power plant load factor is less than 60% compared to the required 85%. Figure 1 depicts the rise of installed power generation capacity. India has experienced tremendous growth in electricity production, with coal-fired power plants accounting for the majority of the increase—approximately 55% of total non-renewable energy production. India has made significant financial investments to increase solar energy production. On the other hand, 0.16 gigawatts (GW) of solar energy capacity were installed in 2010.India has improved its ability to generate renewable energy, as evidenced by its renewable energy initiative. Figure 2 shows that in 2022, coal power generation overtook wind, gas, and nuclear power generation, and solar energy generation came in second. India's installed power generation capacity is broken down by source in Table 1. In an attempt to support green energy, India has set targets to generate 500 GW of electricity from renewable sources by 2030 and 175 GW by 2022. As of 31 March 2022, the nation had deployed 53 GW of solar power. As of 31 March 2021[9], Gujarat's installed solar power generation capacity was 4,430 MW, making it one of India's most solar-developed states[16],[17]. In 2021–2022, 1356 billion units (BU) of thermal, hydro, nuclear, and imported power are to be produced. It indicates a roughly 9.83% increase over the actual generation of 1234.608 BU in the previous year (2020–21). The generation for 2020–21 was 1234 BU, which represents a negative growth of roughly 1.29% when compared to the 1250 BU generated during 2019–20 [9]. India's electrical industry reflects the nation's rapidly growing economy, increasing exports, improving infrastructure, and rising household incomes. Furthermore, the recent coal problem has created anxiety because thermal power plants, which rely on coal, generate more than 60% of the country's electricity. For the country's economy to grow in such a situation, efficient use of energy resources and their conservation are essential.

Gujarat State Electricity Demand and Supply First

Gujarat is a state in western India, ranking sixth in terms of land and ninth in terms of population. Over the past several years, Gujarat's energy sector has experienced substantial expansion. The main sources of electricity production are coal-fired power plants, gas, hydro, nuclear, and renewable energy sources. It is one of the first states in India to increase its capacity for solar production. According to table 2, 59% of Gujarat's total power generation capacity—40939 MW—comes from coal-based power plants, while about 38%—especially solar PV power plants—comes from renewable sources [18]. Table 2 displays the state of Gujarat's real generation capacity from various sources. It reveals that Gujarat produces 10% of the nation's entire demand, with approximately 40% of that energy going towards renewable sources.

Progress in install capacity of Gujarat

The State's installed capacity for electricity generation expanded from 315 MW in 1960–1961 to 40939 MW in 2021–2022. In the State of Gujarat, 1852 kWH of power were consumed per person in 2021. Figure 4 depicts advancement in Gujarat state. The overall installed capacity for electricity generation in January 2018 was 33.35 GW; of this, around 46% of the power came from coal-fired thermal power plants, while the remaining 24% came from renewable energy sources. As stated in Table 3, 37% of the power generated as of January 2022 came from renewable sources as a result of government actions in favour of such sources and particularly successful subsidies for solar roof top and ground

mount solar PV plants, Gujarat's total generation capacity is 41.59 GW, with 15.51 GW or so coming from renewable energy sources [18]. The progress made by Gujarat state's power generation capacity is shown in the table. The sector of renewable energy generation is the state government's primary focus.

Growth of electricity demand in India and future forecasting

India's population is still growing, and the rising standards of living in many developing nations will increase the demand for energy resources. In all, developing nations, led by China and India, are responsible for more than 70% of the rise in energy demand. Products that require energy are more readily available as a result of new technology. People want more consumer goods as wealth is created and lifestyles change. Both the production and use of consumer goods require energy. With 17.7% of the world's population, India is the most populous country in the world and the second most populous in the world overall. Figure 5 shows that 35.0% of India's population resides in cities, and the country's population is expanding at a rate of roughly 1.02% [19]. Despite having 395 GW of installed capacity, India's electricity demand in 2020–2021 was 1275.534 TWH, as shown in Figure 6. Through 2030, an intermediate total power demand figure of 2338 TWH 6.2 percent CAGR(Compound annual growth rate) may be reached, ranging from 2074 TWH (for low GDP, high efficiency) to 2785 TWH (for high GDP, low efficiency). Figure 7 illustrates the sector-by-sector use of electric energy in India in 2021. The sector that consumed the most energy in India in 2021, at 41%, was the industrial sector. With 26%, the residential sector came in second. One percent of India's total electricity consumption was used for traction and railroads [20].

Electricity supply position of INDIA

Any nation's infrastructure has an impact on its potential for growth, with power infrastructure ranking as the most crucial factor in economic expansion. India's continuous urbanization and development will result in high electricity demand. Power availability was 11,37,149 MU in 2021–2022 while demand was 11,41,941 MU, resulting in a power shortfall of -4,792 MU. Figure 8 illustrates how the gap is closing day by day and how consumers are receiving dependable electricity supply. Table 4 displays the demand and supply for electricity year over year, as well as the reduction of the capacity increase gap from the financial year 2015–16 to the current one [21].

India GDP growth and Electricity Demand

Figure 9 illustrates the connection between economic growth and energy consumption in India and other countries. It shows that industrialized nations use a lot of electricity (measured in kWH) and have high GDPs per capita. India is a developing country that will eventually have to meet massive electrical demands as it continues to industrialize and urbanize. At the moment, the nation's per capita electricity consumption is 1200 kWH, while developed countries such as Singapore and Japan use over 5000 kWH [22]. By 2024–2025, India hopes to reach $5 trillion in GDP and become a major player in the world economy. Figure 10 illustrates how India's per capita power consumption rose from 800 kWH in 2012 to roughly 1200 kWH today. At that point, India's economy would rank third globally. India is a developing country with 395 GW of installed capacity for electricity generation and a demand of 1275 TWH for 2020–2021. With a median value of 2338 TWH (at 6.2 percent CAGR), the total amount of electricity consumed by 2030 may rise to a range of 2075 TWH (at high GDP and low efficiency) to 2785 TWH (at high GDP and low efficiency) [23].

Breaking Myths and barriers while promoting knowledge

Below mentioned steps can be taken for breaking Myths and barriers while promoting knowledge.

- Increase awareness of the practical advantages provided by adopting additional green technology to stimulate trade.
- Innovation and quality must be linked to energy efficiency
- Encourage all households to adopt environmentally friendly practises through standardisation and commonplace actions. It's crucial to get through the obstacles of ignorance and resistance to change.
- A collaborative and coordinated effort among all participants, encouraging energy-wise habits.
- Assisting residents in comprehending their home's energy use patterns

- Encourage the installation of smart metres, which would also encourage measures and regulations that would improve energy efficiency.
- Innovative financial models should be supported for increased market penetration and awareness.
- Citizens should be given micro-details on enhancing energy efficiency to provide them a global perspective and the nation's part in improving energy economics (Gross Domestic Product) and reducing emissions.
- Residents who behave sustainably to encourage energy efficiency improvements that inspire other citizens should be emulated.
- Respect the opinions of people who can have a big impact on the energy economy.
- Promote energy-saving initiatives by showing out actual tools, if you can.
- Set up banner and slogan contests at the school level to advance energy efficiency.

For Conservation of Energy following points can be considered for implementation.

1. Lights, fans, and other equipment should be turned off in rooms, workplaces, and other places of this nature while no one is present.
2. Lighting systems that use less energy should be replaced with more energy-efficient systems, such as led lights.
3. Use the task lighting principle as needed
4. Switch to flat-screen LCD monitors from CRT displays.
5. Encourage the adoption of solar-powered water pumps and lighting systems.
6. Invest in equipment with the Energy Star label and requirements.
7. To save energy, use the right use of motion sensors.
8. Make use of and encourage the use of energy-efficient motors, transformers, water pumps, and irrigation systems.
9. Educate yourself about the technological progress in this field and the principles of cost economics, as well as others.
10. Make use of and promote solar water heaters, solar PV generation, and solar cookers.

Instrument used to create public awareness on energy conservation and efficiency is as follows.

1. Outreach programs
2. Online resources creation
3. Social media(Blogs, web pages)
4. Public hoardings
5. Print media
6. TV/Radio advertisements

Energy Saving at schools and colleges in brief is beautifully illustrated in below mentioned picture. Using smart automation techniques to make life more comfortable and use less energy With the help of your smartphone, smart home automation systems enable you to easily control the lighting, media, video surveillance, weather, security, and much more. No matter where you are in the globe, it provides access and confidence so you may devote yourself totally to your priorities. Your home automation system's added benefit will surely be a decrease in the amount of energy used throughout the house. Changing your home's systems lowers your energy costs and consumption. They also give you the opportunity to lessen your carbon footprint, which is a terrific approach to take charge of climate change. Huge monthly savings can be made by carefully planning your lighting, temperature, shades, and ceiling fans, as well as by using the "all-closed" electronics command.

Government policies to Enhance Energy Conservation

Given that peak demand is expected to rise by almost 7% annually and that India's electricity demand is expected to increase by about 4% annually over the next ten years, it is clear that energy efficiency and demand shift will be essential in creating a cost-effective energy system for India. It will be necessary for states and municipalities to

develop their own Energy Efficiency Action Plans with particular goals, like energy-efficient cooling. As well as new building materials like steel, cement and bricks, new energy-efficient building standards are also being created. The steel industry may need to utilise hydrogen to produce green steel for export when Europe launches its massive green procurement projects. I am persuaded that in order to create solutions tailored to India's needs that are both affordable and implementable by millions of people, current international experience needs to be combined with Indian inventiveness and innovation. To influence effective and significant policies and create a healthy ecosystem for successful implementation, AEEE(Alliance for an Energy Efficient Economy) serves as a platform for bringing together key energy players, including industry, government, civil society, and professionals, in a constructive dialogue. This will transform the market for energy efficiency solutions and includes innovative business models and easy access to capital.

National Climate Change Action Plan

India's GDP will have an emission intensity that is 33–35% lower than it was in 2005. These national initiatives may be accelerated with assistance from wealthier nations, enabling India to achieve its goals more quickly. By emphasising the connection between poverty and growth, the Action Plan adopts an innovative approach to reducing stress caused by climate change.

The National Mission for Enhanced Energy Efficiency (NMEEE)

The NMEEE seeks to develop market-based mechanisms that will boost the cost-effectiveness of energy efficiency improvements. The way forward for achieving this goal is to transition to cleaner fuels, create technological advancements that are commercially viable, improve capacity construction, and so forth. The mission's efforts are coordinated by the Bureau of Energy Efficiency (BEE). The Ministry of Power has given Rs. 100 crores in grant-in-aid for the fiscal years 2019–20 and 2020–21. Additionally, the BEE receives money through bilateral cooperation activities as well as from labelling programmes through labelling fees. The mission's scope, impact, and funding are broken down below.

The National Mission on Sustainable Habitat (NMSH)

The strategy to make cities more sustainable includes adapting public transportation systems, creating energy-efficient buildings, and enhancing solid waste management. This Mission is focused on recycling and urban waste management; the expansion of the energy-conservation building code, which addresses the design of new and large commercial buildings to minimize their energy demand; and improved urban planning and a modal shift to public transportation, which develops long-term transport plans to support the growth of medium- and small-sized cities to ensure efficient and practical public transportation. The Ministry of Housing and Urban Affairs is principally responsible for the National Mission on Sustainable Habitat (MoHUA). Through the implementation of sector-specific interventions, the core objectives of NMSH have been met by the current Union Government's flagship AMRUT (formerly the Jawaharlal Nehru National Urban Renewal Mission), Swachh Bharat Mission (Urban), Smart Cities Mission, and Urban Transport Programme. For the past 20 years, India has prioritized energy efficiency and launched a number of initiatives in this field. Efficiency will continue to be a top priority in light of the favorable outcomes. The ultimate objective is to promote energy efficiency through a combination of market enablers and policy.

Indian Ministries' Energy Efficiency and Climate Change Initiatives

In order to launch energy efficiency and conservation initiatives, India passed the Energy Conservation Act of 2001. The Act's multiple components are regulated by the Bureau of Energy Efficiency, which was founded. The nodal ministry in charge of the nation's energy efficiency is the Ministry of Power. In addition, other ministries, such as those in the fields of industries, aviation, agriculture, research, and technology, have identified projects that will increase energy efficiency using funds from their budgets.

Central and State Level Agencies – Overview

State and federal governments have crucial responsibilities in regulating and running the electricity industry. Fig. 12 depicts the importance of various parties in the formulation of laws and regulations. The Ministry of Power and the Ministry of New & Renewable Energy (MNRE) are responsible for developing, implementing, and regulating policies at the national level, while state-level policies are governed by the state's power or energy departments.

Energy Efficiency in Buildings

The use of ECBC (Energy Conservation building code) 2017 in the construction of new commercial buildings is expected to reduce India's energy consumption by half by 2030. This results in a reduction of 250 million tons of CO2 emissions and savings of 35,000 crore INR. Two changes to the code were made in April 2018 and November 2019 in response to market feedback and technical committee approval. In order to increase domestic energy efficiency, the "Energy Efficiency Label for Residential Buildings" was created in February 2019. The labelling programme has the potential to save 388 billion units (BU) of energy by 2030. This code applies to all residential buildings on lots larger than 200 square meters (Sq.m.).For the purpose of energy consumption monitoring.

Energy Efficiency in the Transport Sector

By 2029–2015, India's diesel demand is predicted to quadruple to 163 Mt. Among other things, this will raise pollution and make it more expensive for the government to import petroleum. By increasing vehicle economy, it is essential to take steps to reduce the consumption of petroleum products. BEE has already announced corporate average fuel efficiency norms for light-duty and passenger vehicles. On July 16, 2019, S.O. finalised and unveiled the first phase of Fuel Economy Standards for Light and Medium Commercial Vehicles with Gross Vehicle Weights of 3.5 to 12 Tonnes. Implementation of these guidelines is expected to save 0.06 MMT of fuel each year and 0.25 MMT of fuel over three years. 17 Tyres have been highlighted as a significant component of a vehicle with the ability to save gasoline.

Standards and Labelling Scheme

The purpose of the Standards and Labelling (S&L) program is to enable consumers to make informed decisions about energy conservation. S&L, also referred to as the Star Rating system, is being used in the appliance sector. Appliances must meet minimum energy efficiency standards set by this initiative, with a score of 5 representing the most energy-efficient. The updated energy consumption standards for self-ballasted LED bulbs and air conditioners were released in October 2019.

Municipal Demand Side Management Scheme

The Standards and Labelling (S&L) programme was started with the intention of enabling customers to make educated decisions on energy conservation. Implementation of S&L, commonly known as the Star Rating scheme, is taking place in the appliance industry. According to this effort, appliances must meet minimum energy performance standards that are ranked from 1 to 5, with 5 being the highest energy-efficient level. In October 2019, the updated energy consumption guidelines for air conditioners and self-ballasted LED bulbs were announced. In order to tap into India's enormous potential for energy and water cost savings, the Municipal Energy Efficiency Programme (MEEP) is being put into place in collaboration with the Atal Mission for Rejuvenation and Urban Transformation (AMRUT). By March 2020, agreements had been reached with 390 ULB in 22 states and 3 union territories. Across the various ULBs, investment grade energy audits (IGEA) are being done.

Innovation in energy conservation and management

Digitalization

The power sector change is significantly accelerated by digitalization, which makes it possible to manage vast volumes of data and optimize ever-more complicated systems. Digitalization in the power industry generally involves turning data into value. Decentralization and electrification, two major innovation trends, have advanced, which has increased the significance of digitalization in the power sector. Increased small-scale renewable energy installations, particularly rooftop solar photovoltaic (PV) coupled to the distribution grid, is driving decentralization.

Large numbers of new loads, including electric automobiles, heat pumps, and electric boilers, are required for the electrification of transportation as well as the heating and cooling of buildings. thorough examination of three different digital technology categories: blockchain, artificial intelligence (AI), and the internet of things (IoT).

Energy as a Service

Some futuristic depictions of the energy system center on DERs, which are monitored by a mix of AI and IoT. These elements are part of energy-as-a-service solutions, along with blockchain and the increasing number of energy prosumers. EaaS (energy as a service solution) enables the shift from selling electricity to selling services like production optimization, control, and consumption tracking. Local energy production and storage increases overall energy efficiency and enables greater grid access.

Energy trading platform

Energy trading is made possible by the EaaS platforms created by the Indian business KPay. Pay-as-you-go solar, home appliances, pumps, and agricultural equipment are all available on their platform. By weighing the unique advantages of each model, customers can choose from three different payment options: pay-per-use, pay-per-time, and pay-per-amp.

AI Powered building Energy Services

The US-based company Iota offers EaaS that combines a variety of energy-saving techniques with its Bright AI smart building software. Demand response, lighting, HVAC, and renewable energy use are all included in the solution's energy management optimization. By ensuring savings, this EaaS technique lowers risk and speeds up the implementation of an optimization strategy. Because the technology is independent of the analytics and communications platform, capital expenditures are also decreased.

Distributed Energy Resources.

Distributed energy resources allow for the production of power or heat wherever it is needed. Energy transmission losses and expenses are eliminated in the absence of a network. This suggests that a large number of consumers generate energy for their personal use before transferring any excess to the shared network. This idea states that small and medium-sized power plants function as distributed energy generators. Additionally, it lowers the cost of producing energy and makes the most of the capacity that already exists.

Vehicle to Grid

Depending on demand, electric vehicles (EVs) in a "vehicle-to-grid" system either lower their rate of charging or return electricity to the grid. It is possible to use EV batteries as an energy storage asset if they eventually return energy to the grid via charging stations. EV charging is less expensive when demand is low, allowing the network to withstand heavy loads. V2G solutions serve as adaptable and convenient buffers, which may shorten the length of a power outage.

Virtual Energy Networks

In order to accomplish simultaneous energy balance, the Slovak startup Fuergy builds virtual energy networks of actual energy grids using AI-powered energy sharing systems. The company produces superchargers that are compatible with the existing grid. They provide electric vehicle charging and V2G capabilities to reduce energy costs and prolong battery life. By leveraging the battery capacity of grid-connected electric vehicles, their approach lowers energy fluctuations and costs for building and vehicle owners.

Power to X

Globally, it is becoming more and more crucial to reduce greenhouse gas emissions through the use of renewable energy sources and energy efficiency upgrades. In the industry, power-to-X technologies for electricity conversion, energy storage, and reconversion pathways are becoming more popular. Startups and new PtX technologies transform energy and carbon dioxide (CO2) into new resources and products with a variety of additional uses.

CONCLUSION

By educating the public and dispelling common fallacies about energy saving, we can promote energy conservation. Energy economics must effectively express the technological advancements in energy automation and its use. Government policies should apply to residents of both urban and rural areas. The use of renewable energy and government initiatives related to it should be pushed in society, and programs related to energy innovation and research with awareness programs should be promoted in schools and colleges. With these actions, the nation will increase its energy security while also boosting GDP, cutting emissions, and improving citizen living conditions.

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Table.2 Electric Power Generation Installed Capacity of India- Year

Year	Coal (MW)	Gas (MW)	Diesel (MW)	Nuclear (MW)	Hydro (MW)	Other RE (MW)	Total Generation (MW)
2022	210520	24,900	510	6,780	46,512	105854	395,076

Table.3 Gujarat State Power Generation sector wise[18]

Thermal	Nuclear	Hydel	Other RE	Total MW	% of total Nation	% Of RE
24289.1	559	772	15319.2	40939	10.44	39.3

Table.4 Progress in Power Generation Install Capacity of Gujarat

Year	Coal	Gas	Nuclear	Hydro	RES	Total Installed Capacity
2019	16232.00	7551.41	440.00	1990.00	10178.26	36391.67
2020	16232.00	7551.41	440.00	1990.00	12267.24	38480.65
2021	16092.00	7551.41	440.00	1990.00	15447.36	41520.77
2022	16092.00	7551.41	440.00	1990.00	15517.91	41591.32

Table.5 Electric Power Demand, Availability and Gap[21]

Year	Requirement (MU)	Availability (MU)	Surplus(+)/Deficts(-)	
		(MU)	(MU)	(%)
2009-10	8,30,594	7,46,644	-83,950	-10.1
2010-11	8,61,591	7,88,355	-73,236	-8.5
2011-12	9,37,199	8,57,886	-79,313	-8.5
2012-13	9,95,557	9,08,652	-86,905	-8.7
2013-14	10,02,257	9,59,829	-42,428	-4.2
2014-15	10,68,923	10,30,785	-38,138	-3.6
2015-16	11,14,408	10,90,850	-23,558	-2.1
2016-17	11,42,929	11,35,334	-7,595	-0.7
2017-18	12,13,326	12,04,697	-8,629	-0.7
2018-19	12,74,595	12,67,526	-7,070	-0.6
2019-20	12,91,010	12,84,444	-6,566	-0.5
2020-21	12,75,534	12,70,663	-4,871	-0.4
2021-22* (Jan- 22)	11,41,941	11,37,149	-4,792	-0.4

Table 5.National Mission for Enhanced Energy Efficiency[25]

Nodal Agency	Scope	Results (as of 2019-20)4	Finance
Bureau of Energy Efficiency, Ministry of Power	Promote EE using various approaches and incentives, in the context of providing an increasing amount of energy to meet the demands of a growing population	28.06 Mtoe of energy will be saved overall (2019–20); 115,702 crores of money will be saved; and 177.6 MT of CO2 will be emitted less frequently. India's energy intensity declined from 65.5 toe per INR crore in 2011–12 to 55.5 toe per INR crore in 2018–19.	100 crores in grant money from the Ministry of Power for the fiscal years 2019–20 and 2020–21 Additionally, BEE receives income from bilateral cooperation agreements in addition to labelling fees generated by their labelling programmes.

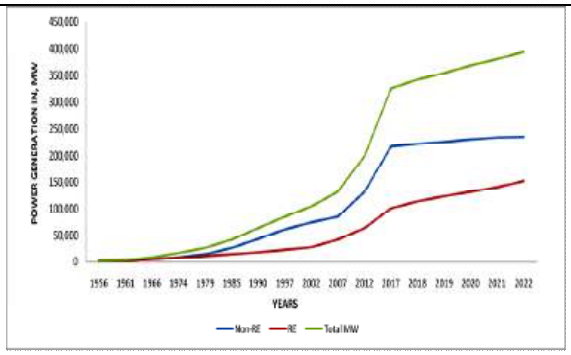


Figure 3: Growth in power generation installed capacity of India[16],[17].

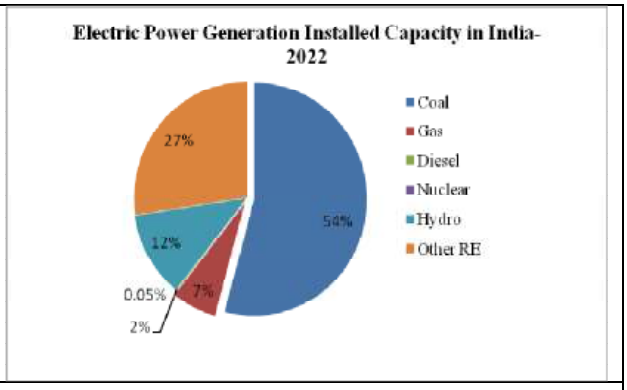


Figure 4: Electric Power Generation Installed Capacity Of India- Year 2022[16][17].

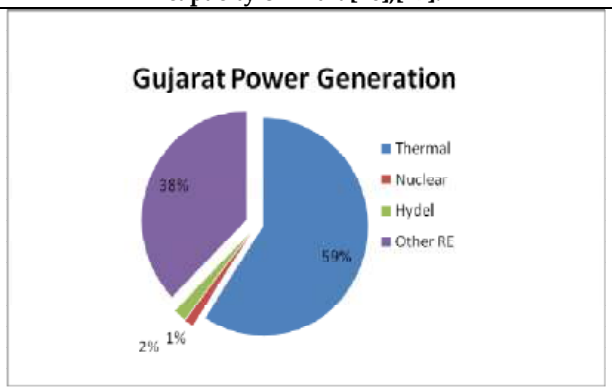


Figure 5:Gujarat state power generation sector-wise [18]

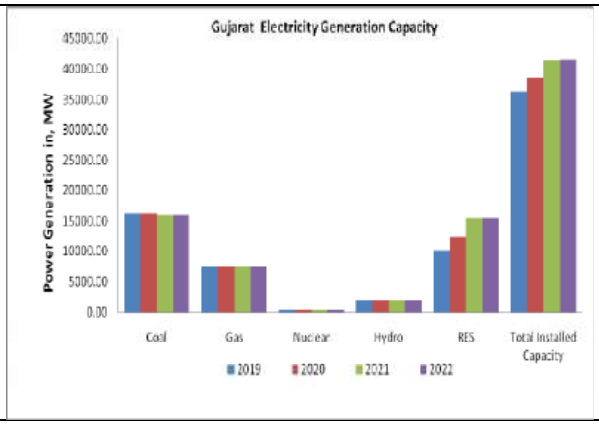


Figure 6: Yearly Progress In Gujarat State Electricity Generation Capacity [18]

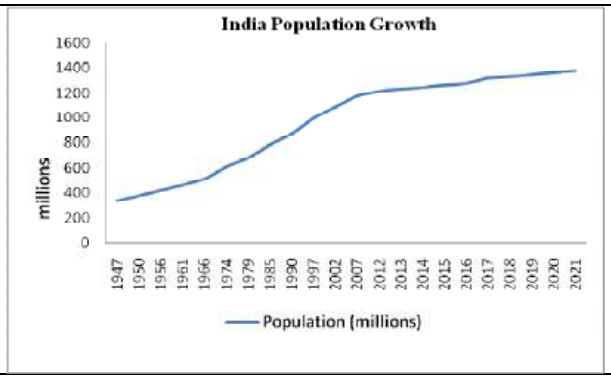


Figure 5: India population growth rate[19]

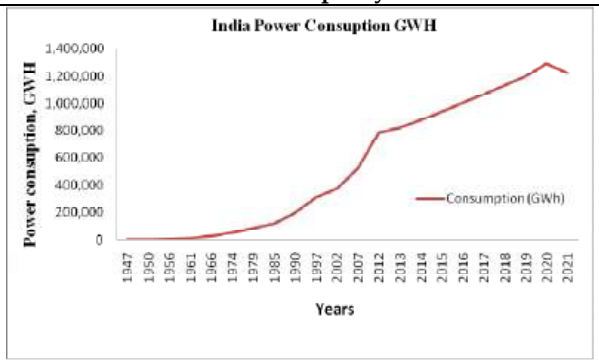


Figure 6: Electric power consumption of India in GWH[20]

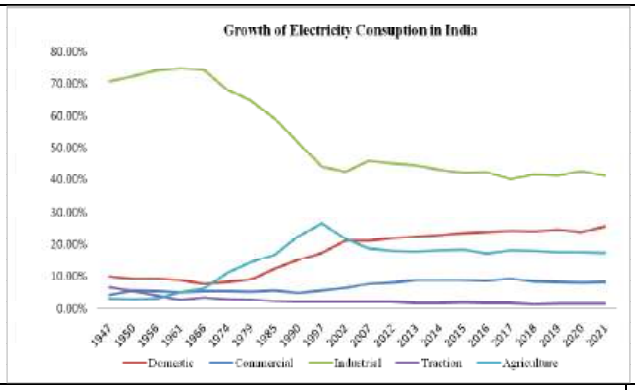


Figure 7: Sector Wise Electric Power Consumption[20]

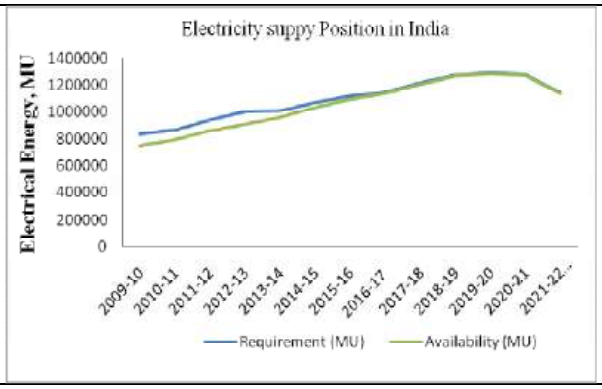


Figure 8: Electric Power Demand and Availability Of INDIA[21]

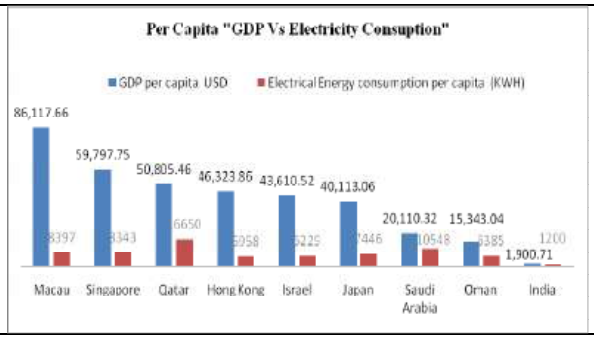


Figure 9: Per Capita GDP Vs Per Capita Electricity Consumption In Different Country[22]

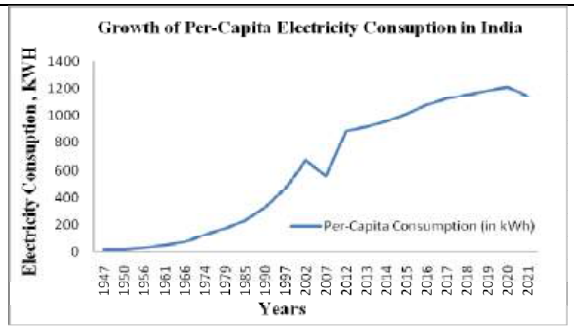


Figure 10: Growth of Per Capita Power Consumption of India[23]



Figure 11: Energy Saving At School and Colleges [24]



Figure 12: Central and State Level Agencies[26]



Figure 13: Star Labelling of home appliances[27]

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RESEARCH ARTICLE

Usage of Social Networking Sites in Relation to Certain Personality Traits among the Post-Graduate Students

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ABSTRACT

Social networking sites as one of the famous platforms for every person all over the world to connect, communicate, participate and share their thoughts, photos, videos, audios, feelings, and information through instant messaging. Personality traits imply people's characteristics and patterns of ideas, behaviours, thoughts, and feelings. Social networking sites are a popular mode of communication at Pondicherry University. This present study finds the relationship between social networking sites and personality traits in post-graduation students. To observe the use of social networking sites in the study of the behaviour of students to predict their personality characteristics, i.e., introvert and extrovert traits. The basic theme of this study is to determine an individual's personality characteristics. The sample consisted of 250 students who use different types of social networking sites. The finding of this paper is to find out the number of introvert and extrovert students, motives of the usage of social networking sites, students awareness, SNWS in the teaching-learning process, effect of usage of social networking sites in postgraduate students.

Keywords: Social Networking Sites, Personality Traits, Introverts, Extroverts.

INTRODUCTION

Nowadays, social networking sites are one of the well-known and most prominent communication tools for people's (Zaidieh, 2012). Social networking sites as one of the famous platforms for every person all over the world to connect, communicate, participate and share their thoughts, photos, videos, audios, feelings, and information's through instant messaging. Social networking sites like Facebook, WhatsApp, YouTube, Myspace, Instagram, LinkedIn etc., are online platforms that allow to connect and interact with others (boyd & Ellison, 2007; Correa et al., 2010; Pornsakulvanich, 2017). The various social networking sites are described as social, for the reason they allow communication and bound relationships with friends and colleagues and become stronger between members of different sites like Facebook WhatsApp in the internet space (Zaidieh, 2012). "Personality is the dynamic organization within the individual of those psychological systems that determine his unique adjustment to his environment" (Allport, 1948). Every person's personality development is a continuous process in multiple ways until death. A person's personality is pushed by examining inherited and combined personality traits during their entire life (Malik et al., 2021).Therefore, the finding of personality traits states that the majority of the male extrovert students maximum as compared to female extrovert students. On the other hand, the majority of the male introvert student's maximum as compared to female introvert students. The significant finding of this study is to find out the number of introvert and extrovert students, social networking sites in the teaching-learning process, awareness of undergraduate students, the motive of the students, and effect of usage of SNWS in postgraduate students.

Social Networking Sites (SNWS)

Social networking sites are one of the famous web-based platforms that permit individuals to create their personal profile within a framework, send a request for accepting communication and connections with each other and view their information quickly (boyd & Ellison, 2007; Karakoyun, 2019). Social networking is divided into two elements, i.e. social and networking. The social site is concerned about the power of the collective, the dynamic networks and the knowledge and absurdity of the crowd. In contrast, the networking site involves connecting and communicating with others. Therefore, social networking means a tool, utility, or device for connecting with people (Kocak *et al.*, 2020; Cohen, 2009). Social networking sites are generally bi-directional communication platforms, but some do not. The one-directional communication is sometimes labelled as followers or fans, but most sites call these followers as well. The bi-directional ties are very famous because communication is done in both ways (Bicen & Cavus, 2010; boyd & Ellison, 2007). Social networking sites are among the famous tool provided by the internet. As per the Digital 2024 October Global Statshot Report, it was revealed that around 5.52 billion people were user's internet, and about 5.22 billion people were users of social networking sites throughout the world.

Personality Traits

Carl Jung established a theory of personality that every person is born with an inborn set of traits that influence how they interact or participate in the world. In this theory of personality he describe introversion and extroversion. Social network sites reflects the concept of Personality Traits like introvert and extrovert trait (Chen & Roberts, 2019). Introvert personality is generally known as a shy people who prefer their feeling, thought, dream, knowledge and talents. While extrovert personality is in contrast to introvert and more outward activities oriented. Furthermore, extrovert students are more expressive than introvert students (De Goma & Moneva, 2020). Personality traits imply people's characteristics pattern of ideas, behaviors, thoughts, and feelings. Personality Traits are based on the contains of Five Factor Model that divide personality into five dimensions i.e. Extraversion, Neuroticism, Agreeableness, Openness to experiences and Conscientiousness. (Correa *et al*., 2010; Dodoo & Wen, 2021; Ehrenberg *et al.*, 2008; Gosling *et al*., 2003; Pornsakulvanich, 2017). Every aspect is bipolar such as introversion vs. extroversion and summaries more specific views e.g., sociability, which includes more specific attributes like talkativeness and outgoingness(Correa et al., 2010; Gosling et al., 2003). Personality traits are shared by totality of all human structure such as Id, ego, superego, conscious and unconscious (Atabek, 2019).

Social Networking Sites users Personality Traits

SNWS have extended the lives of university students throughout the world. University learners utilize social networking areas to convey their documents, thoughts, and feelings, receive news, images, and videos and keep in touch with friends and family making them the best communication medium for today's digitally aware university students (Koranteng *et al*., 2019; Tafesse, 2020).Personality is an ultimate visionary of many behavioral results, whereas traits refer to keeping in the way individuals act, think, and feel (Dodoo & Wen, 2021; Kocak *et al*., 2020). Personality concern a certain combination of attitudinal, emotional and behavioral response and many experimenters have tried to discover a group of traits that define an individual's personality. Personality traits have an essential mark on the way people commit in social networking sites (Maria Balmaceda *et al*., 2014).

Need and Significant of the Study

Social networking sites maximum opportunities for communication, interaction, socializing, sharing knowledge and the teaching-learning process. Subsequently, most of the users started using social networking sites to update their ideas, knowledge, sharing images, audio, video and messages. They allow users to create their profiles, connect, interact, and collaborate (Alwagait et al., 2015; Kocak *et al*., 2020; Malik *et al*., 2021).The basic theme of this study is to determine an individual's personality characteristics. Personality is the sum of qualities or characteristics taken from individuals' distinctive features (Malik et al., 2021). A bulk of study based on the role of personality traits as a visionary of uses social networking sites on the Big Five-Personality theory, which indicates that individual personality differences can be categorized into five aspects, i.e. neuroticism, agreeableness, extraversion, openness to experience and conscientiousness (Chen & Roberts, 2019; Correa *et al*., 2010; Dodoo & Wen, 2021; Malik *et al*., 2021; Maria Balmaceda *et al*., 2014; Pornsakulvanich, 2017; Yang, 2019). This present study finds the relationship between social networking sites and personality traits in post-graduation students. To observe the use of social networking sites on the study of the behavior of post-graduation students to predict their personality characteristics such as introvert and extrovert traits (Malik *et al*., 2021).

OBJECTIVES OF THE STUDY

1. To identify the number of introverts and extroverts in the sample of the study.
2. To study the motives of the usage of social networking sites among the postgraduate students.
3. To study the awareness of postgraduate students pertaining to the usage of social networking sites.
4. To find out the usage of social networking sites in teaching and learning process among the post graduate students.
5. To study the effect of usage of social networking sites among the postgraduate students.

METHODOLOGY

Survey Research Design under Descriptive Research Method has been used.

Population

In the present study, the target population consists of students studying in various departments / schools of Pondicherry University, Pondicherry.

Sampling Technique

Disproportionate Stratified Sampling technique was adopted to select the sample out of the population. Percentage analysis was used for data collection**.**

Sample of the Study

The sample of this study consisted of 250 postgraduate students studying in various schools or faculties, of Pondicherry University. Out of 250 students, male students were 151 and female students were 99.

Research Instruments used for Data Collection

A self-created questionnaire was used for the current investigation and collection of data. The questionnaire was scrutinized and validated by the friends, experts and supervisor. The tool was so developed to translate the objectives of the study in to specific statements, the responses to which will provide the necessary data and explore the area defined by the objectives of the present study.

Analysis of Data

The information gathered by questionnaire was examined by academic specialist, especially the School of Education, Pondicherry University. With the aid of excel was used to tabulate and methodically analysis the data, performing various operations such as translating the data into percentages and interpreted accordance with the study objectives.

ANALYSIS OF DATA AND INTERPRETATION OF RESULTS

Objective :To identify the number of Introverts and Extroverts in the sample of the study

The following table 2 and figure 1 show the number and percentage of introvert and extrovert in the sample distribution of Postgraduate Students pertaining to Gender. In above table 41.60% male and 30% female students were found to be extrovert. Additionally, the chart also reveals that 9.60% of female students and 18.80% of male students were introverted.

Objective: To study the motives of the Usage of Social Networking Sites among the Postgraduate Students.

The following tables show the number and percentage of extrovert and introvert students motivated the usage of social networking sites by postgraduate students. From the above table, SNWS was seen as a socializing tool by 18.43% of extrovert male students, compared to 22.9% of extrovert female students. Additionally, this study showed that 31.84% of extrovert female students agreed with male students that SNWS is a medium of enjoyment, compared to 39.66% of extrovert male students. This objective showed that, extrovert male students are 30.16% more supportive of learning than extrovert female students, who are 28.49% more supportive. Additionally, 14.52% of male extrovert students and 16.20 percent of female extrovert students expressed satisfaction with SNWS as a research medium. Therefore, the study's conclusions showed that the majority of students utilized SNWS entertainment.

According to the table 4,, SNWS was seen as a socializing tool by 26.76% of introverted male students and 11.26% of introverted female students. The research also showed that 25.35% of introverted female students agreed with male students that SNWS is a good source of entertainment, compared to 47.88% of introverted male students. Additionally, this goal showed that introverted male students are 47.88% more supportive of learning than introverted female students (25.35%). SNWS was favored as a research medium by 19.71% of male introvert students and 11.26% of female introvert students. Thus, the findings of the study revealed that majority of the students used for entertainment.

Objective: To study the awareness of Postgraduate Students pertaining to Usages of Social Networking Sites.

Extroverts Male and Female

The table number 5 found that 27.93% extrovert male students visit social networking sites with some specific purpose in mind, in contrast to 30.17% extrovert female students. Additionally, 24.58% extrovert male respondents have no specific purpose to use multiple SNWS and 17.32% extrovert female respondents have no purpose to visit social networking sites in their mind. Therefore, the result of the study shows that the majority of the extrovert students have specific purpose to use multiple social networking sites.

Introverts Male and Female

From the above table 5, 29.57%of introvert male students visits social networking sites with some specific purpose in mind, in comparison to 23.94% introvert female students. Additionally, 36.61% of introvert male respondents has no specific purpose to use multiple social networking sites and 9.85% of introvert female respondents also have no specific purpose to use multiple SNWS. Therefore the introvert students have certain specific purpose to use multiple social networking sites.

Extroverts Male and Female

From the table number 6, it was found that 31.84% of extrovert male sample have more Friends on SNWS than in real life in contrast to 17.87% extrovert female sample. Additionally, 26.25% of extrovert male respondents did not have more friends on SNWS than in real life, and 24.02% of extrovert female respondents did not male more friends on SNWS than in real life. Thus, the majority of the extrovert students make more friends on SNWS than in real life.

Introverts Male and Female

from the table 7, 23.94% male introvert students have more friends on SNWS than in real life in comparison to 12.67% introvert female students. Additionally, found that 42.25% of introvert male and 21.12% introvert female respondents did not have enough friends in SNWS but enough friends in real life situation.

Objective: To find out the Usage of Social Networking Sites in Teaching and Learning Process among the Postgraduate Students.

Extroverts Male and Female

By analyzing the data, it was revealed that 15.08% male extrovert students chose 'always' option of using SNWS in teaching-learning process as contract to 10.05% extrovert female students. Additionally, 5.58% extrovert male respondents and 1.11% female students supported 'never' option of SNWS in teaching-learning process. Additionally, 37.43% extrovert male respondents and 30.72% female respondents 'sometimes' as their choice of SNWS in teaching-learning process. So, result of the study is that the extrovert students use SNWS sometimes for teaching- learning process.

Introverts Male and Female

From the table number 7, 28.16% male introvert sample pick 'always' option for use of SNWS in teaching-learning process in contrast to 14.08% introvert female sample. Additionally, 5.63% of introvert male respondents' opinion to 'never 'use of SNWS in teaching-learning process and 0.0% of introvert female respondents. It was also found that 32.39% of introvert male respondents' to like 'sometimes' usage of SNWS in teaching-learning process and 19.71% of introvert female respondents also use of SNWS in teaching-learning process. Thus, result of the study showed that introvert students used of SNWS in teaching-learning process only 'sometimes'.

Extroverts Male and Female

By analyzing the from the table 8 data, 15.08% male extrovert students mentioned 'negative effect' of SNWS use on grades and performance in studies in contrast to 10.05% extrovert female students. It was found that 12.29% of extrovert male respondents' felt that there is 'no effect' of SNWS use on grades and performance in studies in comparison to 14.52% of extrovert female respondents. Additionally, 30.72% of extrovert male respondents' found 'positive effect 'of SNWS use on grades and performance in studies and 17.31% of extrovert female respondents found 'positive effect' of SNWS use on grades and performance in studies. Thus, the findings of the study revealed that majority of the extrovert students felt that there is 'positive effect' of SNWS use on grades and performance in studies.

Introverts Male and Female

From the table number 8, it was found that 8.45% of introvert male students mentioned 'negative effect' of SNWS use on grades and performance in studies in comparison to 4.22% introvert female sample. It was found that 18.30% of extrovert male respondents' felt that there is 'no effect' of SNWS use on grades and performance in studies in

comparison to 12.67% of extrovert female respondents. Additionally, 39.43% of extrovert male respondents' found 'positive effect 'of SNWS use on grades and performance in studies and 16.90% of extrovert female respondents found 'positive effect' of SNWS use on grades and performance in studies. Thus, the findings of the study revealed that majority of the extrovert students felt that there is 'positive effect' of SNWS use on grades and performance in studies.

Extroverts Male and Female

The table number 9 indicated that 40.78% of Male & 29.05% of Female extrovert students chose WhatsApp as the most appropriate SNWS for teaching-learning process. The findings revealed that 22.90% Male & 21.78% Female extrovert students identified YouTube as an important SNWS for teaching-learning process. It was also found that 18.43% Male & 7.26% Female extrovert students favored to use Facebook as the most appropriate SNWS for teaching-learning process. The data also shows that 11.73% Male & 7.26% Female extrovert students find Instagram as the most appropriate SNWS for teaching-learning process. The data analysis also brought to light that only 7.82% Male & 2.23% Female extrovert students find Twitter as appropriate for teaching-learning process. The findings of the study exposed that majority of the extrovert students preferred WhatsApp as the most appropriate SNWS for teaching-learning process.

Introverts Male and Female

The table number 10 indicated indicated that 49.29% of Male & 28.16% of Female introvert students chose WhatsApp as the most appropriate SNWS for teaching-learning process. The findings revealed that 22.53% Male & 19.71% Female introvert students identified YouTube as an important most appropriate SNWS for teaching-learning process. It was also found that 25.35% Male & 8.45% Female introvert students favored to use Facebook as the most appropriate SNWS for teaching-learning process. The data show that 19.71% Male & 8.45% Female introvert students find Instagram as the most appropriate SNWS for teaching-learning process. The data analysis also brought to light that only 8.45% Male & 4.22% Female introvert students find Twitter as appropriate for teaching-learning process. The findings of the study exposed that majority of the introvert students preferred WhatsApp as the most appropriate SNWS for teaching-learning process.

Objective: To study the effect of Usage of Social Networking Sites among the Postgraduate Students.

Extroverts Male and Female

The table number 11 found that found that 29.61% extrovert male students were ignoring homework/ daily activities due to usage of SNWS, in comparison to 18.99% extrovert female sample. It was also found that 28.49% extrovert male respondents were not ignoring homework/ daily activities because of SNWS while 22.90% extrovert female respondents were not ignoring homework/ daily activities because of SNWS. So, from the finding we can conclude that the majority of the student's especially male extroverts were ignoring homework/ daily activities because of using SNWS. While female extroverts were not ignoring homework / daily activities due to SNWS.

Introverts Male and Female

From the table number 11, it was found that 42.25% of introvert male sample are ignoring homework/ daily activities due to usage of SNWS, in comparison to 18.30% introvert female sample. It was also found that 23.94% of introvert male respondents did not ignore homework/ daily activities due to usage of SNWS and 15.49% of introvert female respondents also ignore homework/ daily activities due to use of SNWS. Thus, the finding shows that most of the introvert students are ignoring homework/ daily activities due to usage of SNWS.

Extroverts Male and Female

By analyzing the data, from the table number 12, 29.05% of extrovert male students are staying up late at night due to usage of SNWS in comparison to 16.76% extrovert female sample. It was also found that 29.05% of extrovert male respondents did not Staying up late at night due to usage of SNWS and 25.14% of extrovert female respondents also staying up late at night due to usage of SNWS. Thus, the findings of the study revealed that female extrovert students did not stay late night while male extrovert students show no pattern.

Introverts Male and Female

From the table number 12, it was found that 38.02% of introvert male sample are staying up late at night due to usage of SNWS, in comparison to 14.08% of introvert female sample. It was also found that 28.16% of introvert male respondents did not Staying up late at night due to usage of SNWS, and 19.71% of introvert female respondents also staying up late at night due to usage of SNWS. Thus, the findings of the study explored that majority of the introvert students are staying up late at night due to usage of SNWS.

CONCLUSION

With technological advancements worldwide, Higher Education Institutions benefit from digitalization, i.e. 'social networking sites'. The SNWS are the well-liked platforms and significantly used by one's higher education students. The students primarily use SNWS in their mobiles, which helps them to search for information, exchange notes or ideas, communicate with teachers, students and colleagues and share knowledge (Vrontis *et al.,* 2015). According to the findings of this study, social networking sites are beneficial to the majority of postgraduate students. The popularity of social networking sites like WhatsApp, Facebook, YouTube, Twitter, and LinkedIn was high. Among various types of SNWS, WhatsApp, Facebook and YouTube were usually the most used. In terms of search engine usage, it was discovered that majority of students use Google as their preferred search engine. Maximum postgraduate students use the WhatsApp site for the teaching-learning process. The survey discovered that SNWS had attracted many postgraduate students towards it. Students primarily used SNWS to communicate with classmates and maintain contact with friends. This investigation has revealed that although multiple students find their SNWS memberships necessary in their daily life, they are also familiar with its negative implication on their educational achievement.

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Table 1: Sample of the study

Gender	Number of the Students	Total
Male	151	151
Female	99	99
TOTAL	250	

Table 2: Number of Introverts and Extroverts in the sample

Respondents		Total	Number of Respondents	Percentage
Male	Extroverts	250	104	41.60
	Introverts		47	18.80
Female	Extroverts		75	30
	Introverts		24	9.60

Table 3: To motivate the Usage of SNWS– Extrovert Male and Female Students

Motives to Usage of SNWS			Percentage(%)	
	Male	Female	Male	Female
Socialization	33	41	18.43	22.90
Entertainment	71	57	39.66	31.84
Learning	54	51	30.16	28.49
Research	26	29	14.52	16.20

Table 4:To motivate the Usage of SNWS - Introvert Male and Female Students.

Motives to Usage SNWS	Number of Respondents		Percentage(%)	
	Male	Female	Male	Female
Socialization	19	8	26.76	11.16
Entertainment	34	18	47.88	25.35
Learning	34	18	47.88	25.35
Research	14	8	19.71	11.26

Table 5: Specific Purpose to usage of Multiple SNWS- Introverts and Extroverts Students

Respondents		Number of Respondents		Percentage(%)	
		Yes	No	Yes	No
Male	Extroverts	50	54	27.93	24.28
	Introverts	21	26	29.57	36.61
Female	Extroverts	44	31	30.17	17.32
	Introverts	17	7	23.94	9.85

Table 6: More Friends on SNWS than in real life- Extrovert and Introvert Students

Respondents		Number of Respondents		Percentage(%)	
		Yes	No	Yes	No
Male	Extroverts	57	47	31.84	26.25
	Introverts	17	30	23.94	42.25
Female	Extroverts	32	43	17.87	24.02
	Introverts	9	15	12.67	21.12

Table 7: Usage of SNWS in teaching and learning process- Extrovert and Introvert Students

Respondents		Number of Respondents			Percentage (%)		
		Always	Never	Some Times	Always	Never	Some Times
Male	Extroverts	27	10	67	15.08	5.58	37.43
	Introverts	20	4	23	28.16	5.63	32.39
Female	Extroverts	18	2	55	10.05	1.11	30.72
	Introverts	10	0	14	14.08	0.0	19.71

Table 8: Effect on Grades and Performance in Studies- Extrovert and Introvert Students.

Respondent		Number of Respondents			Percentage (%)		
		Negative Effect	No Effect	Positive Effect	Negative Effect	No Effect	Positive Effect
Male	Extroverts	27	22	55	15.08	12.29	30.72
	Introverts	6	13	28	8.45	18.30	39.43
Female	Extroverts	18	26	31	10.03	14.52	17.31
	Introverts	3	9	12	4.22	12.67	16.90

Table 9: Most appropriate SNWS for Teaching-Learning Process – Extroverts Students

Major Social Networking Site	Extrovert Respondents	Number of Respondents	Percentage (%)
WhatsApp	Male	73	40.78
	Female	52	29.05
You tube	Male	41	22.90
	Female	39	21.78
Facebook	Male	33	18.43
	Female	13	7.26
Instagram	Male	21	11.73
	Female	13	7.26
Twitter	Male	14	7.82
	Female	9	5.02
LinkedIn	Male	14	7.82
	Female	4	2.23
Other	Male	3	1.67
	Female	1	0.55

Table 10: Most appropriate SNWS for Teaching-Learning Process - Introverts Students.

Major Social Networking Site	Extrovert Respondents	Number of Respondents	Percentage (%)
WhatsApp	Male	35	49.29
	Female	20	28.16
You tube	Male	16	22.53
	Female	14	19.71
Facebook	Male	18	25.35
	Female	6	8.45
Instagram	Male	14	19.71
	Female	6	8.45
Twitter	Male	6	8.45
	Female	3	4.22
LinkedIn	Male	2	2.81
	Female	3	4.22
Other	Male	2	2.81
	Female	1	1.40

Table 11: Ignoring homework/daily activities due to Usage of SNWS-Extrovert and Introvert Students.

Respondents		Number of Respondents		Percentage (%)	
		Yes	No	Yes	No
Male	Extroverts	53	51	29.61	28.49
	Introverts	30	17	42.25	23.94
Female	Extroverts	34	41	18.99	22.90
	Introverts	13	11	18.30	15.49

Table 12: Staying up late at night due to usage of SNWS- Extrovert and Introvert Students.

Respondents		Number of Respondents		Percentage (%)	
		Yes	No	Yes	No
Male	Extroverts	52	52	29.05	29.05
	Introverts	27	20	38.02	28.16
Female	Extroverts	30	45	16.76	25.14
	Introverts	10	14	14.08	19.71

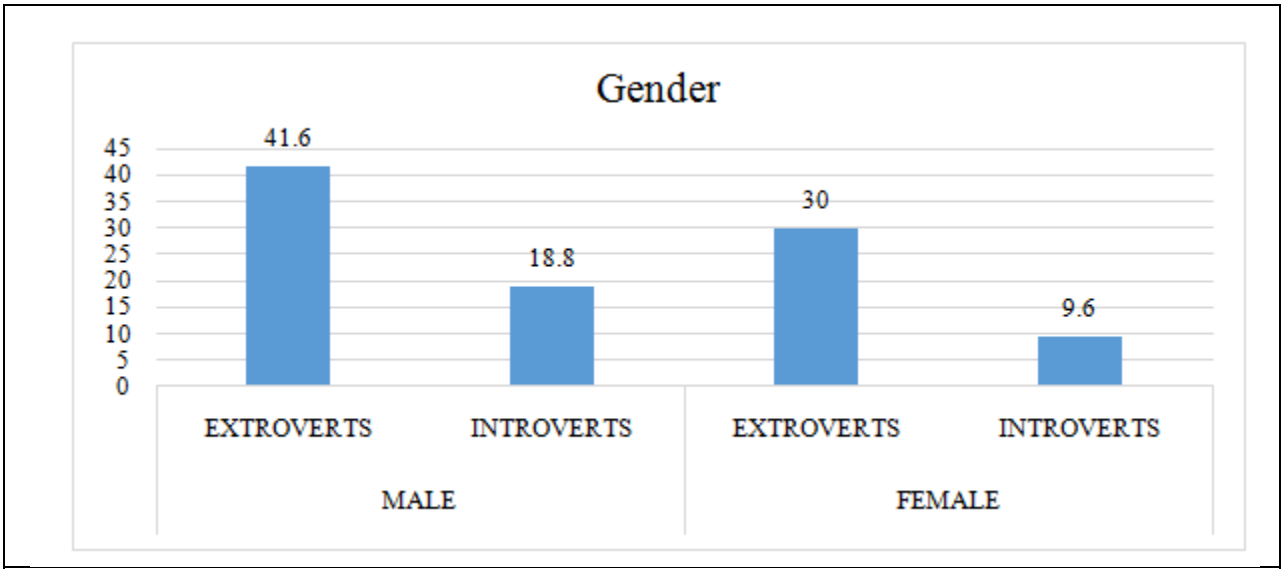


Figure:1 Number of Introverts and Extroverts in the sample

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RESEARCH ARTICLE

A Clinical Study to Assess the Effect of Selected *Yogaasanas* and *Shodhita Hingu* in prevention of Dysmenorrhea - An Open Label Double Arm Comparative Clinical Study

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ABSTRACT

Dysmenorrhea is the most common Gynecological disease in adolescent women with a prevalence of 60% to 93%. Primary dysmenorrhea refers to pain that is not associated with any identifiable pelvic pathology. It is characterized by pain in the lower abdomen that radiate to the thighs and lower back. Associated problems include nausea, vomiting, mood swings, headache, fatigue, constipation etc. Dysmenorrhea can be corelated with *Udavartini Yonivyapad* in Ayurveda. *Apana Vata Dushti* is considered as main cause for *Udavartini Yonivyapad*. *Hingu is Vatashamaka, Shoola Prashamana, Agnivardana* and *Vatanulomana* properties, mentioned in *Charaka Sutrasthana Annapanavidhi*[4]. *Yoga* means the control of thought waves in the mind.[5] *Yoga* is part of an ideal lifestyle for maintaining good health, balancing body and mind through yoga techniques such as asanas and it is also cost-effective treatment without side effects that can be practiced daily at their home. A Total of 60 subjects diagnosed with Primary Dysmenorrhea were selected from out- patient department (OPD) . Subjects who fulfill inclusion and diagnostic criteria were categorized into two groups each having 30 Subjects. Group A**:** Subjects were administered with *Shodhitha Hingu* capsules taken daily in empty stomach (morning) for 30 days. Group B: Subjects were administered with *Shodhitha Hingu* capsules along with *Yogasanas* daily morning for 30 days. The data were collected on 0th, 30th, 60th and 90th day of intervention. The obtained data were analyzed statistically. Overall, within the group in Group-A and Group-B there was significant difference between before and after treatment in all the variables with $p<0.05$. When two groups were compared all the variables shown statistically significant difference between two groups ($p<0.05$) and the mean difference of group B was more than group A. Therefore, Group B has more

statistically significant result in the prevention of Dysmenorrhea. In the present study both the groups have shown statistically significant results. But Group B was statistically more significant when compared to Group A in the management of *Primary Dysmenorrhea*

Keywords: Dysmenorrhea, *Udawarthini, Shodhitha hingu, Yogasanas*

INTRODUCTION

God created woman in such a way that she has the capacity twice that of a man in taking food, four times that of a man in taking decisions with her subtle intelligence, six times that of a man in exertional work and eight times that of a man in getting her desires full filled. This *Subhashita* conveys dynamic charisma of women in dealing her social life [1]. The adolescents are the promising stars of a nation; hence their physical and psychological health is important for a brilliant future. Menstruation is one of the important events in the life of adolescent girls. It is also important indicator of women's reproductive health also [2]. The menstrual cycle is a sequence of events that occurs once in a month in a sexually mature female. Painful menstruation is called as dysmenorrheal [3] which is most common in adolescent girls. More than 70% of teenagers are suffering from dysmenorrhoea [4]. Higher incidences of dysmenorrhea among adolescent girls are common due to stressful life style, depression, anxiety, intake of junk foods, lack of exercise, tight exam schedules, and influence of social media [5]. Dysmenorrhea classified as primary dysmenorrhea and secondary dysmenorrheal [6]. Primary dysmenorrhea is defined as pain which begins in association with menstrual bleeding [7]. Secondary dysmenorrhea means painful menstruation with pelvic pathology [8]. Associated symptoms of dysmenorrhea include nausea, vomiting. diarrhea, stress, anxiety and depression [9]. Prevalence is highly variable, underestimated and at the same time difficult to determine, because a few affected women seek medical treatment, despite the distress experienced, as many consider the pain to be a normal part of the menstrual cycle rather than a disorder (Wong, 2010) [10]. Many cases thus remain un documented (Gould, 1998; Jones, 2004; Chen et al., 2006; Daley,2008) [11]. Due to the different definitions of the condition, and the lack of standard methods for assessing severity of dysmenorrhea, prevalence estimates vary between 45 and 95% of menstruating women (Jamieson and Steege, 1996; Proctor and Farquhar, 2006; Unsal *et al.*, 2010) [12], with very severe primary dysmenorrhea estimated to affect 10–25% of women of reproductive age (Andersch and Milsom, 1982; Dawood, 1987; Sundell *et al*.,1990; Hofmeyr, 1996) [13]. As per WHO records prevalence was 38.1% in 2005 [14]. In India young adults 17-24 years with higher prevalence range of 84.2% in 2015 [15]. In Mangalore district of Karnataka state, 89.96% suffering from physical and 55.71% are from psychological premenstrual symptoms [16].

Another report says in India 79.67% suffer from mild form of dysmenorrhea and 37% suffer regularly from severe dysmenorrhea or pain that prevent them from ensuing day-to-day activities [17]. Dysmenorrhea itself is not life threatening, but is found to have a profound impact on the daily activities and may result in missing work or school, inability to participate in sports or other activities [18]. Thereby, it may accentuate the emotional distress because of the pain. Pain is body's most important alarm system. It is characterized by fluctuating, spasmodic menstrual cramps sometimes referred to as "labor-like" pains [19] that begin only a few hours before or with the onset of menstrual flow, the symptoms of primary dysmenorrhea last only 2–3 days [20]. Dysmenorrhea is not merely a disorder noticeable during menstruation, particularly with regard to pain processing and the perception of pain [21]. It is feasible that recurrent menstrual pain not only associated with central sensitization, but also may predispose women with primary dysmenorrhea to other chronic painful conditions [22]. Limiting the noxious input into the CNS of dysmenorrhea women therefore seems imperative to prevent the possible development of central sensitization, as well as any potential progression of repetitive dysmenorrhea into other chronic pain conditions [23]. *Vata* is responsible for pain. Among the five types of *Vayu*, *Apana Vayu* is given prime importance in gynecological disorders [24]. *Udavartha*, is a gynecological condition caused by impairment of *Apana Vayu*, which has similarities with the symptoms of primary dysmenorrheal [25]. Both conditions have pain as their main symptom. The treatment choosen in the modern system of medicine, such as analgesics, antispasmodics, NSAIDs,[26] anti-prostaglandin drugs and sedatives, can cause complications such as nausea, breast tenderness and intermenstrual bleeding, dizziness,

drowsiness, hearing and vision disorders. The treatment chosen in classical texts include *snehana, swedana* and *basthi* are very difficult for monthly prevention of *udavartha*. Considering the above problems, a better alternative treatment is proposed. In Ayurvedic texts, *Acharyas* have mentioned *Shodhitha Hingu* [27], *Tila kwatha, Sapthasara kwatha* etc. for the treatment of *vathaja yoni rogas* like *udavartha*. *Shodhitha Hingu* is *Vatashamaka, Shoola Prashamana, Agnivardana* and *Vatanulomana* [28] *so* useful in reducing the physical discomfort during menstruation and the psychological discomfort of primary dysmenorrhea can be addressed with yoga. Yoga is a part of an ideal lifestyle and it harmonizes the body with the mind through the means of various yoga techniques like *Asanas. Yogaasanas* like *pavanamukthasana, Bhujangasana, Bhadrasana* effectively targets the affected area of the body by providing long- lasting and immediate relief from the menstrual pain [29]. Yoga being safe, cost effective coupled with high standards of preventive and curative efficacy, can be recommended to all teenagers [30] *Shodhitha Hingu* & *Pavanamukthasana*, *Bhujangasana*, *Bhadrasana* were selected on the basis of *vatashamaka, yonishoola prashamana* and *vataanulomana* properties. The high incidence of the ailment and elevated degree of distress it creates in adolescents and also the limited success of modern medicines, with added disadvantages of side effects has been potential contributory factor in taking up this study.

Objectives of the study

- To assess the effect of *Shodhita Hingu* in Dysmenorrhea.
- To assess the effect of selected *Yogasanas* along with *Shodhita Hingu* in Dysmenorrhea
- To compare the effect of *Shodhita Hingu and* selected *Yogasanas* along with *Shodhita Hingu* in the prevention of Dysmenorrhea.

MATERIALS AND METHODOLOGY

The study was registered in CTRI with No-CTRI/2023/08/057139

Source of data: Female patients who were diagnosed to be suffering from Primary Dysmenorrhea and came under the inclusion criteria were selected from the OPD and IPD, as well as from medical camps and other referrals.

Study design

Randomized open labelled interventional comparative clinical study.

Sample size

60 female subjects diagnosed with Primary Dysmenorrhea were allocated into 2 groups. Group A- 30 subjects and Group B -30 subjects.

Selection criteria

The subjects who fulfill the inclusion criteria and complying with informed consent were selected.

Diagnostic criteria

Subjects fulfilling any 2 of the following diagnostic criteria were selected for the study, irrespective of associated symptoms·

1. Painful menstruation which begins before one or two days of menstruation with onset of menstruation and lasting for 24 to 48 hours.
2. Painful menstruation with pain in the lower abdomen and supra-pubic region.
3. Painful menstruation which is radiating to the thigh and lower back. Associated symptoms such as headache, nausea, Vomiting, altered bowel habits, giddiness etc. *Prathyathma Lakshanas* of *Udavarthini Yonivyapad-Rajah Kricchrata* (Painful menstruation)

Inclusion criteria

Subjects fulfilling the diagnostic criteria., Age between 18-28 years, Known case of Dysmenorrhea for 4 consecutive cycles **and** Subjects with regular menstrual cycles.

Exclusion criteria

Known case of Secondary Dysmenorrhea, Subjects on hormonal therapy **and** Subjects who are not willing to do *Yoga*

Assessment criteria

Subjects were assessed on 0th day, 30th day, 60th day and 90th day by using following scales: Assessment was done on subjective parameters before and after the treatment based on, Onset of pain, Site of pain, Severity of Pain, Duration of pain and Visual analogue Scale (VAS Scale). Along with associated complaints like Nausea, Headache, Vomiting, Diarrhoea, Constipation

Method of collection of data

A special perform a was prepared with all points of history taking, signs and symptoms. The data were collected on 0th day, 30th day, 60th day and 90th day of intervention. The Collected data were analyzed using SPSS Software Version 21.0

Intervention

Group A - After taking informed consent, *Shodhitha Hingu* was told to take everyday morning in empty stomach or with first bolus of food. Dose:250mg

Group B - Along with *Shodhitha Hingu* subjects were advised to practice *yogasanas* for 30 days. *Pawanamuktasana, Bhadrasana, Bhujangasana* were thought to the subjects to practice throughout the 30 days of intervention period.

HINGU SHODHANA

The *hingu* has been fried in ghee(q.s) until it gets solid and dry [145]

Yogasanas* practiced in this study - *PAVANA MUKTHASANA-The name comes from the Sanskrit words Pavana means wind, Muktha means relieve and Asana means posture. It massages the abdomen and digestive organs and is thus very effective in Apana *Vayu Vaigunya* and constipation by massaging the pelvic muscles and reproductive organs.

BADRASANA

Bhadra means gracious and blessed according to *Hatayoga Pradeepika* and *Gheranda Samhita* this asana will destroy all diseases, relieves fatigue and tones Reproductive organs.

BHUJANGASANA

This asana is also called as the Serpent-posture. This always increases the bodily heat, destroys all diseases, and by the practice of this posture the serpent-Goddess (the *Kundalini* force) awakes. When the subject got menstruation the medication and *yogasana* practice was stopped.

RESULTS

The collected data was entered into Microsoft Excel sheet and then it was entered in SPSS Version 21.0.0 for statistical analysis. For the assessment of results, parameters such as VAS Score, duration of pain, nausea, vomiting, headache, diarrhea, constipation, onset of pain, and severity of pain were considered. Evaluations were conducted across four intervals: from Day 0 to Day 30 (intervention period), Day 30 to Day 60, Day 60 to Day 90, and a cumulative assessment from Day 0 to Day 90. The assessments on Days 60 and 90 served as follow-up evaluations.

Comparisons within a group

The Wilcoxon signed rank test was applied to compare any two sessions within the same group. It assessed whether there was a significant difference between these sessions.

Comparisons between groups

The Mann Whitney U Test was applied to compare data between different groups. It assessed whether there was a significant difference between these groups.

Representation and Significance

Observational data was visually represented using Bar Charts. The trend of each variable over time was illustrated using Line Diagrams. The Level of Significance was established as $p<0.001$ and $p<0.01$ to indicate statistically highly significant (H.S) results, $p<0.05$ to indicate significant results and $p>0.05$ to indicate non-significant (N.S) results.

Comparison in between the groups

Mann Whitney U Test to Compare between Groups of Variables on 30th Day

Table no 1 suggest that there were no statistically significant differences between Group A and Group B on the 30th day for any of the parameters assessed.

Mann Whitney U Test to Compare between Groups of Variables on 60th Day

Table no 2 shows significant differences between Group A and Group B were found on the 60th day for VAS Score, Duration of Pain, Diarrhea, Onset of Pain, and Severity of Pain, while other parameters showed no significant differences.

Mann Whitney U Test to Compare between Groups of Variables on 90th Day

Table no 3 represents significant differences between Group A and Group B were observed on the 90th day for VAS Score, Duration of Pain, Headache, Onset of Pain, and Severity of Pain, while other parameters showed no significant differences.

Overall Mean Change Assessment for Group A and Group B (table 4)

Group A demonstrated substantial improvements across multiple parameters from the 0th to the 30th day, with notable reductions in pain, nausea, vomiting, and constipation. The most significant change in the initial period was observed in nausea and vomiting, with reductions of 95.52% and 92.50%, respectively. Pain-related parameters like VAS score, duration of pain, and severity of pain also showed significant reductions, with changes of 58.82%, 82.13%, and 80.42%, respectively. However, after the 30th day, the improvement slowed down, with some parameters like VAS score and severity of pain showing no further change by the 90th day. A minor increase in headache (17.64%) was observed, and there was a modest improvement in diarrhoea (30.0%) by the end of the study.

Group B showed slightly better results in several parameters during the initial period, such as a 67.15% reduction in VAS score and 87.72% in headache by the 30th day. Nausea and vomiting were completely resolved by the 30th day, with a 100% improvement. Group B also exhibited sustained improvements across the study duration in key parameters like VAS score, duration of pain, headache, and diarrhoea. Even though the pace of improvement slowed between the 60th and 90th days, Group B continued to show consistent changes, especially in pain parameters and digestive symptoms. For instance, there was still a 46.52% reduction in the VAS score, 77.19% in headache, and 78.33% in diarrhoea by the 90th day.

DISCUSSION

In present study subjects were happy to practice only 3 *asanas* rather practicing so many numbers of *asanas* and *pranayamas* as there in previous studies. so, we can consider that this protocol is more convenient to the subjects to carry out *yogasana* practice for longer duration in their busy schedule also. Majority of the subjects were use to take analgesics (Tab. Meftal spas-for pain) during this treatment they completely reduced taking analgesics. *Hingu* helped them in reducing pain. *Pitta prakriti* predominant subjects experienced slight burning sensation after intake of medication.It may be due to the *ushna, theekshna* property of *Hingu* . Studies were conducted on some ayurvedic formulations like *Hinguvachadi churna, Rajapravarthini vati* where *hingu* is one of the components the probable mode of action in their study has mentioned that *Hingu* has *Shoolahara* and *Vatanulomana* property which helps in normalizing the function of *Apana vata,* which is main causative factor of *Udawartini*. *Hingu* has anti-flatulent and digestive properties & counteracts spasmodic disorders and may probably supress the secretion of progesterone hormone as the gum resin contains the coumarins, 5-hydroxy-umbelliprenin, as safoetidin etc [31] Studies have proved that the yogasanas are helpful in Dysmenorrhea by improving blood supply to pelvic and abdomen area, and also improves quality of life in females [32] The Probable mode of action of Hingu in Primary Dysmenorrhea are *Ruksha, Sheeta and Shushkaaharas, anashana, adhyashana, vishamashana*etc will lead to improper formation of *rasadhatu* and ultimately *Artavadushti* which resulting in *Kashtartava*/*Udawarthini* [33]. Whatever may be the *nidhana,* finally leads to *vilomagathi* of *Apana vayu,* leads to *vilomagathi*of *rajas* that cause discharging of menstrual blood with difficulty which leading to pain. So, the time of administration of *Hingu* was selected as before food, because *Vagbhata* has mentioned "*Apane vigune annadhou*" [34] *Shodhithahingu*acts on all the 3 *doshas*. (*Hingu-vatakaphahara*) It is purified with *Gritha* (*Pittahara*) Prostaglandins play a key role in the generation of inflammatory response. Their biosynthesis is significantly increased in inflamed tissue and they contribute to the development of the cardinal signs and symptoms of acute inflammation leading to pain during menstruation . hingu acts as Anti-inflammatory drug as it pocesses α-pinene; azulene; β-pinene; ferulic-acid; isopimpinellin; luteolin; umbelliferone [35]Hingu also processes Anti prostaglandine chemical- umbelliferone [36] Mainly affected *dosha* in *Udawartini yonivyapath* is *Vata,* [37] *Hingu* processes *vatahara*, *anulomana* properties it corrects *gathi*of *vata*and helps in easy flow of menstrual blood and reduces pain. *Hingu* was purified and made *Shuddha* by frying it with *Ghrita* [38]. *Shuddha Hingu (*purified*Ferulaasafoetida Linn*) was selected in this study because *Shuddha Hingu*pocesses beneficial property such as *Artavajanaka* (inducing menstruation)[39]. Ferutinin is one among the components of *Hingu*that has phytoestrogenic property [40].

Charaka has explained the qualities of *Hingu*as "*Hingu shola prashamanam vidhyaath paachanam rochanam*", since the gum resin of Ferulaasafoetida Linn, was helpful in reducing the colicky pain (*Shoolaprashamanam*), carminative (*Paachana*) and also palatable (*Rochana*) [41. *Hingu* helps in serotonin modulation by influencing serotonin levels regulates nausea and vomiting [42]. Deepana-*pachana* action of *hingu* also helps in this condition. Improves digestion, absorption and assimilation of nutrients by digesting Ama reduces inflammation. *Hingu* also processes anti spasmodic property as it contains chemical like Azulene; ferulic-acid; luteolin; umbelliferone; valeric-acid α-terpineol; azulene; β-pinene helps in reducing painful menstruation [43]. Acc to *Raja Nighantu Hingu* is *Vibandha nashana* hence, it helps in relieving constipation [44]. The Probable mode of action of *Yogasanas* are Dysmenorrhea often significantly reduces the quality of women's life. Yogasanas helps to Reduces stress and anxiety [45]. Myometrial hyperactivity, decreased uterine blood flow, and tissue ischemia are all caused by an increase in vasoactive prostanoids, which can result in pain or dysmenorrhea throughout the menstrual cycle. It is well known that yoga and pelvic asanas enhance blood flow in the pelvic area, which helps to alleviate bodily pain [46]. Further yoga poses also promote the release of beta-endorphins, which have analgesic properties [47]. In addition the research has demonstrated that yoga poses can assist regulate healthy bodily functions by releasing hormones such as cortisol, glucose, plasma's renin, epinephrine, and norepinephrine into the bloodstream. Numerous yoga interventions have used the voluntary breathing control strategy to reduce autonomic reactivity [48]. In addition, yoga reduces sympathetic activity through the hypothalamic-pituitary-adrenal axis, which is a significant factor in pain management. In addition to relieving pain associated with dysmenorrhea, deep breathing and prolonged exhalation relax the body's skeletal muscles, particularly those in the pelvic regionand also contribute to pain

reduction [49] in dysmenorrhea. Research indicates that *yogasana* practice positively affects the control of alpha brain waves, which are involved in pain alleviation, relaxation, and serotonin release [50] Yoga poses assist control weight and improve physical fitness since one long-term study found that being overweight was a one of the risk factors for both the possibility of experiencing dysmenorrhea and the duration of suffering [51]. Reduced dysmenorrhea and a healthy menstrual cycle have been linked to improved body circulation and sound physical and mental health [52]. Yoga postures are reasonable and may be performed at home as a kind of exercise to enhance one's quality of life and support menstruation health [53]. In this condition, *Yogasanas* has three different effects: it increases flexibility, promotes relaxation, and balances the actions of the sympathetic and parasympathetic nerve systems. In addition to increasing blood flow to the pelvic organs, these asanas also enhances oxygen flow, which relieves muscle hypoxia, one of the main causes of cramps in primary dysmenorrhea. The soothing impact of *pavanamukthasana, bhadrasana* and *bhujangasana* on the mind can be attributed to a decrease in both internal and external environmental cues as well as a general decrease in brain activation. Depression and anxiety are reduced as a result. *Pavanamukthasana, bhadrasana* and *bhujangasana* practice increases muscular strength and flexibility, which facilitates diaphragmatic breathing, which relieves tension in the body and mind [54]. A different strategy for treating menstrual cramps must address the underlying issue and effectively relieve discomfort. Reducing stress can help us avoid holding tension in our pelvis and low back, which can exacerbate period cramps. Looking for aggravating elements in diet, lifestyle, and emotional environment allows us to properly focus on a holistic approach, as we are dealing with a functional problem rather than a disease state that is producing pain. In order to prevent menstrual cramps, dietary concepts stress eating a healthy diet that eliminates junk food and saturated fats and increases whole grains, fruits, and vegetables, which give a variety of nutrients. The uterus's blood flow and metabolism will increase during active stretching activity, which may be useful in the decrease of Dysmenorrheal symptoms [55].

CONCLUSION

Shodhitha Hingu along with selected *Yogasanas* are effective in relieving the pain in dysmenorrhea and prevention of dysmenorrhea episodes.

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Table 1-Mann Whitney U Test to Compare between Groups of Variables on 30th Day

Parameters assessed on 30th Day	Z value	Mann Whitney U Value	p Value between group	Result
VAS Score	-0.918	397.00	0.358	NS
Duration of Pain	-0.779	405.00	0.436	NS
Nausea	-1.000	435.00	0.317	NS
Vomiting	-1.000	435.00	0.317	NS
Headache	-1.426	420.00	0.154	NS
Diarrhea	-1.426	420.00	0.154	NS
Constipation	-0.687	420.00	0.492	NS
Onset of Pain	-0.409	426.00	0.682	NS
Severity of Pain	-0.918	397.00	0.358	NS

Table 2-Mann Whitney U Test to Compare between Groups of Variables on 60th Day:

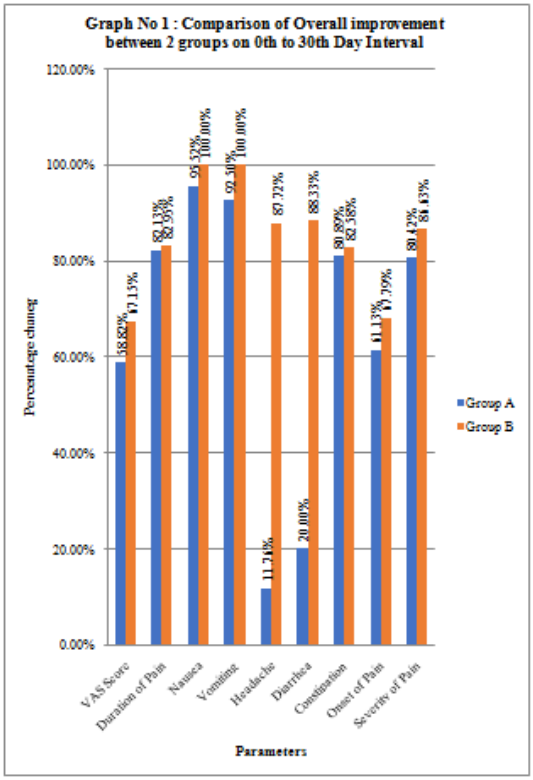
Parameters assessed on 60th Day	Z value	Mann Whitney U Value	p Value between group	Result
VAS Score	-3.809	207.00	0.000	HS
Duration of Pain	-5.115	141.50	0.000	HS
Nausea	-0.587	435.00	0.557	NS
Vomiting	0.000	450.00	1.000	NS
Headache	-1.762	405.00	0.078	NS
Diarrhea	-2.316	375.00	0.021	S
Constipation	-1.810	351.00	0.070	NS
Onset of Pain	-2.340	136.50	0.019	S
Severity of Pain	-3.651	218.50	0.000	HS

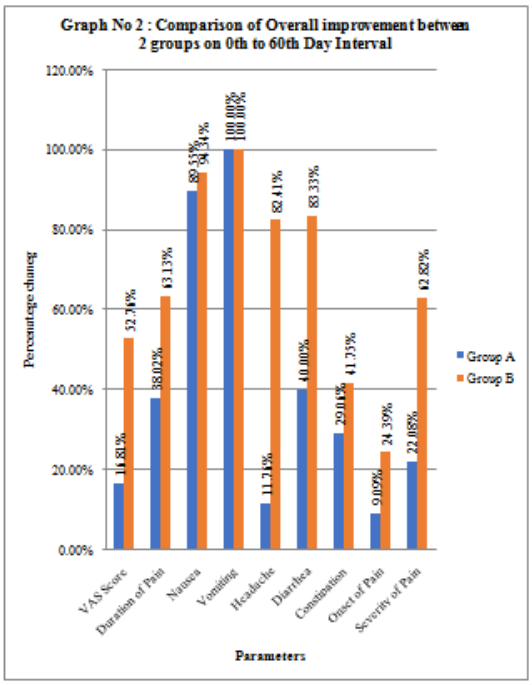
Table 3-Mann Whitney U Test to Compare between Groups of Variables on 90th Day

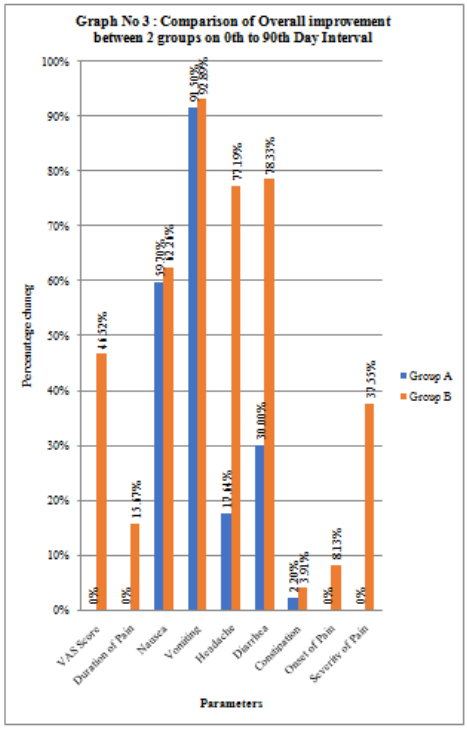
Parameters assessed on 90th Day	Z value	Mann Whitney U Value	p Value between group	Result
VAS Score	-4.281	170.00	0.000	HS
Duration of Pain	-4.839	156.50	0.000	HS
Nausea	-0.605	420.00	0.545	NS
Vomiting	0.000	450.00	1.000	NS
Headache	-3.435	300.00	0.001	HS
Diarrhea	-1.793	375.00	0.073	NS
Constipation	-0.986	390.00	0.324	NS
Onset of Pain	-3.188	270.00	0.001	HS
Severity of Pain	-2.461	293.00	0.014	S

Table 4: Overall Mean Change assessment of Parameters

Parameters	Mean % Change					
	0th – 30th Day		0th – 60th Day		0th – 90th Day	
	Group A	Group B	Group A	Group B	Group A	Group B
VAS Score	58.82%	67.15%	16.81%	52.76%	0%	46.52%
Duration of Pain	82.13%	82.95%	38.02%	63.13%	0%	15.67%
Nausea	95.52%	100.0%	89.55%	94.34%	59.70%	62.26%
Vomiting	92.50%	100.0%	100.0%	100.0%	91.50%	92.89%
Headache	11.76%	87.72%	11.76%	82.41%	17.64%	77.19%
Diarrhea	20.0%	88.33%	40.0%	83.33%	30.0%	78.33%
Constipation	80.89%	82.58%	29.06%	41.75%	2.20%	3.91%
Onset of Pain	61.13%	67.79%	9.09%	24.39%	0%	8.13%
Severity of Pain	80.42%	86.63%	22.08%	62.82%	0%	37.55%




Graph No 2 : Comparison of Overall improvement between 2 groups on 0th to 60th Day Interval
Percentage change
120.00%
100.00%
80.00%
60.00%
40.00%
20.00%
0.00%
16.81%
52.76%
38.02%
63.13%
89.53%
94.74%
100.00%
100.00%
11.71%
82.41%
40.00%
83.33%
29.01%
41.75%
9.09%
24.39%
22.08%
62.82%
VAS Score
Duration of Pain
Nausea
Vomiting
Headache
Diarrhea
Constipation
Onset of Pain
Severity of Pain
Parameters
Group A
Group B


Graph No 3 : Comparison of Overall improvement between 2 groups on 0th to 90th Day Interval
Percentage change
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0%
44.52%
0%
15.47%
59.70%
62.24%
91.30%
92.86%
17.44%
77.19%
30.00%
78.33%
2.20%
3.91%
0%
8.13%
0%
37.53%
VAS Score
Duration of Pain
Nausea
Vomiting
Headache
Diarrhea
Constipation
Onset of Pain
Severity of Pain
Parameters
Group A
Group B

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RESEARCH ARTICLE

Utilization of the Berg Balance Scale (BBS) among Physiotherapists Treating Community-Dwelling Stroke Patients in Kamrup, Assam: A Cross-Sectional Study

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ABSTRACT

Stroke is a prevalent neurological condition that significantly impacts individuals' functional abilities, particularly their balance and mobility. Stroke often results in significant impairment of proprioception, which is the sensation of body position and movement in space, leading to difficulties with motor coordination and balance. Physiotherapists play a pivotal role in the rehabilitation of community-dwelling stroke patients, employing outcome measures to assess and monitor treatment efficacy. This research examines physiotherapists' attitudes towards using the Berg Balance Scale in rehabilitating stroke patients in Kamrup, Assam. It highlights the importance of standardized outcome measures in stroke rehab. This research aims to identify the physiotherapists' demographic factors that influence the use of the Berg Balance Scale (BBS) and provide recommendations to improve the implementation of standardized outcome measures in stroke rehabilitation practices in Kamrup, Assam.

Keywords: Balance, Berg Balance Scale (BBS),Community, Outcome measure, Stroke,

INTRODUCTION

Impairments and varied limitations in motor, sensory, mental, perceptual, and linguistic functions are evident following a stroke. Stroke is the second leading cause of death and a major contributor to disability worldwide [1].In India, the Indian Global Burden of Disease Study 1990-2019 estimated that stroke was the largest contributor to disability adjusted life years (DALYs), and a chief contributor to deaths caused by neurological disorders [2] . Balance

impairment is a common consequence of a stroke, greatly impeding individuals' engagement in daily activities, social interactions, leisure pursuits, and their ability to resume work[3]To continue being physically engaged in life, balancing function must be maintained .Among the variables contributing to balance distortion in these patients are a decline in muscular strength and proprioception, an increase in postural oscillation, and an increased load on non-paretic extremities [4,5].The Berg Balance Scale (BBS) is one of the most widely used and recognized balance measures[6,7,8] The BBS is a 14-item measure that uses direct performance observation to objectively evaluate older person in community-dwelling adults for their balance and fall risk. The scale requires 10 to 20 minutes to complete and measures the patient's ability to maintain balance—either statically or while performing various functional movements—for a specified duration of time [9,10]. The items are scored from 0 to 4, with a score of 0 representing an inability to complete the task and a score of 4 representing independent item completion. A global score is calculated out of 56 possible points. Scores of 0 to 20 represent balance impairment, 21 to 40 represent acceptable balance, and 41 to 56 represent good balance [3]. Since a patient's gait and ability to execute ADLs independently are most affected by their lack of postural control, prompt and effective therapy intervention is necessary. Van der Putten et al. (1999) pointed out that measuring the outcome of health care is a "central component of determining therapeutic effectiveness"

Aim of the study

The use of standardized outcome measures in rehabilitating community-dwelling stroke patients is important**.** This study aims to explore the opinions of practicing physiotherapists on the using of the BBS for the rehabilitation of community-dwelling stroke patients. Although there have been limited reviews on this topic, no similar studies have been conducted in Kamrup, Assam.

The purposes of this study

The study's findings aimed to inform evidence-based practice guidelines and support the standardization of balance assessment protocols for stroke patients in the region. It sought to explore the frequency and contexts in which physiotherapists in Kamrup utilized the BBS for community-dwelling stroke patients, including variations in usage influenced by demographic factors.

METHODOLOGY

Study Design and Setting

This cross sectional study was conducted in Kamrup, Assam, over a three-month period from October 2022 to December 2022, utilizing a purposive sampling technique. Ethical approval was obtained from the Ethical Committee of Assam down town University (AdtU/Ethics/PhD Scholar/2021/063). The study employed a mixed-methods approach, combining quantitative surveys with qualitative interviews to collect comprehensive data on BBS usage. Physiotherapists from various healthcare settings in Kamrup were recruited to participate, ensuring a diverse representation of clinical experiences.

Participants

A purposive sampling technique was used to select participants, consisting of 104 physiotherapists, out of which 65 met the inclusion criteria. The study included practicing physiotherapists in Kamrup who are actively engaged in the rehabilitation of stroke patients. Excluded from the study were physiotherapy interns and those not currently involved in treating stroke patients.

Data Measurement

This study used a set of validated self-administered questionnaire with two sections. The first section gathered socio-demographic information of physiotherapists, while the second section addressed research questions regarding the Berg Balance Scale (BBS). The questionnaire was validated through a pilot study of 5 senior physiotherapists(2

Academician and 3 Clinician) in Assam, who demonstrated high reliability with a Cronbach's alpha coefficient of 0.786 and a Content Validity Index (r=0.38).

Data Collection Procedure

Data were collected using a Google Form questionnaire, which facilitated efficient data collection due to its online format. The questionnaire was disseminated through email, WhatsApp numbers, and physiotherapist WhatsApp groups to reach the targeted sample. Physiotherapists were encouraged to respond at their convenience, ensuring a broad and diverse participation among the targeted physiotherapy professionals in the specified region. Most respondents (41) strongly agreed with the statement that BBS was the mostly used standardized Scale to assess balance in Stroke patients by Physiotherapists, while 23 agreed, and only 1 remained neutral. Gender distribution indicates that a higher percentage of females (65% Agree, 61% Strongly Agree) favour the BBS compared to males (35% Agree, 39% Strongly Agree). Age-wise, younger physiotherapists (≤30 years) predominantly agreed (61%) and strongly agreed (44%), whereas those aged 31-35 showed a higher strong agreement (41%). Educational qualifications reveal that postgraduates (PG) most strongly agreed (51%), while PhD/PhD scholars and undergraduates (UG) showed varied agreement levels. Professional settings reflect a significant presence of teaching institute professionals who both agreed (65%) and strongly agreed (56%). In terms of practice location, urban settings had the highest agreement (65% Agree, 61% Strongly Agree). Experience in treating stroke patients varied, with a notable strong agreement among those with more than five years of experience (34%). The p-values indicate no significant statistical differences across these characteristics (p-values ranging from 0.16 to 0.57). Gender distribution shows no significant difference in preferences between females and males ($p = 0.91$), indicating similar levels of agreement across genders. However, age groups ($p = 0.043$) exhibit statistically significant differences in preferences. Physiotherapists aged 31-35 years show lower agreement compared to those aged <=30 and 36-40 years, suggesting varying preferences based on age. Educational qualifications ($p = 0.89$) demonstrate uniform preferences across PhD/PhD scholars, PG, and UG categories, indicating that educational background does not significantly influence the preference for using BBS.

Similarly, professional setting ($p = 0.27$) and practice locations ($p = 0.25$) show no significant differences in preferences across various settings and locations. Experience in treating stroke populations ($p = 0.38$) also reveals no significant differences in preferences across different experience levels, suggesting that varying levels of experience do not significantly impact the preference for using BBS as a balance measurement tool. Overall, the data suggests a general consensus among physiotherapists that the Berg Balance Scale is preferred for measuring balance in stroke patients, with consistent preferences across different demographic categories surveyed. These findings highlight the scale's perceived utility and acceptance across diverse age groups and professional backgrounds within the field of physiotherapy. Gender distribution shows a trend towards higher agreement levels among females compared to males, though this difference is not statistically significant ($p = 0.26$). Age groups ($p = 0.24$) exhibit varied perceptions without statistical significance, indicating consistent views across different age brackets. Educational qualifications ($p = 0.36$) demonstrate varied perceptions across PhD/PhD scholars, PG, and UG categories, with slightly higher agreement levels among PG and PhD/PhD scholars. Professional setting ($p = 0.43$) and practice locations ($p = 0.32$) also show varied perceptions across different settings and locations, with higher agreement levels generally observed in teaching institutes and urban areas. Experience in treating stroke populations ($p = 0.89$) reveals no significant differences in perceptions across different experience levels, suggesting that varying levels of experience do not significantly influence the perceived effectiveness of BBS in differentiating static and dynamic stability in stroke patients. Overall, the data suggests a strong consensus among physiotherapists that the Berg Balance Scale is effective in differentiating static and dynamic stability in stroke patients, with consistent perceptions across different demographic and professional categories surveyed. These findings underscore the scale's perceived utility and integration into clinical practice across diverse settings within the field of physiotherapy. Gender distribution shows a trend towards higher agreement levels among both females and males, with no statistically significant difference ($p = 0.80$). Age groups ($p = 0.79$) exhibit varied perceptions without statistical significance, indicating consistent views across different age brackets. Educational qualifications ($p = 0.89$) demonstrate uniform perceptions across PhD/PhD scholars, PG, and UG categories, suggesting that educational background does not significantly influence opinions on the effectiveness of BBS in identifying balance issues in stroke patients. Professional setting ($p = 0.71$) and practice

locations (p = 0.93) also show no significant differences in perceptions across various settings and locations. Experience in treating stroke populations (p = 0.57) reveals no significant differences in perceptions across different experience levels, indicating that varying levels of experience do not significantly impact the perceived effectiveness of BBS in assessing balance issues. Overall, the data suggests a strong consensus among physiotherapists that the Berg Balance Scale is effective in assessing and identifying specific balance issues in stroke patients, with consistent perceptions across different demographic and professional categories surveyed. These findings highlight the scale's perceived utility and integration into clinical practice across diverse settings and experience levels within the field of physiotherapy. Gender distribution shows a balanced perception between females and males, with no statistically significant difference (p = 0.78). Age groups (p = 0.52) exhibit varied perceptions without statistical significance, indicating consistent views across different age brackets. Educational qualifications (p = 0.64) demonstrate uniform perceptions across PhD/PhD scholars, PG, and UG categories, suggesting that educational background does not significantly affect opinions on the usefulness of BBS in setting treatment goals. Similarly, professional setting (p = 0.81) and practice locations (p = 0.76) show no significant differences in perceptions across various settings and locations, with urban areas showing slightly higher agreement levels. Experience in treating stroke populations (p = 0.53) reveals no significant differences in perceptions across different experience levels, suggesting that varying levels of experience do not significantly influence the perceived utility of BBS in treatment planning.

Overall, the data suggests a strong consensus among physiotherapists that the Berg Balance Scale is effective in helping to set balance-based treatment goals for stroke patients, with consistent perceptions across different demographic and professional categories surveyed. These findings underscore the scale's perceived utility and integration into clinical practice across diverse settings and experience levels within the field of physiotherapy. Gender distribution shows a trend towards higher agreement levels among both females and males, with no statistically significant difference noted (p = 0.66). Age groups (p > 0.99) exhibit varied perceptions across different age brackets, but without statistical significance, indicating consistent views across age groups. Educational qualifications (p = 0.81) display uniform perceptions across PhD/PhD scholars, PG, and UG categories, suggesting that educational background does not significantly influence perceptions of BBS accessibility and feasibility. Professional settings (p = 0.68) indicate high agreement levels among physiotherapists in teaching institutes, with varying responses in other settings such as hospitals and home care settings. Practice locations (p = 0.80) show consistent perceptions across urban, suburban, and rural areas, with urban locations indicating higher agreement levels. Experience in treating stroke populations (p = 0.57) reveals no significant differences in perceptions across different experience levels. Overall, the data suggests that physiotherapists generally perceive the Berg Balance Scale as more accessible and feasible for assessing balance in community-dwelling stroke patients compared to those in clinic and hospital settings, with consistent views across various demographic and professional categories surveyed.

Variations observed in different settings highlight potential considerations in choosing assessment tools based on practice context. Gender distribution shows a notable difference in responses, with a higher proportion of females agreeing or strongly agreeing compared to males, although this difference approaches statistical significance (p = 0.055). Age groups exhibit varied perceptions without statistical significance (p = 0.27), with younger respondents showing slightly higher agreement levels. Educational qualifications (p = 0.13) demonstrate some variation in perceptions across PhD/PhD scholars, PG, and UG categories, with higher agreement among those with higher educational attainment. Professional setting (p = 0.21) indicates that physiotherapists in teaching institutes generally agree or strongly agree with the scale's utility, with some variability among settings such as hospitals and clinics. Practice locations (p = 0.11) display mixed responses across urban, suburban, and rural areas, with urban locations showing higher agreement levels. Experience in treating stroke populations (p = 0.85) shows no significant differences in perceptions across different experience levels. Overall, the data suggests that the Berg Balance Scale is predominantly perceived as a commonly used and valuable tool among physiotherapists, with varying degrees of agreement across different demographic and professional categories. The differences observed hint at potential influences of gender, educational background, and practice setting on perceptions towards the scale's usefulness in assessing stroke patients' balance prognosis. Gender distribution indicates a trend towards agreement and strong agreement among both females and males, with a slight skew towards higher agreement among females, although

this difference is not statistically significant (p = 0.15). Age groups (p = 0.84) and educational qualifications (p = 0.30) show no significant differences in perceptions, with consistent responses across different age brackets and educational levels. In terms of professional setting (p = 0.15), physiotherapists in teaching institutes and various healthcare settings generally find the BBS scoring and grading system easy to use, although there are some variations across settings such as hospitals and clinics. Practice locations (p = 0.38) exhibit similar perceptions across urban, suburban, and rural areas, indicating a uniform perception of the scale's usability. Experience in treating stroke populations (p = 0.67) shows varied responses across different experience levels, with no statistically significant differences noted in perceptions of the BBS scoring and grading system. Overall, the data suggests that a majority of physiotherapists find the scoring and grading of the Berg Balance Scale to be straightforward and feasible across various demographic and professional categories surveyed, with minor variations among different settings and experience levels. Gender distribution shows a majority agreeing or strongly agreeing that patients sometimes do not wish to execute all BBS components, with no statistically significant difference between genders (p = 0.73). Age groups also display varied responses without significant variation (p = 0.56), indicating consistent attitudes across different age brackets. Educational qualifications exhibit a similar trend (p = 0.73), with respondents across PhD/PhD scholars, PG, and UG categories showing agreement or strong agreement.

Regarding professional setting (p = 0.80), responses vary slightly among different settings such as teaching institutes, hospitals, clinics, and home care, but without statistical significance. Practice locations (p = 0.74) like urban, suburban, and rural areas also show consistent attitudes towards the statement. Experience in treating stroke populations (p = 0.63) reveals varied responses across different experience levels, with no statistically significant differences noted. Overall, the data suggests a general consensus among respondents that patients occasionally decline to perform all components of the BBS, with these attitudes consistent across various demographic and professional categories surveyed. Gender distribution shows that females constitute a slightly higher proportion in the "Agree" and "Strongly Agree" categories compared to males, although the differences are not statistically significant (p = 0.76). Age distribution across categories indicates no significant differences (p = 0.98), with a fairly even spread among age groups. Educational qualifications also show no significant variation (p = 0.84), with similar responses across different levels of education. In terms of professional setting (p > 0.99), responses are evenly distributed across various settings including teaching institutes, government hospitals, and private practices. Similarly, practice locations (p > 0.99) such as urban, suburban, and rural areas show no significant differences in responses. Experience in treating stroke populations (p = 0.84) reveals varied responses across different experience levels, with no statistically significant differences noted. Overall, the data suggests that attitudes towards the Berg Balance Scale are consistent across various demographic and professional categories surveyed, indicating a generally uniform perception of its time-consuming nature among respondents.

RESULTS

The survey results demonstrate a strong consensus among physiotherapists regarding the efficacy and utility of the Berg Balance Scale (BBS) for assessing balance in stroke patients. A significant majority of respondents, regardless of gender, age, educational background, or professional setting, endorsed the BBS as the primary standardized tool for balance assessment. A significant majority of respondents endorsed the BBS, with 41 strongly agreeing and 23 agreeing, indicating its widespread acceptance across the profession. Notably, the consensus is evident across various demographic categories, such as gender, age, and professional settings. In gender Disparities females displayed higher levels of agreement compared to males, these differences were not statistically significant (p = 0.26). This suggests a generally consistent perception of the BBS across genders. Significant age-related disparities were observed (p = 0.043), particularly among those aged 31-35, who exhibited less agreement than younger (≤30) and older professionals (36-40). This implies that age may influence perceptions of the BBS's effectiveness. Analysis showed little variation in preferences based on educational qualifications (p = 0.89). Postgraduates were more likely to strongly agree with the BBS's usefulness, but overall, educational level did not significantly impact opinions on its effectiveness. No significant differences were noted in preferences across different professional environments (p =

0.27) or levels of experience (p = 0.38). This indicates that practitioners, regardless of their work setting or years of experience, generally perceive the BBS similarly. Overall, respondents viewed the BBS as an effective tool for identifying balance issues and setting treatment goals for stroke patients, with uniform perceptions across demographic categories (e.g., urban vs. rural practitioners).Most physiotherapists found the scoring and grading of the BBS to be user-friendly, with minor variations noted in different healthcare settings. This highlights the tool's practicality in clinical practice. These findings offer extensive insights into the diverse perceptions and utilization of the Berg Balance Scale among physiotherapists in stroke rehabilitation.

DISCUSSION

The Berg Balance Scale (BBS) is a valuable tool for assessing balance in stroke patients, as evidenced by the significant insights provided in the literature. The study's findings indicate that the BBS is widely used and preferred by physiotherapists in stroke rehabilitation, as it allows for the evaluation of static and dynamic stability, the identification of balance issues, and the prognosis of balance in stroke patients. While some aspects, such as setting balance-based treatment goals and scoring/grading, did not show statistical significance, the study highlights the challenges and nuances faced by physiotherapists in using the BBS. The demographic variables provide information on the characteristics of the physiotherapists who participated in the study. The Berg Balance Scale (BBS) is a tool which can evaluate balance for individuals with various Disabilities (Down 2015). A study examined the BBS's effectiveness in stroke patients, creating a key form and identifying nine levels to categorize patients based on their balance and can effectively measure and track changes in a patient's balance over time ultimately assisting in their rehabilitation [11] .The findings can support the adoption of evidence-based practices among physiotherapists, encouraging the use of validated tools like the BBS. This alignment with evidence-based practice can enhance the credibility and effectiveness of physiotherapy practices..The findings of the present study indicate a statistically significant association between gender and the use of the BBS Scale in stroke patients, suggesting that gender may play a role in the choice of balance assessment tool (p=0.039).The study revealed a significant association between practice location and the preference for using the BBS as a balance measurement tool in stroke patients (p=0.030).When addressing research questions, physiotherapists often choose to use the Berg Balance Scale (BBS) to measure balance in stroke patients. The BBS is a widely recognized scale that effectively differentiates between static and dynamic stability in stroke patients. This preference for the BBS is supported by a study conducted by Fabio La Porta and Serena (2012)[12], which found that the BBS-12 has high internal validity and reliability as a measurement tool for balance impairment resulting from any neurological disease etiology.

Education affects BBS use in stroke patients (p=0.005) and aligns with Hunt et al. (1998)[13], who emphasized education's impact on clinical decision-making. Various educational backgrounds among physiotherapists may lead to differing BBS suitability perspectives, highlighting the need for targeted educational interventions to standardize practices across diverse groups. The research found that the BBS is accessible and feasible for use across diverse demographic groups and various physiotherapist backgrounds, as no significant associations were identified between demographic variables and the perceived accessibility and feasibility of using the BBS. Concerning the research questions about the Berg Balance Scale (BBS), the focus is on its specific role in assessing and identifying balance issues in stroke patients, as well as its contribution to establishing balance-based treatment goals for these patients. The significance correlation observed between professional settings and the utilization of the Berg Balance Scale (BBS) as a frequently employed tool by physiotherapists to evaluate the balance prognosis of stroke patients which aligns with previous study conducted by Reyes P et .al(2020)[14,18]. In addressing the research question, it is noted that the scoring and grading of the Berg Balance Scale (BBS) are perceived as accessible and comprehensible by physiotherapists. The non-significant correlation identified between the number of daily treatment cases and the perceived ease and feasibility of employing BBS scoring and grading corresponds with the insights from the study conducted by Robinson et al. (2019) [15,19] which emphasized the impact of workload considerations on rehabilitation practice. In addressing the research question, it was noted that patients may occasionally exhibit non-compliance with all components of the Berg Balance Scale (BBS) during a comprehensive assessment. The study

revealed non-significant association between the practice location and patients' willingness to perform all BBS components. The geographical context and cultural factors tied to practice locations may play a role in shaping patients' attitudes toward undergoing thorough balance assessments, necessitating further exploration. Conclusively, concerning the research question on the Berg Balance Scale (BBS) being a time-consuming assessment scale, a non-significance association was found between gender and the perception of the BBS as a time-consuming tool. Duncan and Murray (2012) [16, 21] reviewed the barriers and facilitators to routine outcome measurement for allied health professionals in practice. Successful integration of routine outcome measurement requires targeted actions at the individual therapist, team, and organizational levels within healthcare organizations. In earlier research studies, identified challenges in the findings emphasizing the practical and patient-related concerns expressed by participants regarding outcome measurement in clinical practice[17].The gait and balance performance measures have been found to be sensitive to changes in interventions for preventing fall [20] .In a prospective context, employing a reliable clinical outcome measure for balance enhances a physical therapist's ability to predict fall risks and assists in establishing goals for fall prevention and overall balance improvement. The empirical evidence indicates that the BBS is a suitable tool to screen for the risk of falls and shows good predictability when used with the appropriate criteria and applied to those with neuromuscular disease. In the field of rehabilitating community-dwelling stroke patients, the importance of standardized outcome measures is evident. However, a notable literature gap persists, particularly concerning the impact of demographic variables on physiotherapists' utilization of the Berg Balance Scale (BBS) within Kamrup's context. To fill this gap, the study aimed to investigate the perspectives of practicing physiotherapists on the advantages and obstacles related to the utilization of the BBS in the rehabilitation of stroke patients residing in the community within this specific region. The scarcity of literature reviews and the absence of analogous studies in Kamrup, Assam, up to the present date underscore the novelty and significance of this research. This investigation substantially contributes to understanding the factors influencing physiotherapists' use of the BBS in stroke rehabilitation within this specific geographical context. The findings not only enrich the current knowledge base but also offer valuable insights guiding strategies for the effective implementation of standardized outcome measures in stroke rehabilitation within the region. These outcomes carry potential implications for shaping future interventions, developing targeted training programs, and shaping policies aimed at optimizing the application of standardized outcome measures in stroke rehabilitation within the Kamrup region.

LIMITATIONS

The study's constraints encompass several key areas. While it offers valuable insights into how physiotherapists perceive and utilize the Berg Balance Scale in stroke rehabilitation, the cross-sectional nature of the research limits the ability to establish causal relationships. A longitudinal approach would yield a more thorough understanding of these dynamics. To address these limitations, future studies should consider employing diverse research methods and including a wider range of participants. This approach would enhance the study's applicability and relevance across different settings.

CONCLUSION

This study examines the perceptions, implementations, and challenges related to the use of the Berg Balance Scale (BBS) as an outcome measure for community-dwelling stroke patients by physiotherapists in the Kamrup. The analysis of respondents' opinions provides valuable insights into the factors influencing the use of BBS and its feasibility in different demographic context. The overall findings suggest that BBS can be a valuable assessment tool for stroke patients, accessible and feasible across various demographic groups and some. This study contributes valuable insights into the factors that may influence the choice of the Berg Balance Scale as an outcome measure for stroke patients and can facilitate more effective and patient-centric rehabilitation strategies, benefiting the stroke population in the region. Further research are needed to gain more knowledge in this study and to explore additional factors that may influence the utilization of BBS in clinical practice.

Conflict of interest
No conflict of interest

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Table:1 Research Qeustionnaire Sec- A Socio-Demographic Characteristics of Physiotherapists

Gender	**Female**
	Male
Age	≤30
	31-35
	36-40
	≥41
Educational Qualification	PhD/ PhD Scholars
	PG
	UG
Professional setting	Teaching Institutes
	Govt. Hospital
	Private Practice Clinic
	Private Home Care/Home Visit
	Private Hospital
Practice location	Urban
	Suburban
	Rural
Experience in treating the Stroke population	<=1
	2-3
	4-5
	>5
Number of cases per day	1-3
	4-7
	8-11
	>=12

Table:2 Research Qeustionnaire Sec- B Research Questions Total No of Questions:10

QUESTIONS No.	RESEARCH QUESTIONS	RESPONSES				
		Strongly Agree(4)	Agree (3)	Neutral (2)	Disagree(1)	Total Score (10)
1.	Berg Balance Scale (BBS) is the mostly used standardized Scale to assess balance in Stroke patients by Physiotherapists					
2.	Physiotherapist mostly prefer to use BBS as a Balance measurement tool in Stroke Patients					
3.	BBS is widely recognized scale that helps to differentiate Static and Dynamic stability of stroke patients by Physiotherapists					
4.	Berg Balance Scale (BBS) specifically assess and identify the balance issues in stroke patients					
5.	BBS helps in setting the balance based treatment goals of stroke patients					
6.	Berg Balance Scale (BBS) is a better accessible and feasible balance assessment scale used by Physiotherapists in Community -dwelling stroke patients in comparison to the other balance assessment scales.					
7.	Berg Balance Scale (BBS) is a commonly used balance assessment tool to assess the improvement of balance of a stroke patient by Physiotherapists					
8.	The Scoring and Grading of Berg Balance Scale (BBS) is easy and feasible to be used and understand by Physiotherapists					
9.	Sometimes Patients donot comply with all the components of Berg Balance Scale (BBS) for thorough assessment.					
10.	Berg Balance Scale (BBS) is a time consuming assessment Scale					

Table 3: Berg Balance Scale (BBS) is the mostly used standardized Scale to assess balance in Stroke patients by Physiotherapists.

Characteristic	**Neutral**, N = 1	**Agree**, N = 23	**Strongly Agree**, N = 41	**p-value**[1]
Gender, n (%)				0.57
Female	0 (0)	15 (65)	25 (61)	
Male	1 (100)	8 (35)	16 (39)	
Age, n (%)				0.16
<=30	0 (0)	14 (61)	18 (44)	
31-35	1 (100)	4 (17)	17 (41)	
36-40	0 (0)	5 (22)	6 (15)	

Educational Qualification, n (%)				0.43
PhD/ PhD Scholars	0 (0)	9 (39)	9 (22)	
PG	1 (100)	8 (35)	21 (51)	
UG	0 (0)	6 (26)	11 (27)	
Professional setting, n (%)				0.40
Teaching Institutes	0 (0)	15 (65)	23 (56)	
Govt. Hospital	0 (0)	1 (4.3)	3 (7.3)	
Private Practice Clinic	0 (0)	1 (4.3)	2 (4.9)	
Private Home Care/Home Visit	1 (100)	1 (4.3)	7 (17)	
Private Hospital	0 (0)	5 (22)	6 (15)	
Practice Location, n (%)				0.34
Urban	0 (0)	15 (65)	25 (61)	
Suburban	1 (100)	3 (13)	10 (24)	
Rural	0 (0)	5 (22)	6 (15)	
Experience in Treating Stroke Population, n (%)				0.52
<=1	0 (0)	3 (13)	5 (12)	
2-3	0 (0)	10 (43)	10 (24)	
4-5	0 (0)	4 (17)	12 (29)	
>5	1 (100)	6 (26)	14 (34)	
[1]Fisher's exact test				

Table 4: Since you have knowledge about the Berg Balance Scale (BBS), hence in Stroke Patients you mostly prefer to use BBS as a Balance measurement tool.

Characteristic	**Agree**, N = 37	**Strongly Agree**, N = 28	**p-value**[1]
Gender, n (%)			0.91
Female	23 (62)	17 (61)	
Male	14 (38)	11 (39)	
Age, n (%)			**0.043**
<=30	16 (43)	16 (57)	
31-35	17 (46)	5 (18)	
36-40	4 (11)	7 (25)	
Educational Qualification, n (%)			0.89
PhD/ PhD Scholars	10 (27)	8 (29)	
PG	18 (49)	12 (43)	
UG	9 (24)	8 (29)	
Professional setting, n (%)			0.27
Teaching Institutes	21 (57)	17 (61)	
Govt. Hospital	4 (11)	0 (0)	
Private Practice Clinic	2 (5.4)	1 (3.6)	
Private Home Care/Home Visit	6 (16)	3 (11)	
Private Hospital	4 (11)	7 (25)	
Practice Location, n (%)			0.25
Urban	23 (62)	17 (61)	
Suburban	10 (27)	4 (14)	
Rural	4 (11)	7 (25)	
Experience in Treating Stroke Population, n (%)			0.38
<=1	6 (16)	2 (7.1)	

2-3	9 (24)	11 (39)	
4-5	11 (30)	5 (18)	
>5	11 (30)	10 (36)	
[1]Pearson's Chi-squared test; Fisher's exact test			

Table 5: BBS is widely recognized scale that helps to differentiate Static and Dynamic stability of stroke patients by Physiotherapists.

Characteristic	**Neutral**, N = 8	**Agree**, N = 28	**Strongly Agree**, N = 29	**p-value**[1]
Gender, n (%)				0.26
Female	4 (50)	15 (54)	21 (72)	
Male	4 (50)	13 (46)	8 (28)	
Age, n (%)				0.24
<=30	4 (50)	11 (39)	17 (59)	
31-35	1 (13)	12 (43)	9 (31)	
36-40	3 (38)	5 (18)	3 (10)	
Educational Qualification, n (%)				0.36
PhD/ PhD Scholars	2 (25)	7 (25)	9 (31)	
PG	3 (38)	11 (39)	16 (55)	
UG	3 (38)	10 (36)	4 (14)	
Professional setting, n (%)				0.43
Teaching Institutes	4 (50)	14 (50)	20 (69)	
Govt. Hospital	1 (13)	2 (7.1)	1 (3.4)	
Private Practice Clinic	0 (0)	1 (3.6)	2 (6.9)	
Private Home Care/Home Visit	0 (0)	6 (21)	3 (10)	
Private Hospital	3 (38)	5 (18)	3 (10)	
Practice Location, n (%)				0.32
Urban	4 (50)	15 (54)	21 (72)	
Suburban	1 (13)	8 (29)	5 (17)	
Rural	3 (38)	5 (18)	3 (10)	
Experience in Treating Stroke Population, n (%)				0.89
<=1	1 (13)	3 (11)	4 (14)	
2-3	3 (38)	7 (25)	10 (34)	
4-5	1 (13)	7 (25)	8 (28)	
>5	3 (38)	11 (39)	7 (24)	
[1]Fisher's exact test				

Table 6: Berg Balance Scale (BBS) is used to assess and identify the exact issues related to balance in stroke patients

Characteristic	**Disagree**, N = 5	**Neutral**, N = 1	**Agree**, N = 39	**Strongly Agree**, N = 20	**p-value**[1]
Gender, n (%)					0.80
Female	3 (60)	1 (100)	22 (56)	14 (70)	
Male	2 (40)	0 (0)	17 (44)	6 (30)	
Age, n (%)					0.79
<=30	1 (20)	1 (100)	19 (49)	11 (55)	
31-35	3 (60)	0 (0)	13 (33)	6 (30)	

36-40	1 (20)	0 (0)	7 (18)	3 (15)	
Educational Qualification, n (%)					0.89
PhD/ PhD Scholars	1 (20)	1 (100)	10 (26)	6 (30)	
PG	3 (60)	0 (0)	19 (49)	8 (40)	
UG	1 (20)	0 (0)	10 (26)	6 (30)	
Professional setting, n (%)					0.71
Teaching Institutes	3 (60)	1 (100)	20 (51)	14 (70)	
Govt. Hospital	0 (0)	0 (0)	4 (10)	0 (0)	
Private Practice Clinic	1 (20)	0 (0)	2 (5.1)	0 (0)	
Private Home Care/Home Visit	0 (0)	0 (0)	6 (15)	3 (15)	
Private Hospital	1 (20)	0 (0)	7 (18)	3 (15)	
Practice Location, n (%)					0.93
Urban	3 (60)	1 (100)	22 (56)	14 (70)	
Suburban	1 (20)	0 (0)	10 (26)	3 (15)	
Rural	1 (20)	0 (0)	7 (18)	3 (15)	
Experience in Treating Stroke Population, n (%)					0.57
<=1	0 (0)	1 (100)	4 (10)	3 (15)	
2-3	1 (20)	0 (0)	12 (31)	7 (35)	
4-5	3 (60)	0 (0)	9 (23)	4 (20)	
>5	1 (20)	0 (0)	14 (36)	6 (30)	
[1]Fisher's exact test					

Table 7: After assessment of Balance through Berg Balance Scale (BBS) ,it helps in setting the balance based treatment goals of stroke patients

Characteristic	**Agree**, N = 35	**Strongly Agree**, N = 30	**p-value**[1]
Gender, n (%)			0.78
Female	21 (60)	19 (63)	
Male	14 (40)	11 (37)	
Age, n (%)			0.52
<=30	15 (43)	17 (57)	
31-35	13 (37)	9 (30)	
36-40	7 (20)	4 (13)	
Educational Qualification, n (%)			0.64
PhD/ PhD Scholars	8 (23)	10 (33)	
PG	17 (49)	13 (43)	
UG	10 (29)	7 (23)	
Professional setting, n (%)			0.81
Teaching Institutes	19 (54)	19 (63)	
Govt. Hospital	3 (8.6)	1 (3.3)	
Private Practice Clinic	2 (5.7)	1 (3.3)	
Private Home Care/Home Visit	4 (11)	5 (17)	
Private Hospital	7 (20)	4 (13)	
Practice Location, n (%)			0.76
Urban	21 (60)	19 (63)	
Suburban	7 (20)	7 (23)	
Rural	7 (20)	4 (13)	

Experience in Treating Stroke Population, n (%)			0.53
<=1	5 (14)	3 (10)	
2-3	8 (23)	12 (40)	
4-5	10 (29)	6 (20)	
>5	12 (34)	9 (30)	
[1]Pearson's Chi-squared test; Fisher's exact test			

Table 8: Berg Balance Scale (BBS) is a better accessible and feasible balance assessment scale used by Physiotherapists in Community -dwelling stroke patients in comparison to Clinic and Hospital Based patients.

Characteristic	**Disagree**, N = 6	**Neutral**, N = 8	**Agree**, N = 15	**Strongly Agree**, N = 36	**p-value**[1]
Gender, n (%)					0.66
Female	5 (83)	4 (50)	9 (60)	22 (61)	
Male	1 (17)	4 (50)	6 (40)	14 (39)	
Age, n (%)					>0.99
<=30	3 (50)	4 (50)	8 (53)	17 (47)	
31-35	2 (33)	3 (38)	5 (33)	12 (33)	
36-40	1 (17)	1 (13)	2 (13)	7 (19)	
Educational Qualification, n (%)					0.81
PhD/ PhD Scholars	3 (50)	3 (38)	4 (27)	8 (22)	
PG	2 (33)	3 (38)	6 (40)	19 (53)	
UG	1 (17)	2 (25)	5 (33)	9 (25)	
Professional setting, n (%)					0.68
Teaching Institutes	5 (83)	4 (50)	9 (60)	20 (56)	
Govt. Hospital	0 (0)	0 (0)	0 (0)	4 (11)	
Private Practice Clinic	0 (0)	1 (13)	0 (0)	2 (5.6)	
Private Home Care/Home Visit	0 (0)	2 (25)	4 (27)	3 (8.3)	
Private Hospital	1 (17)	1 (13)	2 (13)	7 (19)	
Practice Location, n (%)					0.80
Urban	5 (83)	4 (50)	9 (60)	22 (61)	
Suburban	0 (0)	3 (38)	4 (27)	7 (19)	
Rural	1 (17)	1 (13)	2 (13)	7 (19)	
Experience in Treating Stroke Population, n (%)					0.57
<=1	2 (33)	1 (13)	3 (20)	2 (5.6)	
2-3	1 (17)	3 (38)	3 (20)	13 (36)	
4-5	2 (33)	1 (13)	3 (20)	10 (28)	
>5	1 (17)	3 (38)	6 (40)	11 (31)	
[1]Fisher's exact test					

Table 9: Berg Balance Scale (BBS) is a commonly used balance tool to assess the prognosis of the balance component of a stroke patient by Physiotherapists.

Characteristic	**Neutral**, N = 2	**Agree**, N = 43	**Strongly Agree**, N = 20	**p-value**[1]
Gender, n (%)				0.055
Female	0 (0)	30 (70)	10 (50)	
Male	2 (100)	13 (30)	10 (50)	

Age, n (%)				0.27
<=30	0 (0)	23 (53)	9 (45)	
31-35	1 (50)	15 (35)	6 (30)	
36-40	1 (50)	5 (12)	5 (25)	
Educational Qualification, n (%)				0.13
PhD/ PhD Scholars	0 (0)	14 (33)	4 (20)	
PG	0 (0)	21 (49)	9 (45)	
UG	2 (100)	8 (19)	7 (35)	
Professional setting, n (%)				0.21
Teaching Institutes	0 (0)	28 (65)	10 (50)	
Govt. Hospital	0 (0)	3 (7.0)	1 (5.0)	
Private Practice Clinic	0 (0)	1 (2.3)	2 (10)	
Private Home Care/Home Visit	1 (50)	6 (14)	2 (10)	
Private Hospital	1 (50)	5 (12)	5 (25)	
Practice Location, n (%)				0.11
Urban	0 (0)	30 (70)	10 (50)	
Suburban	1 (50)	8 (19)	5 (25)	
Rural	1 (50)	5 (12)	5 (25)	
Experience in Treating Stroke Population, n (%)				0.85
<=1	0 (0)	6 (14)	2 (10)	
2-3	0 (0)	14 (33)	6 (30)	
4-5	0 (0)	11 (26)	5 (25)	
>5	2 (100)	12 (28)	7 (35)	
[1]Fisher's exact test				

Table 10: The Scoring and Grading of Berg Balance Scale (BBS) is easy and feasible to use and understand by Physiotherapists

Characteristic	**Agree**, N = 37	**Strongly Agree**, N = 28	**p-value**[1]
Gender, n (%)			0.15
Female	20 (54)	20 (71)	
Male	17 (46)	8 (29)	
Age, n (%)			0.84
<=30	17 (46)	15 (54)	
31-35	13 (35)	9 (32)	
36-40	7 (19)	4 (14)	
Educational Qualification, n (%)			0.30
PhD/ PhD Scholars	8 (22)	10 (36)	
PG	17 (46)	13 (46)	
UG	12 (32)	5 (18)	
Professional setting, n (%)			0.15
Teaching Institutes	18 (49)	20 (71)	
Govt. Hospital	4 (11)	0 (0)	
Private Practice Clinic	1 (2.7)	2 (7.1)	
Private Home Care/Home Visit	7 (19)	2 (7.1)	
Private Hospital	7 (19)	4 (14)	
Practice Location, n (%)			0.38
Urban	20 (54)	20 (71)	

Suburban	10 (27)	4 (14)	
Rural	7 (19)	4 (14)	
Experience in Treating Stroke Population, n (%)			0.67
<=1	5 (14)	3 (11)	
2-3	10 (27)	10 (36)	
4-5	8 (22)	8 (29)	
>5	14 (38)	7 (25)	
[1]Pearson's Chi-squared test; Fisher's exact test			

Table 11: Sometimes Patients do not wish to execute all the components of Berg Balance Scale (BBS) for thorough assessment.

Characteristic	**Disagree**, N = 1	**Neutral**, N = 9	**Agree**, N = 33	**Strongly Agree**, N = 22	p-value[1]
Gender, n (%)					0.73
Female	0 (0)	6 (67)	21 (64)	13 (59)	
Male	1 (100)	3 (33)	12 (36)	9 (41)	
Age, n (%)					0.56
<=30	0 (0)	6 (67)	17 (52)	9 (41)	
31-35	0 (0)	2 (22)	11 (33)	9 (41)	
36-40	1 (100)	1 (11)	5 (15)	4 (18)	
Educational Qualification, n (%)					0.73
PhD/ PhD Scholars	0 (0)	4 (44)	8 (24)	6 (27)	
PG	0 (0)	3 (33)	16 (48)	11 (50)	
UG	1 (100)	2 (22)	9 (27)	5 (23)	
Professional setting, n (%)					0.80
Teaching Institutes	0 (0)	6 (67)	20 (61)	12 (55)	
Govt. Hospital	0 (0)	0 (0)	2 (6.1)	2 (9.1)	
Private Practice Clinic	0 (0)	0 (0)	1 (3.0)	2 (9.1)	
Private Home Care/Home Visit	0 (0)	2 (22)	5 (15)	2 (9.1)	
Private Hospital	1 (100)	1 (11)	5 (15)	4 (18)	
Practice Location, n (%)					0.74
Urban	0 (0)	6 (67)	21 (64)	13 (59)	
Suburban	0 (0)	2 (22)	7 (21)	5 (23)	
Rural	1 (100)	1 (11)	5 (15)	4 (18)	
Experience in Treating Stroke Population, n (%)					0.63
<=1	0 (0)	2 (22)	4 (12)	2 (9.1)	
2-3	0 (0)	4 (44)	10 (30)	6 (27)	
4-5	0 (0)	0 (0)	9 (27)	7 (32)	
>5	1 (100)	3 (33)	10 (30)	7 (32)	
[1]Fisher's exact test					

Table 12: Berg Balance Scale (BBS) is a time consuming assessment Scale.

Characteristic	**Disagree**, N = 25	**Neutral**, N = 7	**Agree**, N = 25	**Strongly Agree**, N = 8	p-value[1]
Gender, n (%)					0.76
Female	14 (56)	5 (71)	15 (60)	6 (75)	

Male	11 (44)	2 (29)	10 (40)	2 (25)	
Age, n (%)					0.98
<=30	12 (48)	4 (57)	11 (44)	5 (63)	
31-35	8 (32)	2 (29)	10 (40)	2 (25)	
36-40	5 (20)	1 (14)	4 (16)	1 (13)	
Educational Qualification, n (%)					0.84
PhD/ PhD Scholars	5 (20)	3 (43)	7 (28)	3 (38)	
PG	14 (56)	2 (29)	11 (44)	3 (38)	
UG	6 (24)	2 (29)	7 (28)	2 (25)	
Professional setting, n (%)					>0.99
Teaching Institutes	13 (52)	5 (71)	15 (60)	5 (63)	
Govt. Hospital	2 (8.0)	0 (0)	1 (4.0)	1 (13)	
Private Practice Clinic	2 (8.0)	0 (0)	1 (4.0)	0 (0)	
Private Home Care/Home Visit	3 (12)	1 (14)	4 (16)	1 (13)	
Private Hospital	5 (20)	1 (14)	4 (16)	1 (13)	
Practice Location, n (%)					>0.99
Urban	14 (56)	5 (71)	15 (60)	6 (75)	
Suburban	6 (24)	1 (14)	6 (24)	1 (13)	
Rural	5 (20)	1 (14)	4 (16)	1 (13)	
Experience in Treating Stroke Population, n (%)					0.84
<=1	2 (8.0)	0 (0)	5 (20)	1 (13)	
2-3	8 (32)	3 (43)	5 (20)	4 (50)	
4-5	7 (28)	2 (29)	6 (24)	1 (13)	
>5	8 (32)	2 (29)	9 (36)	2 (25)	
[1]Fisher's exact test					

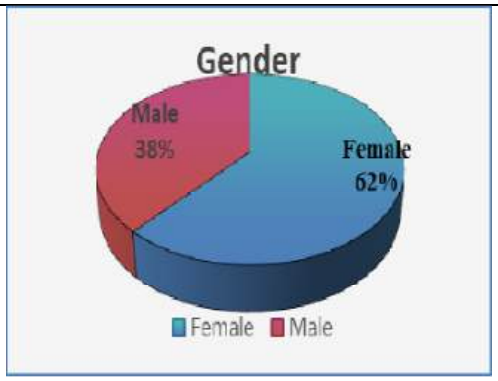


Fig: 1 Pie chart for the percentage according to Gender

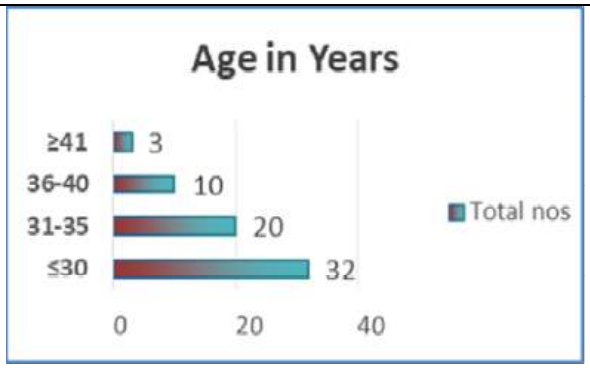


Fig:2 Bar diagram for the different age groups according to respective frequencies

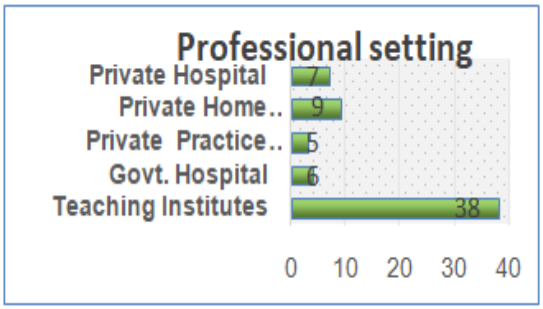


Fig:3 Bar diagram for the different group of professional settings for the respective frequencies

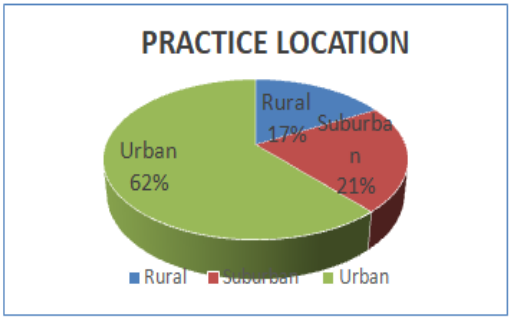


Fig: 4 Pie chart for the percentage according to the practice Educational

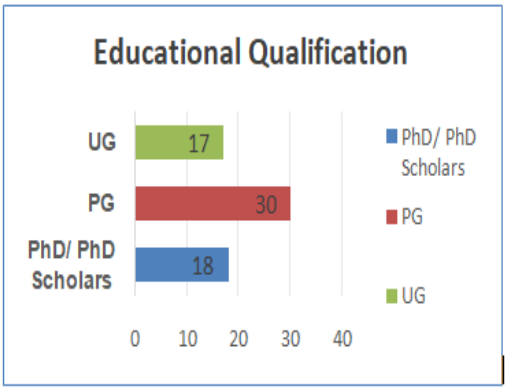


Fig: 5Bar diagram for the frequency of Educational qualification

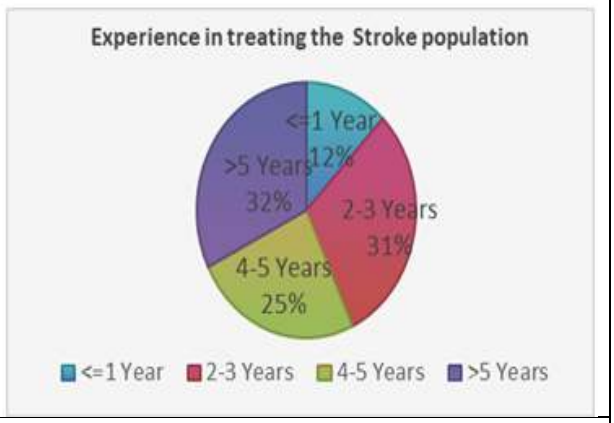


Fig: 6 Pie chart for the percentage according to experience in treating the stroke population

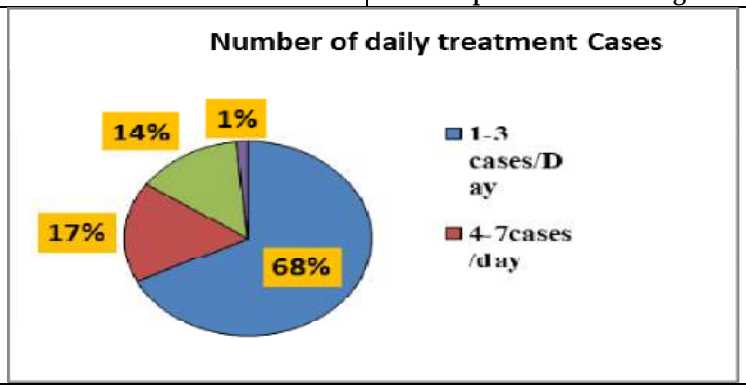


Fig: 7 Pie chart for the percentage according to number of daily treatment cases

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RESEARCH ARTICLE

A Case Report on Ayurvedic Management of Autism Spectrum Disorder (ASD) in Children

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ABSTRACT

Autism spectrum disorder (ASD) is a group of neurodevelopmental disorders marked by impairments with social interaction, and the presence of repetitive, and restrictive patterns of behaviour. Based on clinical characteristics, ASD can be correlated with *Unmad* mentioned in *Ayurveda* classics. In clinical practice, there is a paucity of standard treatment protocols and effective care for the prevention of ASD. The present case report discusses a 3-year-old male patient who presented with fever, aggressive behaviour, hyperactivity, sing song, repetitive action of receiving call and saying hello, poor eye contact, no communication, no social skills, poor speech, and sleep disturbances reported at *Kaumarbhritya* outpatient department. Diagnosis of ASD was established using the Indian Scale for Assessment of Autism (ISAA) test manual. Deepana pachana with *Chitrakadi vati, Abhyanga* with *BalashwagandhaTaila*and *Nasya* with *Brahmi Ghrita* along with other internal medications, Tab Smrutisagar rasa (125mg), *Saraswataristha, Vacha, Yastimadhu, Shatavari, Aswagandha, Gududchi, Sankhapushpiplant, Brahmi ghrita* was given. Remarkable improvement was noted in overall ISAA scores as well as clinical improvement noted in poor eye contact, hyperactivity, and peer relationship. "Child Sleep Habit Questionnaire (CSHQ)" was used to assess the child's sleep pattern and improvement was noted. No adverse effects were reported during the treatment period and follow-up.

Keywords: Autism spectrum disorder, *Ayurveda*, case report, *Nasya, Unmada*

INTRODUCTION

Autism spectrum disorder (ASD) is a neuro developmental disorder that is marked by impairments with social interaction and the presence of repetitive and restrictive patterns of behaviour.[1]The prevalence estimates of autism spectrum disorders (ASD) are 62/10,000.[2] The incidence of ASD prevalence rate of ASD is 1.5%. The number of cases is increasing significantly. [3,4] All psychosocial abnormalities were seen in ASD having similarity with disease *Kaphaja-Vataj Unmada* described in Ayurveda, with the signs to prefer to live in one place, prefers alone time, do not like to socialize, prefer not to speak or communicate, motor mannerism, frequent self-stimulating emotions, and imitation or repetition of sounds or words (Echolalia). *Manas* (mind), *Budhi* (intellect), *Samnja* (consciousness), *Gyana* (knowledge), *Smriti* (memory), *Bhakthi* (desire), *Shila* (manners), *Chesta* (behaviour), and *Achara* (conduct) are affected in *Unmada*. [5] Cardinal clinical features of *Unamda* are described as *Dhivibhrama* [6] (perverted intellect), *Satvapariplavach* [6] (psychic agitation), *Peryakula Drishti* [6] (restlessness in eyes), *Adheerata* [6] (impatience), *Abadhvakyatam*[6] (incoherent speech), and *Hridaya shunyata* [6] (blockage of thought) shows similarity with ASD. The exact pathology of ASD is unknown to date, whereas several factors have been involved in the pathogenesis of autism disorders.[7] *Nidana* (cause) of *Unmada* [8]is intake of *Viruddh* (incompatible), *Dushta* (contaminated), and *Ashuchi* (unclean) food, *Vishama chesta* (adopting difficult posture), *Manoabhighaata*(mental trauma), and *Pragharshanam Devgurudwijanam* (possession by spiritssuch as gods, teachers, and brahmanas). Genetic and environmental factors that affect, the developing brain influence it. Even though there is not a single, overarching etiology for ASD yet, continuing research is expanding our knowledge of various etiologic processes that could be involved in this condition. In addition, attention deficit hyperactivity disorder (ADHD), anxiety, mood disorders, obsessive-compulsive disorder, and other disruptive behaviour disorders frequently co-occur with ASD. As the disease is newly emerged and there is no direct corelation of known etiologies in terms of Ayurveda, additionally the available literatures and case studies along with the case reports suggesting no unanimous statement on the management of disease protocol. In our case study we tried to elaborate the importance of Ayurveda treatment on reducing the features of ASD on the basis of ISAA scale. Which highlights the role of Ayurveda in mainstreaming these therapies with modern protocols. The present case study will discuss a 3-year-old male patient with ASD and the management of the condition with Ayurveda interventions. Reporting is as per CARE guidelines (https://www.care-statement.org/).

Case Report

Patient Information

A 3-year-old male patient reported at *Kaumarbhritya (KB)* outpatient department (OPD) on 17th January 2024, with complaints of with fever, aggressive behaviour, hyperactivity, repetitive singing song, repetitive action of receiving call and saying hello, poor eye contact, no communication, no social skills, poor speech, and sleep disturbances and constipated bowel**.**

Antenatal history

mother's age at the time of birth was 37 years, No history of abortion. Mother was healthy during antenatal period. Birth history: normal full-term vaginal delivery at the hospital. The baby cried immediately after birth, with no history of foetal distress, and the birth weight was 2.75 kg. There was no history of seizures, pathological jaundice, hypoglycaemia, meningitis, etc. No family history of such a condition was found.

Clinical findings and diagnostic assessment

The appearance of patient seemed to be irritated along with repetitive behaviour, hyperactivity, lack of social communication, poor eye contact, and not fixing his gaze on a particular item/person. The patient was conscious but not well-oriented of time, place, or person. He was inattentive and had a lack of concentration. Memory is good. Gross motor development was achieved on time. Fine motor, social and communication, and language and speech development of the patient were delayed. The speech was not clear. The neuromuscular examination was normal. Cardiovascular, respiratory, and abdominal examination was normal, Physical growth for the age is normal. The appetite was reduced, and sleep was disturbed. On performing *Ashtavidha Sthan Pariksha* (eight folds examinations of

the patients), it was observed that the patient's *Nad*i (-pulse) was *Vata-Kaphaja*, pulse rate was 94/min, Mala (-bowel) was *Samanya* (normal), *Mutra* (urine) was *Samanya* (normal) and pale in color, Jihwa (tongue) was *Nirama* (uncoated), *Shabda* (voice) was *Aspashta* (unclear), *Sparsha* (touch/Skin) was *Ruksha* (Dry), *Drika* (eye) was *Samanya* [normal), and *Akruti* (body built) was *Samanya* (Normal). Indian Scale for Assessment of Autism (ISAA) rest manual [9]was used to diagnose the condition**.** Other assessment scales i.e., Child Sleep Habit Questionnaire (CSHQ) was used to assess the sleep pattern of the child.[10].

Timeline

The patient was well before2 years of age, after that parent started noticing the child having poor eye contact, inappropriate speech, communication and social milestones delaying, and solitary play activities, and also getting hyperactive. The patient also has sleep disturbances and constipated bowel (on/off) for the past 1 year. As per the parents, the patient was diagnosed with autism before but no documentation was available. The patient was taking Ayurveda treatment from our OPD since March 2021 and did not take any other treatment from elsewhere, earlier. *Deepana-Pachana* (digestion and metabolism-enhancing) and *Medhya* (intellect enhancer) medicines were prescribed. Mild improvement in eye contact, decreased hyperactivity, mild improvement in speech were noticed, but not much improvement in other complaints was observed. The patient did proper follow-up during that treatment. The patient was reassessed and the baseline assessment was done using the "ISAA test manual" on January 17, 2024. The patient was diagnosed with a moderate level of autism. The course of treatment was then modified.

- January 2021 (OPD base treatment due to COVID-19)
- January 17,2024 (Assessment was done pre-treatment)
- January 18, 2024 (Internal medication, Abhayanga, Nasya at Hospital)
- February 19, 2024 (Internal medication, Abhayanga, Nasya at Home)
- April 05, 2024 (Post treatment Assessment)

Therapeutic interventions

Baseline assessment was done on January 17, 2024, using the "ISAA" to diagnose the level of autism which was around 96, the "CSHQ" to assess the sleep behaviour of the patient. *Smrutisagararasa* (125mg) 1 BD, *saraswataristha* 10ml BD, *Vacha +Yastimadhu+Shatavari +Aswagandha +Guduchi+Shankhpuspi (*5 gm each in powder form[divided it equally into 60 parts (near about 0.5 gram in each part) Given this combination of medicine in form of *Phanta*[50 ml (1 part)] evening (OD), with honey.*Brahmi ghrita* 5ml orally for 1 week followed by *Brahmi ghrita Nasya* for 21 days. *Abhyanga* (massage) with*Bala Ashwagandha Taila*and *Pratimarsha Nasya*with *Brahmi ghrita* was done From January 17, 2024, to February 18, 2024, *Abhyanga* (massage) and *Nasya* were done at the *Panchakarma* unit of the *KB* department. Internal medications remained the same. From February 19, 2024, Abhyanga (massage) and Pratimarsha Nasya were advised to be done at home. Internal medications remained the same. on April 05, 2024, assessment (after treatment) was done using the same scale and tools i.e. ISAA,CSHQ [table 3,4]

Follow-up and outcomes

The treatment regimen was properly followed at the KB Panchakarma unit as well as at home except for the *Phanta* preparation which was missed a20-21timesdue to palatability issues. A good response to treatment was noticed. Autism level decreased to mild level. The sleep behaviour pattern of the patient also [Tables 4].

DISCUSSION

The patient presented with fever, aggressive behaviour, hyperactivity, repetitive singing song, repetitive action of receiving call and saying hello, poor eye contact, no communication, no social skills, poor speech, and sleep disturbances and constipated bowel**.** As there is no standard treatment for ASD, Ayurveda therapy has been carried out to manage this condition and is presented in this case report. *Chitrakadi Vati* was given for *Deepana-Pachana* before starting the main medications and procedure as the child had complaints of reduced appetite and constipation. The appetite was improved and constipation was relieved. There was no adverse effect observed. *Smrutisagar Rasa* is

processed with *Vacha* (*Acorus calamus*), *Brahm*i (*Bacopa monnieri*), and *Jyotishmati* (*Celastrus paniculatus*), which help prevent memory impairment and oxidative stressand prevent deposition of amyloid-β plaque in the brain[11-14]Working memory is important for reasoning and guidance of decision making and behavior. It temporarily holds the information available for processing. Working memory and reference memory are the two variables that report the physiological status of the brain and this suggest the increase in the behavioural parameters which again proves that *Saraswataarishta* has the ability to sustain memory and promote learning and memory performance [15] Acharya Charaka described four Medhya *Rasayanas* e.g., *Mandukparni Swarasa, YashtimadhuChurna, Guduchi Swarasa,* and *Shankhapushpi Kalka* for improving the intelligence.[16] These drugs can be used singly or in combinations [17]*Vacha (Acorus calamus Linn.) Churna was prescribed for vak-shudhhi (Speech enhancer) by Acharya Vaghbhata.*[18] *Vacha*is *Medhya, Deepana, Sangyasthapaka, and Vaathara* (improves memory, improves digestion, increases *retention power, and cures Vata disorders)*[19]Vacha is known to calm nerves and helps improve a person's memory. Being similar to a nerve tonic it helps a person to relax and rid one's self off stress and depression. [20] *Yastimadhu* was prescribed as the roots and rhizomes of Glycyrrhiza glabra is efficient brain tonic; it increases the circulation into the CNS system [21] Liquorice of *yastimadhu* has significant action on memory enhancing activity [22] Methanolic extract of *A. racemosus* has shownsignificant antidepressant activity[23*] Ashwagandha* has been historically used in traditional Ayurvedic medicine for memory enhancement and improvement in cognition[24,25] possibly by acting as a GABA mimetic [26], a cholinomimetic [27]*Guduch*i has neuro-protective activity, learning and memory enhancing activity [28] antioxidant activity [29, 30]*Guduchi* helps in cognitive enrichment by increase production of acetylcholine, which enhances choline. [31] *Shankhapushpi* is also effective in anxiety, neurosis, insomnia, cerebral abnormalities and serve as effective nervine tonic.[32] *Shankhapushpi* enhances memory function due to its Antioxidant and Acetyl cholinesterase Inhibitory Properties [33] Autistic children lack the feeling of affection or a desire to interact with others.[34] In Unmad, the higher mental functionality altered and distorted reality perception.[35] *Ghrita* is considered applicable for the treatment in combination with single drug and other nootropic drug and mood stabilizing drugs.

The DHA, an omega 3 long chain polyunsaturated fatty acid is abundant in ghee which is seen in brain cells [36]. The Ingredients of Brahmi *Ghrita* [37] which increased Mental Stability, increased Concentration. Improves Intelligence, improves learning skills & speech, improves skin texture, increases cheerfulness, removes depression & stress in unmad [38] Thus molecules in the circulation gain access to brain ISF (interstitial fluid) via only one of the two mechanisms: (1) lipid-mediated free diffusion through the BBB or (2) carrier- or receptor-mediated transport (RMT) through the BBB. Ghee being a lipid in nature is rapidly cross the BBB and make the drug available in the CNS.[39] The study has internal medication and Panchakarma in the management of ASD.While performing the procedure, it consists of three parts: *Poorva Karma, Pradhana Karma*, and *Paschat Karma*. Almost all studies follow the treatment principle [40] of *Unmada* in ASD, according to the line of management patients suffering from *Unmada* should be administered *Pradeha* (thick ointment), *Utsadana* (anointing), *Abhyanga* (massage), *Dhuma* (fumigation), and intake of *Ghrita* to arouse mind, intellect, memory, and consciousness. *Tikshna Nasya* (irritant snuffing) and *Anjana* (collyrium) should also be used. Here, study have included *Abhyanga* [41-43] as a therapeutic procedure for ASD. The study suggests children with ASD have impairments in muscle strength in comparison to healthy peers.[44] *Abhyanga* [45] comes under *Poorva Karma* it improves blood supply to muscles, activates the skin's sensory nerve endings, and reduces muscle fatigue and pain.[45] Abhyanga (massage) is useful in reducing subjective stress.[47]. It has been shown anxiety, enhanced performance of alertness and also reduces subclinical depression.[48]Massage has been used in an effort of improve symptoms, disease progression, and quality of life. Considering the dominance of *Vata Dosha* in this condition, *Bala ashwagandha taila* was used for *Abhyanga* (Massage) to alleviate the *Vata Dosha.* The nose is said to be the path of the brain. *Nasya* administered through the nostrils reaches up to*Sringataka Marma*, spreads all over *Urdhvajatru*, an deliminates the deep-seated *Dosas*.The dose of *Nasya* was calculated using the child's index finger where we soaked the finger into the *Sneha* i.e., *Brahmi Ghrita* Considering the *Sneha Nasya* dose mentioned by *Acharya Sushruta* in *Chikitsa Sthana,* as 4 *Bindu(Heena),*[49]we took *Heena matra* for *Nasya* considering the irritability and age in this case which was equivalent to 0.8 ml. *Ghrita* gave a remarkable improvement in the patient. Using the CHSQ some sort of improvement was observed like goes to bed at same time, falls asleep in own bed, falls asleep in 20 min, sleeps the right amount and sleep same amount each day. The ISAA score pre-treatment assessment was 96 which came down to 84 post-treatment assessment. Social relationship and reciprocity score came down from 31 to

24. Emotional responsiveness score from 10 to 8. Speech-language and communication treatment, BT-Beforecommunication from 20 to 19. Behavior patterns from 20to 18. Sensory aspects from 7 to 7. Cognitive componentfrom 8 to 8. There seemed not much improvement inthe speech-language and communication domain. Clinicalimprovement in eye contact, peer relationship, and a decreasein hyperactivity were also observed in the child. CSHQ wasused to assess the sleep pattern, it has been found that a sort of improvementwas noticed in the sleep patternof the patient. No adverse effects were reported during the treatment period and follow-up.

CONCLUSION

The present case report has shown a good response of Ayurveda Panchakarma and oral drugs in the child with autism. Behavior interventions and occupational therapies are the mainstays of conventional therapies in ASD management. Ayurveda therapy can play an important role in this domain and it is proposed through this case report that if Ayurveda therapy is given along with behavior therapy and occupational therapy, additional benefits can be expected in children with ASDs.

Informed consent
Informed consent was obtained from the parents for documentation and publication of the case.

Declaration of patient consent
The authors certify that they have obtained all appropriate patient consent forms. In the form, the legal guardian has given his consent for images and other clinical information to be reported in the journal. The guardian understands that names and initials will not be published and due efforts will be made to conceal patient identity, but anonymity cannot be guaranteed.

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Conflicts of interest
There are no conflicts of interest.

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Table : 1 Anthropometry measurements

SR. NO	DIMENSION	ANTHROPOMETRY MEASUREMENTS
1	Height	95 cm
2	Weight	15.8 kg
3	Mid upper arm circumference	17.5 cm
4	Head circumference	51 cm
5	Chest circumference	55 cm

Table 2: Therapeutic intervention medication

Serial number	Intervention	Dose	Frequency	Timing	Duration
1.	*Chitrakadi vati*	250 mg	Twice a day	Before meal	5 days
2.	Tab S*mrutisagar Rasa*	125 mg	Twice a day	After meal	4 months
3.	*Saraswataaristha*	10ml	Twice a day	After meal	4 months
4.	*Vacha +Yastimadhu+Shatavari + Aswagandha+ Guduchi+Shankhpuspiphanta* preparation	50 ml	Twice a day	After meal	2 months
5.	*Brahmi Ghrita*	5ml	Once a day	Empty stomach	1 week
6.	*Panchakarma* procedures At panchakarma unit KB department *Bala Aswagandha taila* followed by P*ratimarsha Nasya*with *Brahmi Ghrita*2 drops in each nostril 21 days in each month At home *Bala Aswagandha Taila*followed by *pratimarsha Nasya*with *Brahmi Ghrita*2 drops in each nostril for 21days in each month. **NOTE:** (Standard operative procedure was explained to parents in detail)	*Sarvanga Abhyanga* *Sarvanga Abhyanga*	Once a day for 15 min OD	Morning (9:00 A.M - 10:00 A.M) Morning (9:00 A.M - 10:00 A.M)	1 month 21 days 2 months

Table 3: Indian Scale or Assessment of Autism Test Manual

Domain	Number of questions	BT	AT	% Relief	Significance Level
Social relationship and reciprocity	9	31	24	22%	S
Emotional responsiveness	5	10	8	20	NS
Speech-language and communication	9	20	19	5	NS
Behaviour patterns	7	20	18	10	NS
Sensory aspects	6	7	6	14	NS
Cognitive component	4	8	7	12	S
Total score		96	84	12	NS

AT-After treatment, BT- Before Treatment

Table 4: children's sleep habits questionnaire (abbreviated)

Domain	BT	AT	% relief
1. Bedtime resistance			
Goes to bed at same time R*	2	3	33%
Falls asleep in own bed R*	1	3	66%
Falls asleep in others bed	2	1	50%
Needs parent in room to sleep	3	3	0%
Struggles at bedtime	2	1	50%
Afraid of sleeping alone	3	1	66%
2. Sleep-onset delay	1	3	66%
Falls asleep in 20 min R*			
3. Sleep duration			
Sleeps too little	3	1	33%
Sleeps the right amount R*	1	3	33%
Sleeps same amount each day R*	1	3	33%
4. Sleep anxiety			
Needs parent in room to sleep	3	3	0%
Afraid of sleeping in the dark	3	1	66%
Afraid of sleeping alone	3	3	0%
Trouble sleeping away	3	1	66%
5. Night walking's	2	1	50%
Moves to others bed in night	2	1	50%
Awakes once during night	3	1	66
Awakes more than once	3	1	
6. Parasomnias			
Wets the bed at night	2	1	50%
Talks during sleep	1	1	0%
Restlessness and moves a lot	1	1	0%
Sleep walks	1	1	0%
Grinds teeth during sleep	1	1	0%
Awakens screaming, sweating	1	1	0%
Alarmed by scary dream	1	1	
7. Sleep disordered breathing	1	1	0%
Snores loudly	1	1	0%
Stops breathing	1	1	0%
Snorts and gasps	1	1	0%
8. Daytime sleepiness	3	1	33%
Wakes by himself R*	2	1	50%
Wakes up in negative mood	1	1	0%
Others wake child	3	1	66%
Hard time getting out of bed	2	1	50%
Takes a long time to be alert	3	1	66%
Seems tired	2	1	50%
Sleeps while watching TV	1	1	0%
Sleeps while riding in car	1	1	0%





Fig: 1 *Sarvanga Abhyanga* with *Bala Aswagandha TailaNasya* with *Brahmi Ghrita*



Fig: 2

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RESEARCH ARTICLE

Effect of *Bauhinia tomentosa* Leaves on Epigenetic Markers in A549 Lung Carcinoma Cells

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ABSTRACT

Epigenetics is defined as a heritable change in gene activity and expression that occur without alterations in DNA sequence. Epigenetic modifications are reversible that makes them a potential method for providing cancer preventive and therapeutic strategies. *B. tomentosa* is a medicinal plant that belongs to the *Caesalpinaceae* family. It has many potential phytochemicals which confer antioxidant, anti-inflammatory and anticancer activity to the plant. The present study is aimed at to investigate the effect of ethanol extract of *B. tomentosa* (EBT) on various epigenetic markers like DNMT 3a, DNMT 3b, HDAC1, H3 and Acetyl Histone proteins in lung cancer cell line, A549. The expression of these protein markers was studied by western blotting method. From the results, it was observed that the EBT down regulated the expression of pro carcinogenic markers like DNMT3a, DNMT 3b and HDAC1. The expression of anti-carcinogenic markers H3 and Acetyl histones were upregulated by EBT. Hence it can be concluded that EBT has potential anti-cancer effect at the epigenetic level also. Further identification and isolation of active principle may throw light in the path of drug discovery for lung cancer.

Keywords: Bauhinia, Lung cancer, medicinal plant, epigenetic marker, anticancer

INTRODUCTION

Phytochemicals in diet plays a vital role in the pathogenesis of many diseases and also form key regulator in normal physiological process. Diseases which are linked to modifications in genetic or epigenetic markers are influenced by various environment and dietary factors. Especially, phytonutrients, drugs, chemicals that are used in pesticides, inorganic contaminants like heavy metals and various other environmental compounds are capable of altering the epigenome which may further contribute to the development of abnormalities or disease conditions. Phytochemicals present in grains, vegetables, fruits and spices were known to have potential anticancer properties. Nowadays there has been a considerable interest in the usage of such naturally occurring phytochemicals for the prevention of many ailments including cancer. Various studies have demonstrated that these phytochemicals might exhibit their properties through diverse complementary and overlapping mechanism of action which includes induction of detoxification enzymes, inhibition of nitrosamines formation, antioxidant/free radical scavenging activity, binding/dilution of carcinogens in digestive tract, alteration in hormone metabolism and modulation of carcinogenic cellular/signaling events (Wang *et al*., 2012). Recently, many studies have demonstrated that phytochemicals may target various epigenetic factors like DNA Methyl transferase (DNMT) and Histone Deacetylase (HDACs) and these could be useful in prevention and treatment of many diseases including cancer. In lung cancer, hypermethylation of promoter CpG islands of tumor suppressor genes are associated with specific histone markers such as deacetylation of histones H3 and H4. In addition, histone H2 and H3 acetylation and trimethylation status were also detected in Non- small cell lung carcinoma (NSCLC) and Small cell lung carcinoma (SCLC) (Van den Broeck *et al*., 2008). Besides, methylation of promoter processes begins in early phases of lung cancer pathogenesis itself and its detection in the sputum of smokers with dysplasia have identified individuals whom were at increased risk (De Fraipont *et al*., 2005). DNA methylation predicts the early recurrence in stage I NSCLC (Brock *et al*., 2008). *Bauhinia tomentosa,* commonly called as *Thiruvachi* in Tamil and Yellow bell orchid tree in English falls under *Caesalpinaceae* family. It is one of the versatile medicinal plant used as home remedy for various ailments including abdominal problems, liver diseases, antidote for snake bite and scorpion sting, etc (Kirtikar and Basu, 2006). Different parts of this medicinal plant are used for the treatment of many diseases in traditional system of medicine and also in folklore medicines (Mannangatti *et al.,* 2010; Aderogba *et al.,* 2008; Kannan *et al*., 2010). Previous studies of the authors have evidenced the anticancer and apoptosis inducing potential of *B. tomentosa* (Balabhaskar and Vijayalakshmi, 2019)). Since the data on effect of *B. tomentosa* on epigenetic markers are scarce, the present study was aimed at to evaluate the effect of *B. tomentosa* on the regulation of key epigenetic markers of lung cancer using A549 cell lines.

MATERIALS AND METHODS

Plant Collection and authentication

B. tomentosa leaves for the study was collected from Chennai and authenticated by Director, Plant and Anatomy Research Centre, West Tambaram, Chennai (PARC/2014/2294).

Sample preparation

After washing the collected leaves with water, it was dried in shade, and made into coarse powder. Crude ethanol extract was obtained after soaking with 95% ethanol at room temperature for 72 h and the process was repeated till exhaustion of the material. Then, the ethanol crude extract was distilled, evaporated, and dried under reduced pressure to yield ethanol extract of *B. tomentosa* leaves, EBT.

Cell lines and Chemicals

A549, human lung adenocarcinoma cell line was purchased from National Centre for Cell Science (NCCS), Pune, India. It was maintained in RPMI 1640, with 10% Fetal Bovine Serum, 2% antibiotic (penicillin) in a humified atmosphere of 5% CO2 at 37C till it reaches confluence. The stock cultures were sub cultured in culture flask and used for the experiments in 96 well plate. Rose well Parker Memorial Institute (RPMI) medium, Fetal calf serum

(FCS), DMSO, penicillin-streptomycin solution, and all other reagents used in the present study were of analytical grade and purchased from Himedia, Mumbai. Antibodies used for the study was purchased from Santacruz biotechnology Inc, USA. Aprotinine, NP-40, Tris –base, TBST, PMSF, PBS were of Sigma make, USA. All other chemicals and reagents used were of analytical grade.

Epigenetic markers studies

Preparation of the Protein extracts

A549 Cells (1.5×10^6) were seeded onto 100-mm culture dishes in the presence or absence of extract, and were treated for 24h with 100, 150 and 200 μg/mL concentrations. The medium was then removed and the cells were washed with 0.01M PBS (pH 7.2) for many times and lysed on ice in lysis buffer (100 μg/ml phenylmethylsulfonyl fluoride (PMSF), 50 mM Tris–base at pH 8.0, 150 mM NaCl, 1% NP-40, and 1g/ml aprotinine). After centrifugation at 10,000×g for 5min at 4°C, the supernatants were collected and this was used as cell protein extracts. Concentration of the protein yield was estimated using a protein assay kit (Bio-Rad).

Western Blotting

Western blotting was carried out as described previously by Tu *et al.,* (2004). Cell protein extract obtained as mentioned above were applied to 12% SDS–polyacrylamide gel and electro transferred onto PVDF membrane. Proteins were blocked overnight with 5% non-fat dried milk in PBS-T at 2-8°C. After washing in PBS containing 0.1% Tween 20 for 3 times, the membrane was incubated with the specific primary antibodies and kept for overnight incubation at 4°C. Then the membrane was washed thrice with TBST and incubated further with alkaline phosphatase conjugated goat anti-mouse antibody, or anti-rabbit antibody at room temperature for 2 hours. Followed by three times wash with TBST, horseradish peroxidase-conjugated goat anti-mouse antibody was added and the immune complexes were visualized by chemiluminescence ECL PLUS detection reagents following the manufacturer's procedure (Amersham Bioscience).

Statistical Analysis

The statistical analysis was performed using SPSS version 20 from IBM. The results were expressed as mean ± SD. One-way analysis of variance was applied to the data and the significance of the results were derived by running post hoc test. $P<0.001$ was considered statistically significant. Graphs were plotted using graph pad prism."

RESULTS AND DISCUSSION

Epigenetic processes are natural and they play a key role in many biological functions of living organisms. Unlike genetic modifications, changes in epigenetic genes are reversible and it can be altered by various intrinsic and extrinsic factor like environmental stimuli, diet or therapeutic interventions, etc (Jaenisch and Bird, 2003). Various researchers have evidenced that dietary phytochemicals present in fruits, vegetables which were known only for their antioxidant or chemo preventive effects earlier were found to potent epigenetic modulators. These epigenetic markers could target any abnormal modification or can revert the abnormalities which leads to various ailments including cancer (Gerhauser, 2013; Fabbri *et al*., 2007; Huang *et al*., 2011; Thakur *et al*., 2014; Hauser and Jung, 2008). Epigenetic mechanisms like methylation at promoter DNA sequence, histone modification, mi-RNA mediated post-transcriptional modifications can silence the critical tumour suppressor genes, cell cycle regulators, nuclear receptors, signal transducers, apoptotic genes & its products and DNA repair gene products ultimately contribute to carcinogenesis. Targeting such epigenetic modifications has gained much attention in cancer chemoprevention research because all these alterations are reversible and occur only during early carcinogenesis. Dietary phytochemicals exhibit enormous chemo preventive potential due to their ability to alter DNA methylation, histone modifications and mi-RNA expression. Herbal medicines are capable of regulating the epigenetic mechanisms involved in lung cancer. Most of the herbal medicine and its bioactive components targets DNMTs and HDAC activity to combat cancer through epigenetic regulation (Giaginis *et al*, 2014; Yuan *et al*., 2019). DNMT mediates specific methyl transfer in DNA which leads to epigenetic silencing of multiple genes (Mirza *et al*., 2013). Whereas,

HDAC mediates deacetylation of lysine residues in N-terminal of histone proteins and regulates the expression of related genes (Verdin *et al*., 2003). *B. tomentosa* was a well-known medicinal plant which has much therapeutic and chemo preventive value. The effects of EBT on the selected epigenetic markers are presented in Figures 1-5. The expression of DNMT 3a was significantly ($p<0.001$) down regulated by EBT at a concentration of about 150 µg/mL and 200 µg/mL (Figure 1) whereas DNMT 3b expression was down regulated significantly ($p<0.001$) at 200 µg/mL concentration (Figure 2). Thus, it was evident that EBT could prevent DNA methylation and thus prevents carcinogenesis process. Several dietary polyphenols act as potential DNMT inhibitors. These polyphenols have ability to reverse methylation-induced gene silencing and thereby restores the expression of various tumour suppressor genes (Priyadarsini *et al*., 2011; Tan *et al*., 2009; Lee *et al*., 2005; Berger *et al*., 2013; Kim *et al*., 2015). Since *B. tomentosa* was rich in polyphenols like quercetin, Kaempferol, rutin, etc., it can act as a good DNMT inhibitor.

Figure 3 depicts the effect of EBT on HDAC 1 activity. At 150µg/mL and 200 µg/mL concentration, EBT could significantly down regulate the expression of HDAC 1. Various secondary metabolites like polyphenols are known to have strong HAT and HDAC inhibitory activities. Alkaloids and quinones have the ability to act on HDAC. Emodine, a quinone was found to inhibit HDAC and thereby increases the acetylation of histones (Godoy *et al*., 2017). Rajendran *et al* (2011) has reported that curcumin decreases histone acetylation by inhibiting HAT activity but without altering HDAC levels in human hepatoma cells. Bora-Tatar *et al* (2009) has demonstrated that curcumin is a potent HDAC inhibitor. Another flavonoid called Kaempferol have hyperacetylaed H3 in hepatoma cell lines, HepG2 and Hep 3B. This kind of effect observed could be because of inhibition of class I, II and IV HDAC enzymes. Since, *Bauhinia tomentosa* contains polyphenols like quercetin, kaempferol, quinones and alkaloids as their constituent phytoconstituents, it could effectively inhibit HDAC enzyme and thereby acts as a chemo preventive agent.

Figure 4 and 5 depicts the effect of EBT on H3 and Acetyl histone proteins. From the results, it was evident that EBT could upregulate the expression of both the proteins at 150 µg/mL and 200 µg/mL ($P<0.001$). As EBT acts as a potent HDAC inhibitor, it could prevent the deacetylation of histones and thus prevent epigenetic modifications which lead to lung cancer. Lee *et al* (2011) have demonstrated that quercetin have increased the acetylation of H3 histone through HAT activation in HL-60 cells. Lu *et al* (2016) have also evidences that Jinfukang (JFK), a Chinese traditional medicine which was used regularly in practice for lung cancer treatment also works through epigenetic modifications. JFK able to reduce the H3K4me3 modification levels of various genes like PTN, BCL2A1, IL31RA, WISP2 and TMEM158etc, in A549 cells. All these studies have strongly demonstrated the potential role of herbal medicine for therapeutic use for lung cancer. As *B. tomentosa* was rich in many polyphenols like quercetin, similar effect was observed in the present study also. These results indicate that the phytochemicals of *B. tomentosa* have potential to prevent carcinogenesis by acting on the key regulatory epigenetic markers of lung cancer in A549 cells. Thus, it can be concluded that the phytochemicals present in *B. tomentosa* have chemo preventive activity through epigenetic regulations also.

CONCLUSION

Prevention is better than cure, this phrase holds true for complex and dreadful diseases like cancer. Various cellular functions and important cell signalling pathways are dysregulated in cancer through epigenetic modifications of critical tumour suppressor genes via methylation of promoter CpG islands, acetylation or methylation of histone and some non-histone proteins. Herbal medicine plays a very important role in epigenetic regulation of cancer development. *B. tomentosa*, a versatile medicinal plant which has various pharmacological activity was also proved to have potent anticancer property. From the results of the present study, it was scientifically validated that EBT have positive effect on the reversion of cancer in A549 cells. Further research in future are very much essential to translate this effect of EBT to pre-clinical cancer models and also in humans. Elaborative studies are also warranted to elucidate the molecular pathways involved in the epigenetic modifications of lung carcinogenesis.

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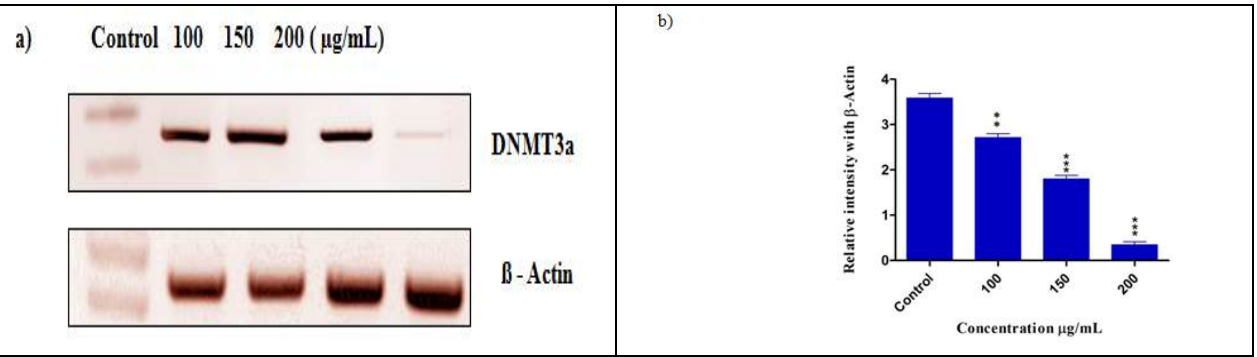


Figure 1. Effect of EBT on DNMT 3a Protein

a) Immunoblot of effect of EBT on various proteins with β-actin as control.
b) Graphical representation of effect of EBT on various protein expression
Each bar represents mean ± SD of 3 independent observations
Proteins level were normalized to β-actin level by using a Molecular Dynamics densitometer and expressed as relative intensity with β-actin.
Statistical significance: *** - p<0.001, ** - p<0.01, *- p<0.05
The comparison was done between control with other groups.

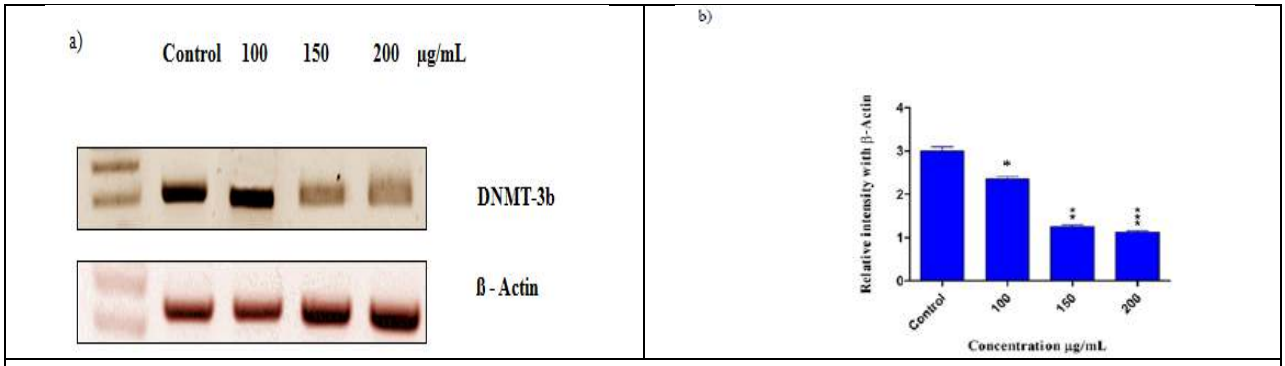


Figure 2. Effect of EBT on DNMT 3b Protein

a) Immunoblot of effect of EBT on various proteins with β-actin as control.
b) Graphical representation of effect of EBT on various protein expression
Each bar represents mean ± SD of 3 independent observations
Proteins level were normalized to β-actin level by using a Molecular Dynamics densitometer and expressed as relative intensity with β-actin.
Statistical significance: *** - p<0.001, ** - p<0.01, *- p<0.05
The comparison was done between control with other groups.

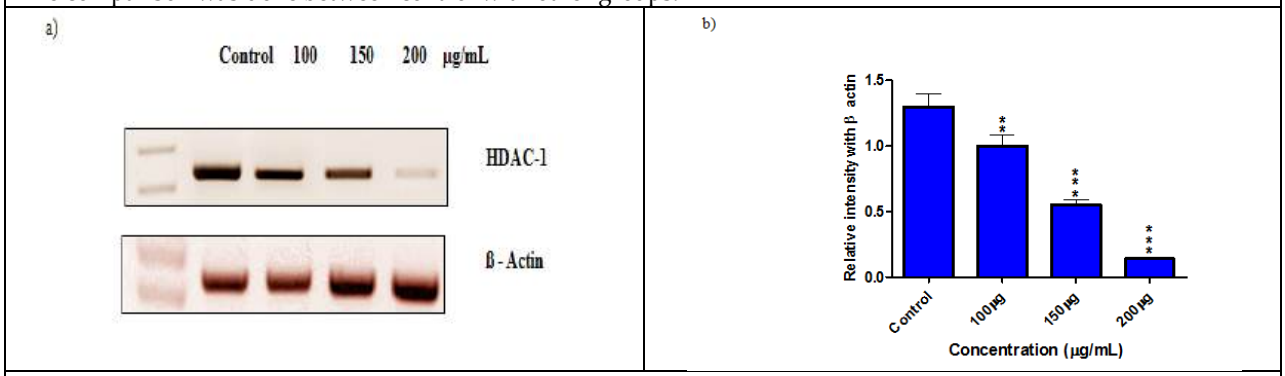


Figure 3. Effect of EBT on HDAC – 1 protein

a) Immunoblot of effect of EBT on various proteins with β-actin as control.
b) Graphical representation of effect of EBT on various protein expression
Each bar represents mean ± SD of 3 independent observations
Proteins level were normalized to β-actin level by using a Molecular Dynamics densitometer and expressed as relative intensity with β-actin.
Statistical significance: *** - p<0.001, ** - p<0.01, *- p<0.05
The comparison was done between control with other groups.

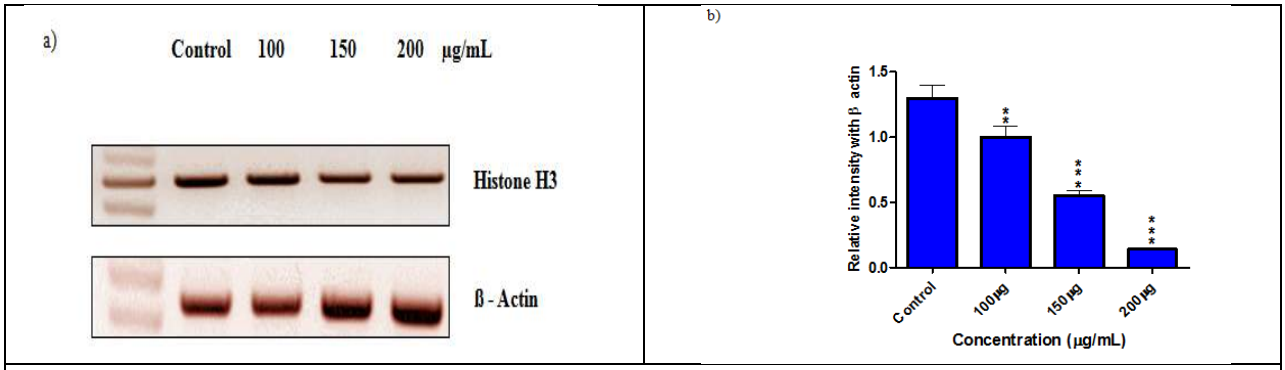


Figure 4. Effect of EBT on Histone protein

a) Immunoblot of effect of EBT on various proteins with β-actin as control.

b) Graphical representation of effect of EBT on various protein expression

Each bar represents mean ± SD of 3 independent observations

Proteins level were normalized to β-actin level by using a Molecular Dynamics densitometer and expressed as relative intensity with β-actin.

Statistical significance: *** - p<0.001, ** - p<0.01, *- p<0.05

The comparison was done between control with other groups.

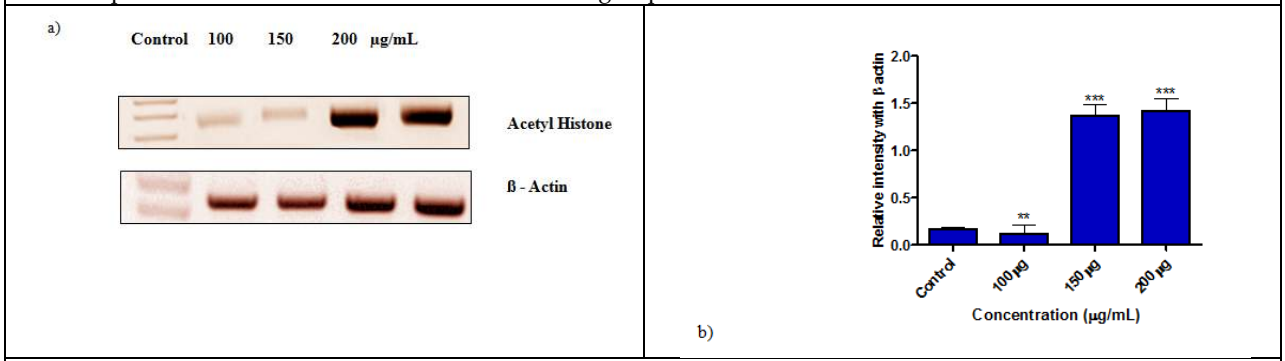


Figure 5. Effect of EBT on Acetyl Histone protein

a) Immunoblot of effect of EBT on various proteins with β-actin as control.

b) Graphical representation of effect of EBT on various protein expression

Each bar represents mean ± SD of 3 independent observations

Proteins level were normalized to β-actin level by using a Molecular Dynamics densitometer and expressed as relative intensity with β-actin.

Statistical significance: *** - p<0.001, ** - p<0.01, *- p<0.05

The comparison was done between control with other groups.

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RESEARCH ARTICLE

Emphasising Reading for Enhanced Soft Skills among Tertiary Level Students: Inspirational Literature an Apt Tool

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ABSTRACT

Reading inspirational literature enables the readers to explore new ideas and complex emotions and it also produces a kind of reality simulation that runs on the minds of the readers just as a computer simulation. Books on inspirational literature will improve the reading habit and inculcate soft skills in students at tertiary level. Graduates of today need to meet the requirements of the corporate world and sustain in their career. The study explores the main ideas of the select works to prove the prevalence of soft skills in them which help them deal with difficult situations in their lives. By highlighting the positive elements in the chosen works, otherwise called soft skills, the study helps the readers realise the fact that there is a Frederick Henry and a Santiago in every individual and the discovery of the potential in them enhances their personal qualities for an enhanced personal and professional life.

Keywords: Reading habit, inspirational literature, life skills, self-motivation and visualization.

INTRODUCTION

Reading skill is vital for any human being to function, contribute and develop in today's society. There is strong evidence that reading plays a vital role in improving one's perception about life, personal achievements, educational outcomes etc. Educational researchers have found a correlation between reading and personality development. Reading habit helps the readers to nourish and stimulate their minds and keep the mental faculties sharp and intact. It builds empathy and improves thewell-being of the mind. According to a recent research, people who read regularly are on an average happier and more satisfied in life. Smith & Robinson (1980) define reading as an active

attempt on the part of a reader to understand a writer's message. According to Toit (2001) reading is the process of thinking, recalling and relating concepts under the functioning of written words. Devarajan (1989) defines reading as the art of interpreting printed and written words. Irvin (1998) describes the reading process as the interaction of what is in the head with what is on the page within a particular context that causes students to comprehend what they read. The importance of regular reading is undeniable, particularly, in higher education where texts are the main sources of information. Thus, reading is the ability to recognise and examine words or sentences and understand the information within. It is a cognitive process of understanding a written linguistic message and to examine and grasp the meaning of written or printed words.

People read for different reasons and purposes, some of which include pleasure, leisure, relaxation, information and knowledge. Reyhene (1998) observes that when children read for pleasure, they involuntarily and unconsciously improve their language skills. Bignold (2003) indicates that the habit of reading improves children's reading skills. Hence, the issue of reading whether it is for learning or leisure is important since it helps broaden young people's experiences and knowledge says Green (2002). Reading habit contributes to psychological traits such as the ability to concentrate and strong self-discipline. Since reading opens a window to the world, it allows the reader to adapt easily in a variety of social situations. Reading is an important communicative process and reading skill is required for academic and professional progress. It is an important gateway to personal development, and to social, economic and civic life (Holden, 2004). It allows one to learn about other people, about history and social studies, language, arts, science, mathematics, and the other content subjects that must be mastered in school (Lyon 1997). Huey (1968) defines reading as the complicated working of the human mind. Students, who read actively and frequently, improve their comprehension of text as a consequence (Cipielewski & Stanovich 1992).

Reading often can increase sight word recognition, vocabulary, fluency, text comprehension, as well as knowledge (Morgan & Fuchs 2007). Studies show that students who like to read score better in most subjects than students who do not like to read (Krashen 2004).Students who struggle with reading, often avoid the discomfort by choosing not even to try. Several researches show that the more the students read, the better they read and the more pleasure they get out of reading for, it lowers stress levels, encourages positive thinking and strengthens relationship. Reading inspirational literature enables the readers to explore new ideas and complex emotions and it also produces a kind of reality simulation that runs on the minds of the readers just as a computer simulation. Books on inspirational literature are used for the present study to improve the reading habit and inculcate soft skills in students at tertiary level. Graduates of today need to meet the requirements of the corporate world and sustain in their career. So, in order to improve their expertise to face the job market and also enhance their personal skills, inculcating soft skills in them is the foremost objective of modern curriculum. Soft skills are a cluster of productive personality traits that characterise one's relationships in a milieu. Soft skills may include an individual's ability for leadership, his or her oral and written communication, the willingness and aptitude for team-work, aptitude for conflict resolution and problem solving, the ability and willingness to learn, and the work ethics (Case 1998; Fann & Lewis 2001; Nelson et al. 2001; Taylor 2005a). They are vital for personal well- being and also form an important part of an individual's contribution to the success of an organisation.

Soft skills are increasingly sought out by employers in addition to standard qualifications. In the workplace, soft skills are considered as complement to hard skills. Soft skills are vital for all graduates regardless of their field of study. It is necessary for them to get acquainted with the behavioural skills of the work place as Stephen Johnston and Helen McGregor (2005) view. Modern professional practice requires not only the recognized technical skills, but also high-level of generic or soft professional skills. Recent professional laxity claims suggest that technically well-qualified professionals with deficiencies in these generic skills may fail to effectively identify and satisfy client requirements. Soft skill is an abstract concept, which is, in fact, a compendium of several components like attitude, abilities, habits and practices that are combined adeptly to maximise one's work effectiveness (Ramesh Gopalasway & Ramesh Mahadevan 2010). Roselina (2009) argues that soft skills are quite different as compared to core or hard skills that tertiary students need to acquire and master. Hard skills are those that are needed to perform a particular job. These often vary depending on the type of role that will be performed or the industry will be looking for. They

can usually be developed through studying and training. Compared to soft skills, hard skills are normally easy to observe and evaluate because they involve specific skill sets related to the particular job of a worker (Pool & Sewell 2007). Hard skills are very much related to the technical procedures based on the core business of an organisation and they can be administrative. Books on inspirational literature contain stories of people who overcome adversity and reach new levels of success that inspire and encourage readers to follow the lessons they carry. The genre inspirational literature is meant to uplift critical thinking as well as provide entertainment to the readers. It requires more than just a positive character; it requires encouragement and the ability to inspire others with the realisation that they can do great things and be better people. Books on inspirational literature have been read and followed by people right from their primary education to higher education periods. While reading great literature is a privilege for some, others consider it difficult, time-consuming and inherently stodgy.

But most will agree that the more effort invested in reading books on inspiration, the greater the return and it can earn high yields in one's career and personal life. Understanding the actions of the characters in these texts will open the inner resources of a person's intuition, logic and potential. In the present world of technological advancement, the study of humanities is essential since civic responsibilities from ethics to moral intelligence are lacking more than ever before. The superhighway of information overload is a crippling side-effect from the insatiable hunger for the most current news, trend, or market flinch and to "turn-off" is becoming more difficult. Be it family, workload, financial constraints, or other personal reasons, the crucial point to live life in the present for a better tomorrow makes a person free and a fuller human being. The anxiousness to be always doing something and the inability to be alone with oneself is a detriment. Business has reached extraordinary levels of competition, appropriate educational qualifications, and prolific work experience. Though reading literature does not reconcile the financial statements for an annual report, maximise a profit margin or re-align a product campaign, the values and insights that the reader glean from inspirational literature sensitise themselves to problems inherent in managing people at home or in an organisation. Reading great literature can start one's journey to enlightened mind and spirituality thereby prepares an individual to face the challenges of modern life. It provides a moral imagination with interaction. It is a supplement to elevate the worldly intuitiveness and rationality. The reflections upon the actions and consequences literary figures have on their attitudes, beliefs, and concerns will always encapsulate the desire for power, self-esteem, freedom, solidarity and virtue. It is the practicality towards the human condition that can be assimilated and aggregated into the profession and personal leisure of the reader. Books written by writers like Robin Sharma are helpful in the comparison of literary works to the everyday corporate contexts.

CONCLUSION

Though students at the tertiary level possess certain people skills due to their background and exposure, they are inadequate to impress the recruiters. The corporate sectors seek and opt for candidates who not only have the requisite academic qualifications but also soft skills to function in the competitive corporate setting where they have to deal with people of different culture. So, training in soft skills has become compulsory for today's graduates. Universities and colleges all over the world adopt many training techniques considering the industrial scenario and to cater to the needs of students. Training in soft skills is one such indispensable part of academics that helps students become dynamic in their career. An important inquiry here is whether traits like team leadership, team building, assertiveness, perseverance, strategic planning, facilitating, mentoring, learning from criticism, conflict resolution and diversity awareness can be taught. The answer is 'yes'. It is possible by choosing an appropriate mode of training depending on the level of the students. The method of teaching must show some variation from the regular pedagogical methods like delivery of lectures and demonstration of concepts and themes. A different approach is needed for creating interest among the students. Soft skills training accompanied by reading and performing activities will definitely help the students acquire the skills easier and perform better. As lecturing method continues to be the most popular method of teaching, it should also be a part of the training. One of the best ways to acquire soft skills is reading books on literature especially inspirational literature. Unlike training drives or lecture on soft skills, reading inspirational literature offers cues and invites readers to draw their own inferences. By

engaging the reader in drawing inferences about what characters in the stories are feeling, inspirational literature is very much like a conversation and introspection into one's own self. Learning about the inner states of others through reading inspirational literature will prompt the readers to explore themselves and improve their personalities and, in the process, they become more open and aware of other people's feelings. This helps in enhancing their soft skills. Reading also gives the opportunity of exploring the subjective world of its characters and provides social expertise to the readers. The style and figurative expressions used in any work of literature put the reader through an emotional experience similar to that of the protagonist. Like dance or music, inspirational literature offers a distinct experience to the reader which is beyond comparison. Hence, reading can be considered one of the best ways to acquire people skills or soft skills. Literature, which is a mirror of human lives, can be used in classrooms to introduce and enhance the students' knowledge of soft skills. Since it distinguishes itself from other types of academic discourse, literature urges the reader to adopt an interactive approach to acquire soft skills or people skills. It can familiarise students with the formation and function of sentences, the different ways of connecting ideas and provide a good training ground for improving reading skills and soft skills. Reflecting on the central role of life experiences in shaping one's self-concept, attitudes, and behaviors, Hayakawa an educational researcher suggests that literature has the ability to produce profound changes in individuals by affording them the experience of an almost infinite number of alternative lives and personas. Hence, reading motivational literature that emphasises on the virtues of possessing soft skills will really bring a change in the attitude of the readers leading to a positive and permanent transformation in them.

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RESEARCH ARTICLE

Synthesis, Growth and Characterization Study of Nonlinear Optical Studies of Zinc 3-Phenylprop-2-Enoate for Frequency Conversion

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ABSTRACT

This is the first time 3 phenyl 2- bromophenol(3P2BP) of a new organometallic nonlinear optical crystal has been reported in the literature. It was synthesized and grown at room temperature by the slow evaporation method. The cell parameters of the 3 phenyl 2-bromophenol (3P2BP) crystal are confirmed by using powder X-ray diffraction. And single X-ray analysis. This research is concerned with the nonlinear optical, fluorescence, UV, FT-IR, thermal and structural properties of organically grown 3 phenyl 2-bromophenol(3P2BP) single crystals. By employing Fourier Transform Infrared (FT-IR) spectral analysis, the functional groups and characteristic vibrations of 3 phenyl 2-bromophenol(3P2BP) crystals were determined. UV- visible NIR spectrum analysis showed the optical quality of the grown crystal. The high optical transmittance is evidence by the grown crystal in the range of 200-1100 nm.

Keywords: Crystal growth, UV-visible, FT-IR, SEM, Fluorescence

INTRODUCTION

Nonlinear optical (NLO) materials have played a significant role in advancing contemporary technology, which in essential broadens their applicability in technological and industrial processes. The past few years have witnessed an abundance of studies focused on synthesizing newer NLO materials whose properties match other NLO materials because of their extensive use for opto electronics, photonics, broad terahertz imaging and spectroscopy, laser remote sensing, optical information processing, optical switching, pharmaceuticals, color display and frequency conversion. Thus, the growth and merging of novel organic, semi-organic and inorganic NLO materials has hence become a topic of great scientific interest. Organo-metal crystals are unique here as potentially very promising due to their huge spontaneous birefringence and nonlinearities, high packing density, very good long-term stability and modifications of their chemical structures to perfection. The most attractive materials among these are organic crystals, which have high packing densities often large macroscopic nonlinearities, outstanding long-term orientation and photo chemical stabilities and tenability of the chemical structure. However, the production of large and good-quality crystals has been limited by the difficulty level of doing this. This is why bulk growth of novel nonlinear optical crystals falls under the research spotlight. Clear and defect-free single crystals of large size are important for use in optical devices and further improve the possibility of optical switching and optical limiting applications and researchers are focusing on synthesizing such crystals. In particular, organic crystals have push-pull p-conjugated bridges with electron-donor and acceptor groups on each side of the p-bond system. The increased mobility is caused by the overlap between the p-orbits and the delocalized electronic charge. Optical nonlinearity increases as the ground or excited state electron charge density distribution is improved.

Typically, well known organic materials such as aldehydes, ketones, hydrocarbons, amines, amides and amino acids possess strong electron-withdrawing characteristics and exhibit significant second and third order nonlinear optical responses. Aldehyde derivatives are considered one of the most important classes of hetero-cycles that provide chemical scaffolds to the development of synthetic drugs as they are involved in the manufacture active medicines, given that fragrances, cosmetics, dyes, flavorings, disinfectants and preservatives are just a few of the production benefits. The primary benefits of this group of compounds are leveraged in colorants, fragrances, fumigation, preservatives, medicaments and synthesis. Other than that, they are also used for manufacturing plastics, disinfectants and embalming fluids and function as medicines with anti-inflammatory, anti-cancer, anti-fungal and anti–diabetic properties. Aldehydes, especially aromatic aldehydes, have attracted interest for nonlinear optics (NLO) applications owing to their ability for nonlinear optical property. Aldehydes –based organic nonlinear optical crystals have a high thermal and environmental stability, as well as significant microscopic and macroscopic nonlinear optical susceptibility. They also generate powerful broadband THz waves when pumped at near –infrared and infrared wavelengths. Cinnamaldehyde is a one-dimensional donor-$\pi - accept(D - \pi - A)$system used in nonlinear optics and organic electronics [1]. It consists of an electron donor group, a π-conjugated system and an electron acceptor group. This combination enables the molecule to making it useful for optoelectronics and NLO applications. These groups form a 180- degree bond with a simple aromatic benzene ring's-crystal/adduct technology develops unique solid forms of drugs with diverse physiochemical features-conjugated organic systems have become a popular choice for synthesizing efficient second and third order compounds due to their rapid reaction. In this present study, we synthesized organic and metal compound to form new organic crystals 3 Phenyl to bromo propanol has been synthesized and grew optically high quality single crystal using slow evaporation solution technique with ethanol as solvent. The grown crystals were characterized, using single crystal X-rays diffraction (XRD),Powder XRD (PXRD),Fourier transform Infra-red (FTIR),UV-Visible-NIR,thermogravimetric (TG) and Differential thermal analysis (DTA),fluorescence examination, SEM with EDAX and nonlinear optical methods.

EXPERIMENT

Material synthesis

In a 100 ml beaker, weight 10 g of potassium bromide (KBr) and dissolve it in 50 ml of pure water. Add 20 g of weighed cinnamon aldehyde to the KBr solution. Until the cinnamon aldehyde has completely dissolved, stir. Warm

the blend to 100 ^{0}C.For twenty-four hours, the solution was constantly agitated with a magnetic stirrer. The appropriate amount of ethanol solvent was added to the calculated amount of material. Let the mixture cool gradually until it reaches room temperature [2]. It then showed up as a transparent solution with a yellowish tint. Whatman filter paper was used to filter the prepared solution, and pour the mixture into a crystallization dish or a dry, clean glass container. Allow the solution to stand at room temperature 20 to 25 degree Celsius for slow evaporation until some light yellow crystals of 3 phenyl 2-bromophenol(3P2BP) have been collected. Allow the solution to stand at room temperature (20^0-25^0) C for slow evaporation until some light-yellow crystal 3 phenyl 2-bromophenol(3P2BP) have been collected.

CHARACTERIZATION STUDIES

The 3 phenyl 2-bromophenol (3P2BP) cell characteristics were determined from single crystal x-ray diffraction investigations (MoKα radiation (λ =0.7170A^0) the Enraf Nonius CAD4 diffractometer was employed for the measurements. This compound was studied using PXRD on the single crystal stage with an Xpert pro diffractometer and CuKa radiation (λ =1.54060A0) in the range of 10-60 degrees. Optical transmission spectra for the 3P2BP single cinnamaldehyde and potassium cinnamate were coordinated in the 4000-400 cm-1 range (KBr pellet approach), using a BRUKER 66 VFT-IT spectrometer. The thermal behavior was analyzed in a nitrogen atmosphere using thermo gravimetric and differential thermal methods collected with the SDT Q 600 V8.0 thermal analyser. The melting points were taken with the crystal were recorded using a shimadzu UV-Vis spectrophotometer between 200 and 1100 nm range. FTIR analyses determined that melting point apparatus [3]. 1,3-Dibromo-1-phenylpropan-1-one and potassium hydroxide are the products of an electrophilic addition process with the bromine ions (from KBr) and cinnamaldehyde (CHO).

The mechanism of reaction

1. The bromine ions (Br-) from KBr) and cinnamaldehyde to form the intermediate bromonium ion.
2. The intermediate bromonium ion forms 2,3-Dibromo-1-phenylpropan-1-onea dibromo compound by the addition of an addition Br-ion.
3. The hydroxyl ions(OH-) generated combine with each of the K+ions at the end of the reaction to generate potassium hydroxide(KOH).

RESULTS AND DISCUSSION

Single Crystal X-ray diffraction

Single crystal x-ray diffraction (SXRD) analysis of the grown 3 phenyl 2-bromophenol(3P2BP) crystal was carried out using a Enraf Nonis CAD 4 X-ray diffractometer equipped with graphite monochromatic Mok radiation(λ=0.710A0). The grown crystal belongs to monoclinic crystal system α=90^0, β=96.98^0 γ=$90^0$and the crystal cell volume is 779A^3. Which is in good agreement with the earlier reported values a=5.64,b=17.98,c=7.74 and it is given in Table.1. Single XRD was carried out as a confirmation of the associated monoclinic crystal structure and P space group, basic requirements for nonlinear optical applications. The produced chemical exhibits non-Centro symmetry as may be expected due to relatively good correlation between literature values and predicted lattice parameters. [4].

Powder X-ray Diffraction

With powder X-ray diffractometers, the sample type of crystallinity was determined; the peak intensity shows the level of crystalline nature of the compound. Figure demonstrates the 3P2BP crystal powder XRD pattern observed. This pattern provides additional information besides establishing that the crystalline nature of the crystal is different. Differences that may lead to patterns of crystals viewed within two hours are established through the (hkl) indices. The peaks were tried to be identified by powder XRD.A fine example of the same is the overlap of the hkl peaks and intensities for the simulated PXRD patterns and the ones that were actually obtained experimentally. The PXRD pattern diffraction peaks were tried to be indexed with the d-spacing for the corresponding (hkl) values [5]. The 3 phenyl 2-bromophenol(3P2BP) X-ray powder diffraction pattern was recorded on a Rigaku Mini Flex 600

diffractometer. The powder sample was scanned once every minute over a time period of 10 to 40 minutes. From Table, the unit cell parameters of the crystal are a a=5.64, b=17.98, c=7.74,α=90^0,β=96.98^0,γ=90^{0}and the crystal cell volume is 779A^3.These values agree well with the published values. The type of crystallinity of the sample was determined with powder X-ray diffractometers; the degree of crystalline nature of the compound is reflected in the sharp peak of intensity. The triclinic nature of the crystal was also confirmed by powder X-ray diffraction and the lattice parameters were found to be quite close to the reported values. The solid diffraction peak and triclinic crystal structure of the melt-grown 3 phenyl 2-bromophenol(3P2BP) were confirmed. The value of 2θ suggests good crystalline purity and quality, which can be beneficial in NLO devices.XRD pattern for potassium bromide form 3 phenyl 2- bromophenol(3P2BP) crystal doped with cinnamon aldehyde, is shown in Table Distinct finely refined peaks at defined 2q angles indicate a high degree of cystallinity of the 3 phenyl 2-bromophenol (3P2BP).X-ray diffraction has showed markedly increased signal intensity with sharp peaks suggest high quality and single crystal growth for 3 phenyl 2-bromophenol(3P2BP).

UV-Vis Spectral Analysis

The visible spectrum reveals the sequence pattern of molecular structure. Absorption in the UV-visible spectrum involves the transition of the electron in the π and π^* orbital from the ground state to the excited energy state. The UV-visible absorption and transmission spectra were recorded in the solid phase using Perkin Elember Lambda 935.Transparent single crystals are suited for use in optical devices [6]. In broad terms, the transmittance properties are highly correlated with the substance atomic structure, band gap and quality. A UV-Vis-NIR spectrometer for the 200-1100 nm range is displayed in fig.Description of the optical transmission spectrum and was found to possess good optical transmittance in the visible and near-infrared ranges. The cut-off wavelength was 275.9 nm, growingly towards the surface. The optical absorption coefficient (a) is one of many important factors in choosing a material for optical applications. In the inset of figure, the crystal shows significant transmittance around 81% in the 300-1100 nm range. This also shows that the crystal has arbitrary absorbance of less than 0.12. One key features of the window of constructive transmittance is combined with devices that need to emit blue-green light [7].

Optical Band Gap Energy

The optical energy gap of the formed crystal computed using the transmittance spectrum using the equation mentioned. $\alpha h\vartheta = A(h\vartheta - Eg)m$. Where A is a transition-dependent constant,Eg is the Energy gap of the material and n is a constant according to the type of electronic transitions ½ for allowed direct transitions,3/2 for allowed indirect transitions,2 for forbidden direct transitions and 3 for forbidden indirect transitions [8]. In this case,n is chosen as ½ for a permitted direct transition and a is the absorption coefficient calculated using this formula, $\alpha h\vartheta = A(h\vartheta - Eg)1/2$ The grain distribution and a few microcrystals on the surface of the growing crystal are clearly visible in fig. Tauc's plot can also be used to obtain an extrapolation value for direct band gap, which is 3.62 eV between $(ahv)^2$ and hv. Due to improved optical band gap and attenuated absorption in the UV and visible regons, the material is a suitable candidate for optoelectronic applications.

FTIR Analysis

The geometry of a molecule and the interaction among its numerous functional groups is exposed by the FT-IR spectra. Molecules are made to show bands of bending and stretching due to infrared radiation. This is shown in the spectroscopic images of 3 phenyl 2-bromophenol(3P2BP) in fig .6.Olefin and aromatic C-H stretching are accountable for the sharp peak at 3065cm^{-1} and the peak at 3027.42cm^{-1} in the higher energy region.[9] The C-H aldehydic doublet stretching is represented by the peaks at about 2942.23cm^{-1} and 2749cm-1, respectively. C-H aldehydic stretching appears in the band at 2942.23cm^{-1}.A maxima at 690cm-1 and at 750 cm-1 are due to monostable benzene ring and aromatic C-H out of plane bending stretching vibrations, respectively. Double bonds C=O are identified by bands at1681.39 cm-1.The C-O stretching vibration of an un-saturated aromatic aldehyde is represented by the edge at 1125 cm-1.Waveumbers and corresponding assignments are tabulated. All its functional groups were determined to exist in 3 Phenyl 2- bromophenol (3P2BP). A weak absorption band may be present around 3400cm^{-1} due to water vapour or moisture. The C-O alpha, beta unsaturated aromatic stretching vibration was found to be at a frequency of 1681.39cm^{-1}.The skeletal structure of benzene vibration is exhibited by the 1504cm-^{1} peak.

Thermal Analysis

Because of the high quality of heat generated during the cutting process, thermo gravimetric analysis (TGA) are crucial for assessing thermal stability in the fabrication technology.DTA and TGA of the prepared 3 phenyl 2-bromophenol(3P2BP) crystal were done from 30 to 987^{0}C.The simultaneous TGA and DTA thermo grams are shown in fig. The melting temperature of the material may be found by locating the strong endothermic peak at 146^{0}C according to the DTA curve. The narrow peak at 146 0C shows that can therefore, be made is that phase transitions have not been recorded until the melting point is reached, thus enlarging the temperature range within which this crystal will work well in NLO applications.[10] Thus, there is no weight loss almost until 250^{0}C, which implies absence of water in the structure of the compound. The maxima were found at 270.2^{0}C due to the compound decomposition stage. There are three phases of weight loss as seen on the TGA curve. This, coupled with a quick drop in weight over the region starting at around200.8^{0}C and marking the commencement of melting, corresponds to the first phase. The subsequent weight loss takes place in a region ranging from 296.7 to 557.4 ^{0}C and maintain their overlap with respect to the second stage of weight loss(stage II).Weight loss at temperatures greater than 557.4^{0}C could be attributed to the chemical breakdown associated with the third stage of weight loss(stage III).

Micro Structure Morphology Analysis

Scanning electron microscopy photographs of3P2BP chloride crystal are shown in figure.SEM was used to study the surface topography of the evolving 3p2bp sample. Figure shows the SEM photograph of the 3p2bp crystal. The absorb particle can take many different shapes and be composed of small crystals in aggregates. They existed in bulk form and nano scale form with the mean diameter of the bulk particle being 10 mm. Nanoparticles prepared under experimental conditions exhibit detectable early aggregation in the micrographs. The smaller particles are likely to agglomerate into larger particles as they possess more surface activity. While scanning at 20 keV, the scanning electron microscope effectively utilizes an estimated beam of 10-10 amp. Micrographs reveal a clear early aggregation of the spherical nanoparticles produced under experimental conditions. Smaller particles are more surface active and aggregate to form larger particles. Scanning electron microscope successfully employs a beam of approximately 10-10 amp at 20 keV. Produced crystals with even surfaces and well-defined planes were the only one selected for SEM study; no polishing was performed. The researchers also found that the crystals produced exhibit a very fine rod-like morphology by employing a scanning electron microscope.

EDAX Analysis

The samples of crystals that were produced and analyzed by a JEOL JSM JSM 5610 LV scanning electron microscope to analyze for energy dispersive X-rays in an effort to confirm the presence of metal ions in the 3 phenyl 2-bromophenol(3P2BP) crystal. Figure is the integration of the cinnamaldehyde into the crystalline matrix of 3 phenyl 2-bromophenol. EDAX analysis confirmed the presence of cinnamaldehyde in the doped material. The surface analysis at some points indicates that the incorporation of cinnamaldehyde was not uniform throughout the crystal surface .Figure gives the EDAX spectra of the 3 phenyl 2-bromophenol(3P2BP) crystal. Figure10 indicates the weight percentage of each element as obtained from the EDAX spectrum. The weight percentage bar chart made it very apparent that 3 phenyl 2-bromophenol(3P2BP) was the primary component in the crystal mixture. The peak reveals that potassium and sulfur are present in the crystal. Atomic percentages of C,O,K,Br were 78.66,15.55,3.24,2.55respectively as shown in figure.

Fluorescence

Fluorescence is typically expected in aromatic compounds or molecules with many conjugated double bonds and high resonance stability. Fluorescence is widely used in the fields of medicine and biochemistry. Fluorescent lights, light Emitting Diode (LED) lampstands other lighting devices also use it. Figure.11 displays the excitation and emission spectra for 3 phenyl 2-bromophenol(3P2BP) that were captured using the FP-6500 spectro fluorometer.[28] The measurement range of the emission spectrum was 350-600 nm. The carbonyl chromophore causes the compound 3 phenyl 2-bromophenol(3P2BP)

NLO Studies

The optical crystals of 3 phenyl 2-bromophenol (3P2BP) subjected to this experimental analysis were tested for nonlinear optical property with a modified kurtz and perry powder technique. A Q-switched Nd-YAG laser beam operating with a repetition rate of 10 Hz and each pulse for 10 nm was employed at I.I.Sc ., Bangalore, at a wavelength of 106 nm and with an input power of 1.2 mJ.[11] The powdered 3 phenyl 2-bromophenol(3P2BP) single crystals of uniform particle size are passively packed into a glass micro capillary tube .a photo-multiplier tube allows second harmonic generation (NLO-SHG) with cathode ray oscilloscope excitation. The source of the 532 nm output generated by the emission f green light was investigated to confirm the non-centrosymmetric space group of the 3 phenyl 2-bromophenol(3P2BP) grown single crystal. The nonlinear optical activity of this crystal with respect the green light of 530nm provides evidence to an inner coordination of space group symmetry SHG. The output powder is assessed to be 10 mV for 3 phenyl 2-bromophenol(3P2BP) and 8 mV for KDP, respectively, the constant input energy being 1.2 mJ pulse for both crystals. According to older studies, SHG efficiency of crystals is comparable to that of normal KDP, While the current study indicates that the efficiency of SHG of the herein - produced crystal is 1.25 times higher than normal KDP. Bearing this in mind, it is likely that the increased efficiency value influences its NLO characteristics.

CONCLUSION

For the first time, 3 phenyl 2-bromophenol(3P2BP) single crystals with well-defined structures have been synthesized by the slow evaporation solution method. The 3P2BP crystal possesses a monoclinic crystal structure, as confirmed by SXRD studies. The FTIR was utilized to ascertain the functional group positions of the target molecule. The optical quality at the absorption edge of 282 nm is excellent, as confirmed by the UV-Vis NIR study; with transmittance exceeding 80%.It is found that the optical band gap energy is 3.62 eV. The crystals have two peaks at wavelength of 330.97 and 643.33 nm. This result does, indeed, show that the crystals give off blue and red light. In addition, it can be seen that the crystal is of extremely high crystallinity since only two are most prominent.SEM analysis of the crystal indicated that, even though it had a very strong resemblance to a rock, its surface was level. Various non-instructive techniques were employed to study the composition of the crystal. EDAX experiments on the formation of the crystal were conducted with the aim to determine its elemental composition. Also, TG and DT experiments were performed to research the thermal behavior of the 3 phenyl 2- bromophenol(3P2BP) crystal.

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Table.1 Single Crystal XRD of 3P2BP crystal

Crystal System	a	b	c	α	β	γ	Volume
Monoclinic	5.64	17.98	7.74	90	96.98	90	779

Table.2 FT-IR Assignment of 3P2BP crystal

Wave number (cm^{-1})	Vibrational assignment
3065	Olefinic C-H stretching vibration
3027.42	Aromatic C-H Stretching vibrations
2924.23	Aldehydic C-H Stretching in aromatic ring
2749	Aldehydic C-H Stretching
1681.39	C=O stretching vibration of an-unsaturated aromatic aldehyde
1504	Skeletal system of benzene vibration
1344	C-H plane bending vibration of aldehyde group
1125	C-O stretching vibration of an -unsaturated aromatic aldehyde
3400	weak absorption band
769	Aromatic C-H out of plane bending vibration
690	Aromatic C-H out of plane bending vibration

Table.3 EDAX Analysis of 3P2BP Crystal

Element	Line	Mass%	Atom%
C	**K**	62.00±0.16	78.66+0.20
O	**K**	16.32+0.18	15.55+0.17
K	**K**	8.31+0.06	3.24+0.03
Br	**L**	13.36+0.11	2.55+0.02
Total		100.00	100.00
Spc_005	Fitting ratio 0.0414		



Figure 1 Grown 3 phenyl 2-bromophenol (3P2BP) Crystal

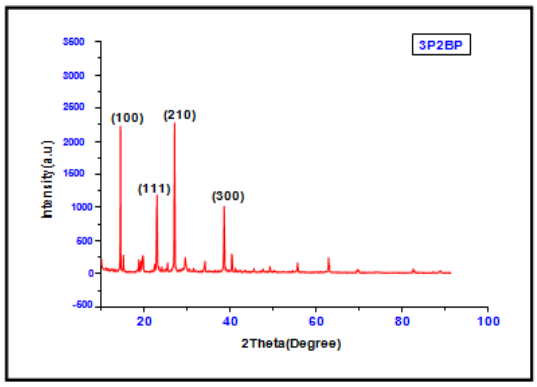


Figure.2 Powder X-ray Diffraction of 3P2BP Crystal

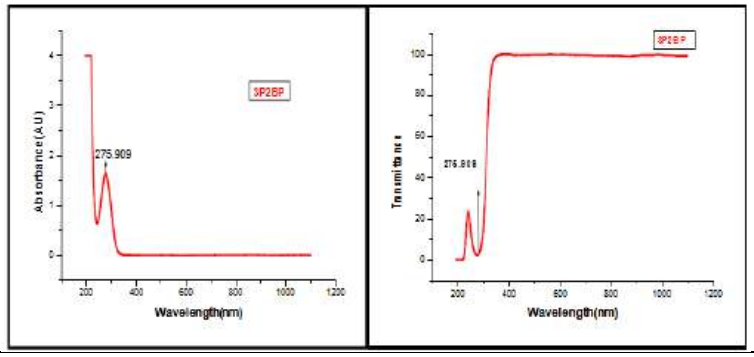


Figure.3 UV-Vis NIR Spectrum of 3P2BP Crystal

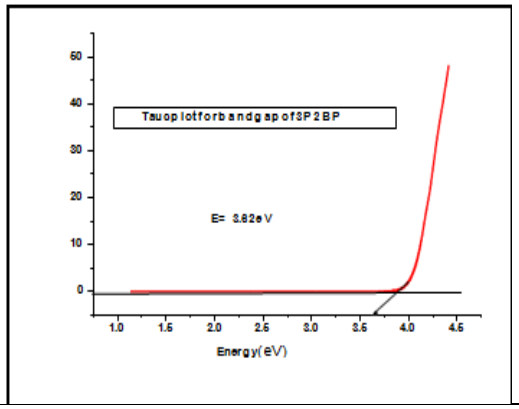


Figure.4 Tauc's Plot of the 3P2BP crystal

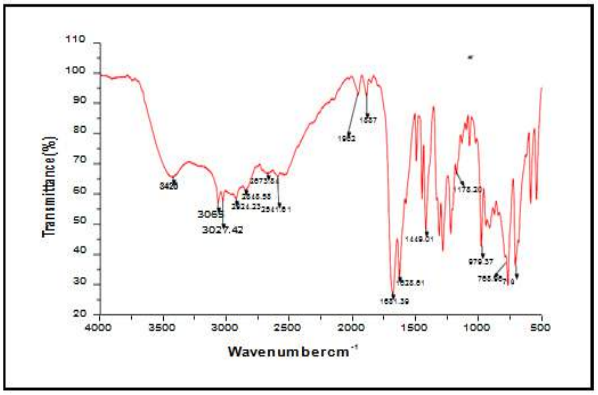


Figure.5 FT-IR Spectrum of 3P2BP crystal

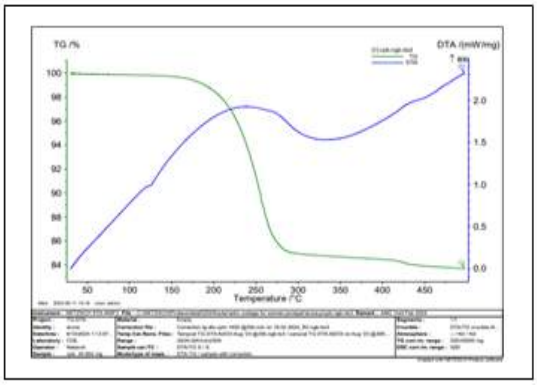


Figure.6 Thermal analysis of 3P2BP Crystal

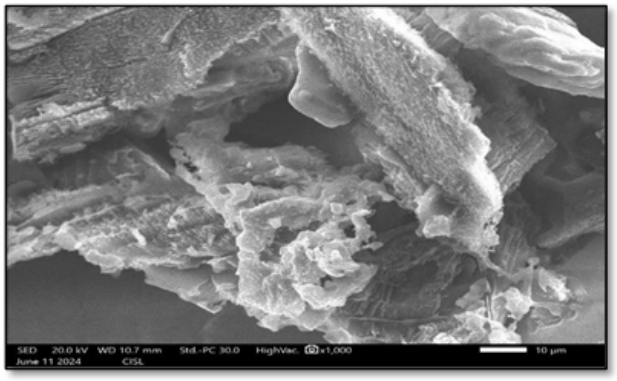


Figure.7 SEM Analysis of 3P2BP Crystal

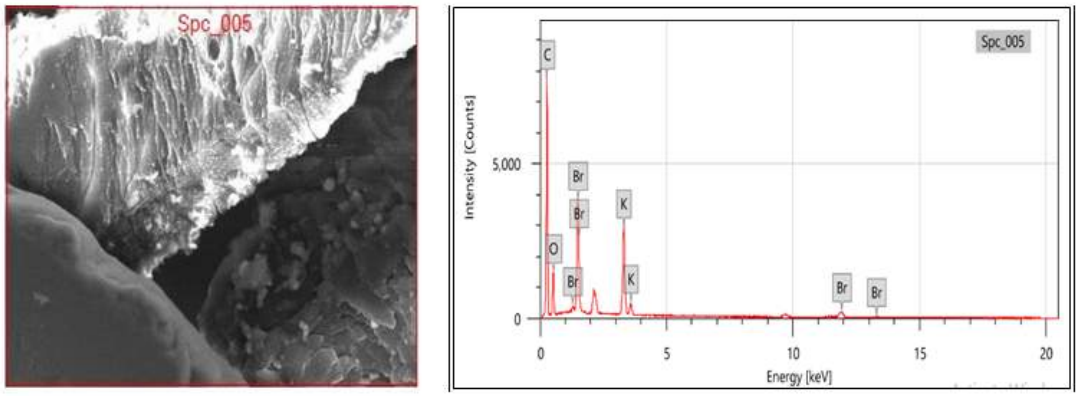


Figure.8 EDAX Analysis of 3P2BP Crystal

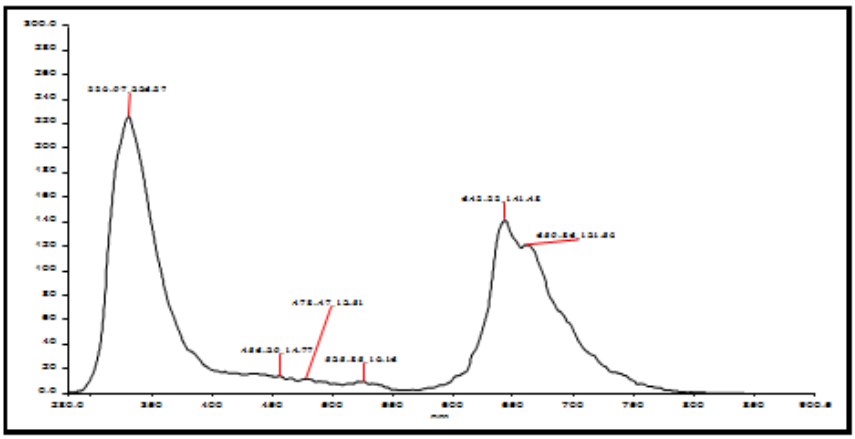


Figure. 9 Fluorescence Spectrum of 3P2BP Crystal

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RESEARCH ARTICLE

Evaluation of Tuberculosis by Application of MSCT

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ABSTRACT

A particular infectious disease called tuberculosis is brought on by the Mycobacterium tuberculosis. The illness causes pulmonary TB and mainly affects the lungs. Additionally, it may impact the skin, lymph nodes, bones, joints, intestines, meninges, and other bodily structures. The illness typically has different clinical symptoms and is persistent. A physical examination, a chest radiograph, a medical history, and microbiologic smears and cultures are all necessary for a thorough TB evaluation. A skin test for tuberculin and a serologic test may also be part of it. One crucial element of public health initiatives to eradicate tuberculosis has been the treatment of latent TB infection to stop the disease from progressing to active form. In this study maximum number of patients was affected in the age group of 46 to 60 years in which male are 60% and female are 40%. There are 30 patient detected active pulmonary tuberculosis, where as 16 are inactive pulmonary Tuberculosis. Additionally, 4 patients are normal. CT scan revealed pathological findings in 50 patients (100%) which include consolidation (38%) centrilobular nodules (6%) cavitation (2%) in bud appearance (4%) ground glass opacities (30%) pleural effusion (16%) and traction bronchiectasis (4%).Fifty patients with clinical signs of pulmonary tuberculosis participated in this investigation. HRCT is essential to this study's assessment of pulmonary tuberculosis. Where necessary, CECT was also required. However, HRCT is generally the most effective method for detecting pulmonary tuberculosis. Additionally, HRCT was found to be useful in differentiating between pulmonary tuberculosis that is active and that is inactive. The results of the HRCT showed centrilobular nodules, pleural effusion, consolidation, cavitation, and a tree-in-bud look.

Keywords: Tuberculosis, Symptoms, Primary Tuberculosis, Reactivation Tuberculosis, Airway Tuberculosis, Miliary Tuberculosis, Diagnosis.

INTRODUCTION

The anatomy of a thin slice of the body is displayed in a computer tomography (C. T.) image, which is created by obtaining and reconstructing images from many X-ray absorption measurements taken around the body's perimeter. There are two ways in which these CT images vary from traditional film projections. Obtain a cross-sectional image without any structure superimposition (plain x-rays contain structures superimposed). Compared to plain film screen projection, CT is at least ten times more sensitive to minute variations in X-ray attenuation. Godfrey Housenfield of EMI, UK, created the first CT scanner in 1972. Since then, CT has advanced significantly in terms of maturity and technical sophistication. Sir Godfrey Housenfield and Alan Cormack (USA) were awarded the 1979 Nobel Prize in Medicine for their creation of the CT scanner. The mathematical formula for reconstructing the image was created by Cormack.

TUBERCULOSIS

A particular infectious disease called tuberculosis is brought on by the Mycobacterium tuberculosis. The illness causes pulmonary TB and mainly affects the lungs. Additionally, it may impact the skin, lymph nodes, bones, joints, intestines, meninges, and other bodily structures. The illness typically has different clinical symptoms and is persistent. The most significant type of tuberculosis that affects humans is pulmonary tuberculosis. Mode of transmission: Sputum-positive patients with pulmonary tuberculosis are the primary source of droplet infections and droplet nuclei that spread the disease. The particles must be sufficiently fresh to carry a living organism in order to spread infection. The most droplets of all sizes are produced when coughing. Infection transmission is influenced by coughing frequency and intensity as well as environmental ventilation. Many individuals who contract TB do not exhibit any symptoms and may never get TB illness. Latent TB infection (LTBI) is present in these individuals. However, those with TB infection who take certain immunosuppressive drugs, including TNF-alpha blockers, or have compromised immune systems as a result of diabetes, HIV infection, kidney failure, or other conditions may be at a higher risk of developing active TB illness with symptoms. The rise of drug-resistant TB strains and the COVID-19 pandemic have made global TB control efforts more difficult, despite the World Health Organization's (WHO) 2030 aim to eradicate TB under the Sustainable Development Goals (SDGs).

SIGNS AND SYMPTOMS OF TB

The majority of the time, the symptoms are modest and appear over weeks, months, or even years. The following are the typical signs of tuberculosis in the lings: More than three weeks of coughing, weight loss and, coughing, fever and, night sweet and, chest pain, Knowing your TB status is crucial because, if necessary, treatment of a TB infection will eliminate the few TB bacteria in your body before it develops into active TB disease. TB disease is frequently preventable. When coughing, it's crucial to cover the mouth and nose to prevent the transmission of tuberculosis. A third of the world's population is thought to be asymptomatically infected with TB, and 5–10% of them will go on to develop clinical symptoms in their lifetime. the majority of new instances and in developing nations, where infections are frequently contracted as children, deaths do occur. According to estimates, the annual chance of contracting tuberculosis in high-burden nations is between 0.5 and 2 percent. A patient with infectious pulmonary tuberculosis disease can infect 10 to 15 others in a year. Rapid molecular tests is among the novel TB diagnostics that have been developed, however The BCG vaccine is used all over the world, mostly to protect newborns and young children from potentially fatal tuberculosis. However, it has not been successful in containing the global tuberculosis epidemic.

PRIMARY TUBERCULOSIS

The first parenchymal focus of tuberculosis (TB) may grow and cause a region of airspace consolidation, or it may, more frequently, heal by turning the granulomatous tissue into mature fibrous tissue. Primary tuberculosis happens most frequently in youngsters, although it is also becoming more common in adults. Lymph node enlargement is the most prevalent anomaly in children, occurring in 90–95% of cases. Usually unilateral, the lymphadenopathy is found in the paratracheal region or hilum. The enlarged nodes usually have peripheral rim enhancement on CT, which

reflects the vascular rim of the granulomatous inflammatory disease, and central low attenuation, which represents caseous necrosis.

Reactivation tuberculosis

Focal or patchy heterogeneous consolidation involving the superior segments of the lower lobes and the apical and posterior segments of the upper lobes is the most prevalent radiological manifestation of reactivation pulmonary tuberculosis. According to histology, the tuberculoma's core is made of caseous material, while its periphery is made up of multinucleated giant cells, epithelioid histiocytes, and varying the amounts of the collagen. In up to 80% of cases, there may be satellite nodules surrounding the TB. It has occasionally been reported that tuberculomas accumulate 18F-FDG and cause PET scans to be interpreted as false-positive for malignancy due to active glucose metabolism brought on by active granulomatous inflammation.

Airway Tuberculosis

The main CT findings of airway tuberculosis are luminal constriction and circumferential wall thickening, together with the involvement of a lengthy tract of the bronchi. While the airways in fibrotic disease are smoothly narrowed and have thin walls, those in active illness are irregularly narrowed in their luminaand have thick walls. While both main bronchi are equally implicated in active disease, the left main bronchus is more commonly involved in fibrotic disease.

Miliary Tuberculosis

In the latter case, military TB can be the sole pulmonary abnormality or it might be observed in conjunction with normal parenchymal alterations. Every miliary infection focus causes local granulomas, which when fully developed comprise a central necrotic area encircled by a reasonably well-defined rim of fibrous tissue and epithelioid histiocytes. Acute respiratory distress syndrome may be indicated by diffuse or localized ground glass opacity.

Development of Infection and Pathogenesis

When the mycobacteria enter the pulmonary alveoli, they enter and multiply inside the alveolar macrophages, initiating the TB infection. Alveolar macrophages phagocytize inhaled mycobacteria, and through their interactions with T lymphocytes, the macrophages differentiate into epithelioid histiocytes. Granulomas are the product of epithelioid histiocytes and lymphocytes clumping together into little clusters. CD4 T lymphocytes (effector T cells) in the granuloma release cytokines such interferon-γ, which trigger macrophages to eliminate the bacteria they are infected with. Additionally, cytotoxic T cells, or CD8 T lymphocytes, have the ability to kill infected cells directly.

The superior segments of the lower lobes and the apical and posteri segments of the upper lobes are typically affected by reactivation TB. The combination of comparatively elevated oxygen tension and compromised lymphatic outflow in these areas is probably the cause of this location. The primary anomalies include increasing inflammation and necrosis, often accompanied by the creation of cavities and the establishment of airway communication. A TB infection in the same or different lobes may arise from the endobronchial dissemination of necrotic material from a hollow. Military tuberculosis may arise from hematogenous spread.

Diagnosis

A physical examination, a chest radiograph, a medical history, and microbiologic smears and cultures are all necessary for a thorough TB evaluation. A skin test for tuberculin and a serologic test may also be part of it. One crucial element of public health initiatives to eradicate tuberculosis has been the treatment of latent TB infection to stop the disease from progressing to active form. Nowadays, a tuberculin skin test (TST), which produces a delayed-hypersensitivity-type reaction to pure protein derivatives of M. tuberculosis, is used to diagnosis latent infection in nonimmunized individuals. However, there are a number of drawbacks to the TST, which has been used for years to diagnose latent TB infection. These include false-positive test findings in people who received the Bacille Calmette-Guérin (BCG) vaccination andas well as in people with infections unrelated to M. tuberculosis. The goal of developing these new TB tests is to provide more accurate, quick, and affordable TB testing. These novel diagnostics employ whole-blood interferon-γ assay and polymerase chain reaction detection of bacterial DNA.

DISCUSION

In our study, there are 50 cases, out of which 46 are found quick pulmonary Tuberculosis and 4 are normal patients. In this study maximum number of patients was affected in the age group of 46 to 60 years in which male are 60%and female are 40%. There are 30 patients detected active pulmonary tuberculosis, where as 16 are inactive pulmonary Tuberculosis. Additionally, 4 patients are normal. CT scan revealed pathological findings in 50 patients (100%) which includes consolidation(38%) centrilobular nodules (6%) cavitation (2%) in bud appearance (4%) ground glass opacities (30%) pleural effusion (16%) and traction bronchiectasis(4%).

CONCLUSION

Fifty patients with clinical signs of pulmonary tuberculosis participated in this investigation. HRCT is essential to this study's assessment of pulmonary tuberculosis. Where necessary, CECT was also required. However, HRCT is generally the most effective method for detecting pulmonary tuberculosis. Additionally, HRCT was found to be useful in differentiating between pulmonary tuberculosis that is active and that is inactive. The results of the HRCT showed centrilobular nodules, pleural effusion, consolidation, cavitation, and a tree-in-bud look.

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Table 1.Gender wise distribution of patients

Gender	Frequency	Total	Percentage
Male	30	50	60%
Female	20	50	40%

Table-2.Distribution of abnormalities in various age groups

CT Diagnosis	1 to 15 years	16 to 30 years	31 to 45 years	46 to 60 years	61 to 75 years	76 to100 years	Total
Consolidation			6	5	7	1	19
Centrilobular Nodules		1	1	1			3
Traction Bronchiectasis			1				1
Pleural Effusion			2	2	3	1	8
cavitation		1					1
Ground Glass Opacities		1	4	3	5	2	15
Tree -In -Bud		1		1			2

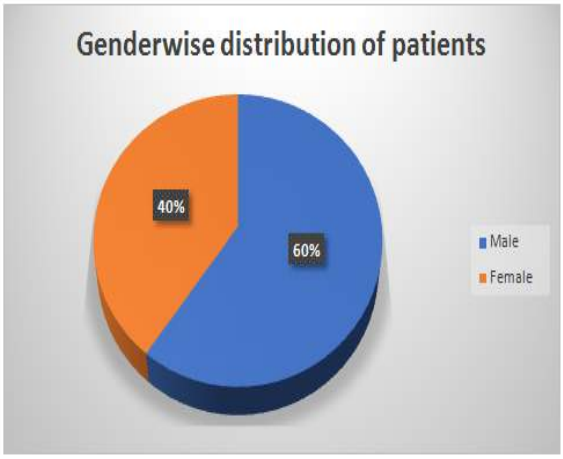


Fig.1. Gender wise distribution of patients.

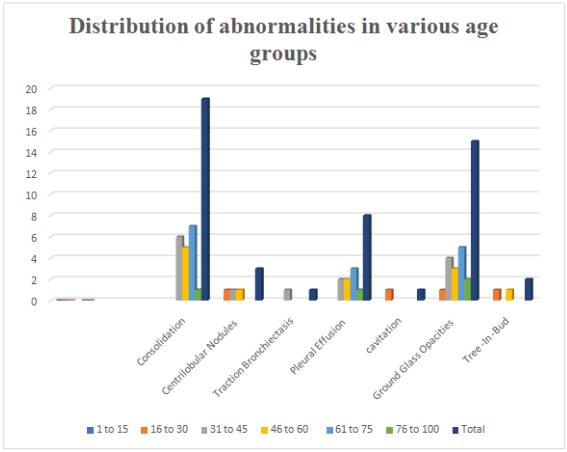


Figure-2.Distribution of abnormalities in various age groups

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RESEARCH ARTICLE

The Effects of High-Intensity Circuit Training Versus Low-Intensity Circuit Training on Body Composition and Weight Reduction in School-Going Children with Obesity

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ABSTRACT

To find the effect of circuit exercise training with high-intensity and low-intensity exercise among school-going children with childhood obesity About 100 children were tabbed and stationed on the inclusion and exclusion criteria. Written informed consent was claimed from all the children's parents before the kickoff of the research. The preliminary covenant and logistics were presented to all the children and parents before they gave their consent. These 100 children were scattered into 2 gangs. One is the high-intensity circuit exercise group, and the other is the low-intensity circuit exercise group. Children in Group A will undergo high-intensity circuit exercise training. This will involve 45 minutes of exercise per session, five days a week, for 8 weeks. Group B: Children in Group B will undergo low-intensity circuit exercise training. This will involve 45 minutes of exercise per session, five days a week, for 8 weeks. Both groups will participate in a circuit exercise program consisting of a series of exercises The Pre-test and Post-test values were hypothesized. Results suggest that the high-intensity Circuit exercise training group has significant improvement when compared with the low-intensity Circuit exercise training gang with $P<0.0001$. The study's findings show that circuit exercise training, both high- and low-intensity, can successfully lower body fat and body mass index in obese school-age children. In contrast to the low-intensity group, the high-intensity exercise

group showed more notable improvements in body composition, which may indicate better advantages for managing weight and general health.

Keywords: Circuit exercise training, high-intensity exercise group, low-intensity exercise, BMI index, Skinfold caliper

INTRODUCTION

World Health Organization (WHO) referred to obesity as a "global epidemic." The prevalence of obesity and overweight, as determined by BMI, has increased in spite of this. Many countries had rates higher than 50% indicating that children were also heavily affected [1] diabetes mellitus, antithetical sleep apnea malady and psychological controversy at the time of childhood and adolescence, all of which increase the prospect of initial fatality in adulthood, chiefly from cardiovascular drills [2] Studies on obesity divide the illness into two primary categories: common obesity, which is impacted by multiple genetic variants with small individual effects, and rare, severe, early-onset obesity inherited through chromosomal deletions or single-gene abnormalities[3] A negative energy balance must be created to combat obesity, as the main cause of the condition is a chronic imbalance favoring energy expenditure over intake. This is why pharmacological treatments are not a necessary part of the battle against obesity[4]. Youngsters as young as 4 or 5 years old may start internalizing the food and exercise habits of their parents. This implies that the ideal time to change environmental hazard elements for childhood obesity may be in the early years of life. [5] Children now rely more on cars and other automated modes of transport rather than walking or climbing stairs. Outdoor playtime for children has decreased, and many schools have reduced or eliminated physical education programs.[6] Conversely, in low-income countries, obesity tends to be more prevalent among middle-aged individuals residing in affluent urban areas. [7] Consistent physical activity in children plays a crucial role in their overall health, Research strongly suggests that higher levels of physical activity in early childhood may reduce the risk of developing obesity and obesity [8]. PE sessions may prevent juvenile obesity without adding more physical exercise. The children's excessive quantity of active time and low average intensity are the main issues with PE programs [9] These strategies include primary prevention, therapy, weight reduction intervention, maintenance, and prevention of excess weight gain [10] Children who are enmeshed in a marathon of exams and classes due to job concerns are unable to find time for physical exercise or even be sent to medical facilities for these issues[11] While several tests exist to measure these skills, only the Burpee test has been shown to be reliable and useful to use in a field experiment[12]. Resistance training appears to be more beneficial than endurance exercise in lowering blood pressure, resting heart rate, and fat mass [13]. Compared to other exercise types, high-intensity resistance training may have an equivalent or higher metabolic benefit. Insulin resistance and glucose regulation in individuals with diabetes and obesity[14].HIIT on inflammation and immunological function are less evident; it improves cardiometabolic health, which may lower the hazard for T2D and cardiovascular disease in twain healthy and clinical populace [15]. Endothelial function can be enhanced by training regimens that include high-intensity training (HIT) and conventional moderate continuous training (MCT). reaction during individual exercise bouts that is primarily driven by abrupt increases in blood flow and laminar shear stress [16] HIIT, which is comparable to unstructured play in early life. Enhanced enjoyment ought to encourage high levels of exercise adherence, which would then result in an efficient exercise regimen [17]. Low-intensity exercise affects antioxidant maches and the construction of susceptible oxygen stripes in the spinal cord of rodents. Low-intensity exercise has been shown to intensify motor function in people with obesity, according to a recent study [18]. Energy expenditure (EE) and energy intake (EI) must be changed to reduce obesity; neither factor should be prioritized over the other. In this regard, a potent nonpharmacological method to prevent and control obesity and associated comorbidities [19] Additionally, offering psychological support in addition to physical exercise. Collaboration between educators, families, and social circles is also crucial for fostering long-lasting and constructive behavioral changes in kids [11].

MATERIALS AND METHODS

Childhood obesity is a growing global public health concern with multifaceted causes, including genetic predispositions, poor dietary habits, and sedentary lifestyles. It leads to numerous health issues such as diabetes, cardiovascular disease, and mental health difficulties, alongside social and psychological challenges like stigmatization and low self-esteem. Addressing this problem requires a comprehensive approach spanning individual, familial, community, and policy levels to promote healthy lifestyles and prevent long-term health consequences. Research into childhood obesity is momentous for tracking hazard factors and promoting potent avoidance and intervention schemes to mitigate its impact on individuals and society. The choice imperative for participants in the study encompassed both the incorporation and exclusion imperative. Inclusion criteria involve children with a body mass index (BMI) falling within the spectrum of >26-32, along with documented records of obesity or related conditions. Additionally, the study targets children aged 11 to 17 years who are either generally healthy or possess specific health issues associated with obesity, with consideration for including both genders based on the study's requirements. Conversely, exclusion criteria entail children with a medical history of cardiovascular problems, generalized asthma, limb length discrepancy, lower limb fractures, or any generalized infections. These criteria aim to ensure a specific cohort of participants with relevant characteristics for the study's objectives while mitigating confounding factors that may interfere with the analysis. The official approval from the Institutional Scientific Review Board with the ISRB number(04/030/2023/ISRB/SR/SCPT). One hundred children with obesity will be recruited from local schools. The children will be haphazardly divided into two groups: Group A and Group B, each subsist of 50 children.

Group A: Children in Group A will undergo high-intensity circuit exercise training. This will involve 45 minutes of exercise per session, five days a week, for a period of 8 weeks. Group B: Children in Group B will undergo low-intensity circuit exercise training. Like Group A, this will involve 45 minutes of exercise per session, five days a week, for a period of 8 weeks. Both groups will participate in a circuit exercise program consisting of a series of exercises. The high-intensity circuit will involve exercises performed at a high intensity, aimed at increasing heart rate and challenging the muscles. The low-intensity circuit will involve exercises performed at a lower intensity, focusing on maintaining a moderate heart rate and providing a less strenuous workout. Participants' progress will be monitored throughout the study, including measurements of weight, body composition, and physical fitness. Data collected from both groups will be analyzed to resolve the fallouts of high-intensity vs. low-intensity circuit exercise on obesity in children. Statistical analyses will be counseled to correlate the outcomes between the two gangs and assess the persuasiveness of each exercise program. Circuit exercise training like burpees (30 sec), jumping jacks (30 sec), squats (30 sec), high knees (30 sec), and knee pushups (30 sec) for 15 minutes. Circuit training is a form of exercise where you move promptly from one exercise to another, bull's-eyeing divergent muscle compartments in succession with little to no rest in between. The circuit typically includes a series of exercises performed for a certain number of reiterations or a set time before shifting on to the next exercise. This type of training can improve cardiovascular fitness, strength, and endurance. It's a versatile workout that can be adapted for various fitness levels and goals. High-intensity exercise: weighted squats, kettlebell exercise, plank, weighted plank, and crunches. Low-intensity exercise: walking, jogging, sit-ups, alternative toe touch, raised arm circles, mountain climbers.

Outcome measures

Body Mass Index (BMI) is an individual’s weight in kilograms (or pounds) divided by the square of height in meters (or feet). A high BMI can indicate high body fat. BMI shows that the weight categories may lead to health problems. Body Mass Index (BMI) is a measure used to estimate whether a person has a healthy body weight for their height[20] Skin fold measurement is the method used to determine the amount of fat on the body. A device called a skin fold caliper is utilised to slightly punch the skin and lurking fat in various places. A high level of expertise is needed to estimate body fat using this instant and easy technique. Skin fold caliper is also used to measure how thick the fold of skin and subcutaneous fat is at particular locations on the body. [21]. Before the initiation of intervention, the pre-test values of body mass index and skin fold caliper measurements are taken post intervention was taken

post-test values on the final day of intervention. The huddled report was ratiocinated and inspected. For each criterion, the mean and standard deviation were enforced. The statistically momentous divergence between pre-test and post-test measures were scrutinized using the paired t-test. The divergence between post-test values was settled. The data was tabulated and appraised.

RESULTS

Indicates that high-intensity circuit exercise may offer greater advantages for managing weight and improving overall health in this population. These results underscore the importance of implementing structured exercise programs, particularly those incorporating high-intensity intervals, as a viable strategy for addressing childhood obesity. post-test values of skinfold caliper for group A and group B. The values were as follows for group A: post-test mean (22.290), (22.190), (22.942), (21.442), SD (0.166), (0.166),(0.193),(0.193); Group B: post-test mean(22.940),(22.930),(21.359),(21.850), SD(0.143),(0.134),(0.178),(0.178). The T values were 9.3471, 10.9638, 5.3853, and 5.3842. Because of this, the results were scrutinized as statistically momentous when the p-value was less than 0.0001. (as shown in table 1). post-test values of BMI index for group A and group B. The values were as follows for group A: post-test mean (27.950), SD (0.207); Group B post-test mean(28.683), SD(0.122). The T value was 8.5694. Because of this, the results were scrutinized as statistically momentous when the p-value was less than 0.0001. (as shown in table 2).

DISCUSSION

The intent of the current study was to look at how the health of school-age obese children was affected by high- and low-intensity circuit exercise training. The corollary of the study offers important new erudition on the expedient advantages of varying exercise intensities in controlling pediatric obesity and enhancing general health. The study's findings showed that both the high-intensity and low-intensity exercise groups significantly reduced their body mass index (BMI) and skinfold measures. This result is Persistent with other studies have shown the constructive fallout of regular exercise on body weight reduction and improved body composition in obese children. According to the study by Jackson *et al.* (2020), A complete strategy to controlling pediatric obesity must include food and lifestyle adjustments in addition to exercise and physical activity. A balanced diet and better food choices can assist kids in reaching and maintaining a healthy weight. control over food promotion and marketing, especially when it comes to kids. Despite tremendous advancements in our knowledge of and efforts to combat pediatric obesity, a few obstacles still need to be overcome. One of the main obstacles is the issue's complexity, which calls for a thorough and well-coordinated response due to the numerous interconnected aspects involved. According to Loos & Yeo et al. (2022). There are many different contributing factors to pediatric obesity, including intricate interactions between behavioral, environmental, and genetic variables. Genetics are important because certain people may be predisposed to obesity because of particular genetic differences, but behavioral and environmental variables also play a big role in the obesity pandemic. According to Yuksel *et al.* (2020). Several elements can be included in school-based interventions, such as nutrition education, physical education programs, and changes to the surrounding area to promote physical activity (e.g., providing safe playgrounds and recreational places) Additionally, research should be done on how new technologies, such virtual reality, wearables, and mobile apps, might encourage kids to lead healthy lifestyles and engage in physical exercise. According to the study by Dias *et al.* (2018). HIIT entails quick bursts of high-intensity exercise interspersed with low-intensity rest or recovery intervals. Additionally, because HIIT is intermittent and mimics unstructured play, kids seem to like it more than MICT, which may improve commitment to exercise. Furthermore, further study is required to comprehend the underlying processes and long-term impacts of various therapies, especially across a range of age groups and demographic groupings. This information can help create solutions that are more specialized and successful. According to the study by Liu et al. (2020), the efficacy of several exercise techniques in treating pediatric obesity has been investigated. Numerous studies have demonstrated the potential prosperities of high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) in enhancing cardiovascular and cardiometabolic outcomes in obese children. HIIT

entails quick illuminations of high-intensity exercise interspersed with low-intensity rest or resumption intervals. It has been discovered that this kind of training is superior to MICT in terms of raising cardiometabolic risk factors, decreasing body fat, and increasing cardiovascular fitness in obese kids. Research has also been done on the possible advantages of moderate-intensity continuous training (MICT), which includes jogging or brisk walking, in the management of pediatric obesity. Even while MICT might not improve some outcomes as much as HIIT does, it still provides for lowering heart disease risk factors and encouraging weight reduction.

CONCLUSION

The findings of this study suggest that circuit exercise training, with high- or low-intensity, can effectively reduce body fat and body mass index in obese school-age children. However, the high-intensity exercise group exhibited more significant improvements in body composition compared to the low-intensity group. This indicates that high-intensity circuit exercise may offer greater advantages for managing weight and improving overall health in this population. These results underscore the importance of implementing structured exercise programs, particularly those incorporating high-intensity intervals, as a viable strategy for addressing childhood obesity. Such interventions can not only help reduce body fat and BMI but also potentially reform cardiovascular fitness, muscular strength, and metabolic health. Future research could further investigate the long-term effects of different exercise intensities on obesity management and explore additional benefits for the overall well-being of obese school-age children..

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Table 1: Comparison between the Post-test values of Skinfold caliper for GROUP A and GROUP B

OUTCOME MEASURE	GROUP A& GR0UP B	MEAN	SD	T VALUE	P VALUE
SKINFOLD CALIPER (ABDOMEN)	POST TEST (group A)	22.290	0.166	9.3471	<0.0001
	POST TEST (group B)	22.940	0.143		
SKINFOLD CALIPER (THIGH)	POST TEST (group A)	22.190	0.166	10.9638	<0.0001
	POST TEST (group B)	22.930	0.134		
SKINFOLD CALIPER (TRICEP)	POST TEST (group A)	22.942	0.193	5.3853	<0.0001
	POST TEST (group B)	21.350	0.178		
SKINFOLD CALIPER (CHEST)	POST TEST (group A)	21.442	0.193	5.3842	<0.0001
	POST TEST (group B)	21.850	0.178		

Table 2: Comparison between the post-test values of BODY MASS INDEX (BMI) for GROUP A and GROUP B

OUTCOME MEASURE	BMI INDEX	MEAN	SD	t VALUE	P VALUE
GROUP A	POST TEST	27.950	0.207	8.5694	<0.0001
GROUP B	POST TEST	28.683	0.212		



Fig.1 shows the skin fold caliper measurement



Fig.2 shows the squat exercise

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RESEARCH ARTICLE

Analysis of Curvature Characteristics in Weak Singularity of Tolman-Bondi Model

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ABSTRACT

In this study, we analyze the curvature characteristics associated with weak shell-crossing singularities in the inhomogeneous Tolman-Bondi model without a cosmological constant. We investigate the formation of such singularities during gravitational collapse, identifying that they arise when the outer collapsing shells attain a higher velocity than the inner shells of the same radius. These conditions are found to be sufficient for the occurrence of weak singularities. Additionally, we examine how the initial data influence the emergence of shell-crossing weak singularities and establish that the pressure at these singularities is determined by the initial velocity distribution. Our findings provide deeper insight into the curvature behavior near weak singularities, contributing to a better understanding of their role in gravitational collapse scenarios.

Keywords: Causal structure of space time, Gravitational Explosion

INTRODUCTION

The Tolman-Bondi model describes the gravitational collapse of a spherically symmetric dust matter distribution and plays a significant role in understanding singularity formation in general relativity [5,14]. This model is matched to an exterior Schwarzschild solution, where all metric components g^{ij} are smooth functions of class C^{∞}. The initial density and velocity profiles in the Tolman-Bondi model depend solely on the radial coordinate rr. As the collapse is pressureless, every individual dust shell with a finite radius eventually contracts through its Schwarzschild radius,

leading to the possibility of singularity formation [6,15]. In the case of a homogeneous dust cloud, all collapsing shells are synchronized in their evolution, preventing the occurrence of weak singularities. The Oppenheimer-Snyder model [6] exemplifies such a scenario where no weak singularities arise. However, for an inhomogeneous matter distribution, the proper time for collapse varies with the radial (co-moving) coordinater. This variation can lead to shell-crossing singularities [3], which are not genuine curvature singularities but rather momentary density singularities caused by the intersection of neighboring collapsing shells. Although the Kretschmann curvature scalar may diverge locally in such cases, these singularities can often be removed through an appropriate extension of the spacetime [8]. A detailed analysis by Szekeres and Lun [P1999] explored both Newtonian and relativistic spherically symmetric matter distributions, leading to the following key observations:

1. Jacobi fields remain finite as they approach the singularity.
2. The boundary region of the singularity can be transformed through a C^1 coordinate transformation.

These findings suggest that shell-crossing singularities could potentially be avoided if the free functions in the Tolman-Bondi metric are chosen appropriately [7]. By analyzing the curvature characteristics associated with weak singularities, we aim to deepen the understanding of their formation and explore conditions under which they may be mitigated or removed within the framework of gravitational collapse.

This Paper

This study presents a comprehensive investigation into the curvature characteristics associated with weak shell-crossing singularities in the inhomogeneous Tolman-Bondi model, specifically in the absence of a cosmological constant. Our analysis is structured into three main sections to systematically explore the formation and behavior of these singularities [13]. In the first section, we introduce the Tolman-Bondi spacetime, detailing its fundamental properties and the mathematical framework governing its evolution [15]. This includes a discussion on the metric formulation, initial conditions, and the role of in homogeneity in gravitational collapse [10]. The second section focuses on establishing the necessary conditions for the occurrence of shell-crossing singularities [2], identifying key factors such as initial density and velocity profiles that influence their formation and discussing their physical significance in the context of dust collapse. In the final section, we delve into the curvature characteristics near weak singularities, providing a detailed analysis of the curvature tensors and their behavior in the vicinity of shell-crossing points [4]. To support our findings, we present graphical representations of the curvature evolution, illustrating its dependence on the radial coordinate and time. These visualizations offer deeper insight into the nature of weak singularities and their impact on the overall spacetime structure [11]. Through this study, we aim to enhance the understanding of weak singularities in gravitational collapse and their implications in the broader framework of general relativity.

Tolman-Bondi Spacetime

The Tolman-Bondi model represents the gravitational collapse of a spherically symmetric, inhomogeneous dust cloud. It is formulated in synchronous co-moving coordinates such that $g_{ti} = 0$ $(i = r, \theta, \phi)$ and $g_{tt} = -1$. The velocity of the dust particles is given by:

$u^i \equiv (1,0,0,0)$ (1)

indicating that the coordinate time tt coincides with the proper time of freely falling particles. The cosmological constant Λ is set to zero. The spherically symmetric Tolman-Bondi metric is given by:

$ds^2 = -dt^2 + e^{-2\nu(t,r)}dr^2 + R^2(t,r)\, d\Omega^2,$ (2)

where $\nu(t,r)$ is an arbitrary function and

$d\Omega^2 = d\theta^2 + sin^2\, \theta\, d\phi^2.$ (3)

The energy-momentum tensor for a dust distribution is:

$T_{ij} = \rho(t,r)u_i u_j,$ (4)

where $\rho(t,r)$ represents the energy density, and the only non-vanishing component of T_{ij} is:

$T_{00} = \rho.$ (5)

Einstein Tensor Components

For the given metric, the independent components of the Einstein tensor are:

$$G_{00} = \frac{-1+e^{2\nu}\left(R'^2+2RR'\nu'+2RR''\right)-\dot{R}^2+2R\dot{R}\dot{\nu}}{R^2}\ , \tag{6}$$

$$G_{01} = \frac{2\left(\dot{R}'+R'\dot{\nu}\right)}{R}, \tag{7}$$

$$G_{11} = \frac{e^{(-2\nu)}\left(2\dot{R}R+\dot{R}^2+1-e^{2\nu}R'^2\right)}{R^2} \tag{8}$$

$$G_{22} = R\left(-e^{2\nu}\left(R'\nu'+R''\right)-\dot{R}\dot{\nu}+\ddot{R}+R(\dot{\nu}^2-\ddot{\nu})\right) \tag{9}$$

$$G_{33} = -R\,sin^2\theta\,\left(e^{2\nu}\left(R'\nu'+R''\right)+\dot{R}\dot{\nu}-\ddot{R}+R\left(-\dot{R}^2+\ddot{\nu}\right)\right) \tag{10}$$

Where $\dot{R} = \frac{\partial R}{\partial t}$ and $R' = \frac{\partial R}{\partial r}$

Auxiliary Functions and Einstein Equations

Defining the auxiliary functions:

$$f(r) = e^{2\nu}R'^2 - 1 \tag{11}$$

$$F(r) = R\left(\dot{R}^2 - f\right) \tag{12}$$

Einstein's equations simplify to:

$$\dot{R}^2 = \frac{F}{R} + f \tag{13}$$

$$\dot{f} = 0 \tag{14}$$

$$\dot{F} = 0 \tag{15}$$

Since $\dot{f} = 0$ and $\dot{F} = 0$, both f and F are function or r alone. The constraint equation:

$$F' = R^2R'T_{00} \tag{16}$$

Further determines the structure od the solution. The Tolman-Bondi metric can then be rewritten as

$$ds^2 = -dt^2 + \frac{R'^2}{1+f(r)}dr^2 + R^2(t,r)\ d\Omega^2, \tag{17}$$

Parametric Solutions

The general solutions of the Tolman-Bondi equations are given in parametric form for different values of f(r):

Hyperbolic Case ($f(r) > 0$)

$$R(t,r) = \frac{F}{2f}(cosh\eta - 1), \tag{18}$$

$$sinh\eta - \eta = \frac{2f^{\frac{3}{2}}(t-a_0)}{F}. \tag{19}$$

Parabolic Case (f(r) = 0)

$$R(t,r) = \left(\frac{9F(t-a_0)^2}{4}\right)^{\frac{1}{3}}. \tag{20}$$

Elliptic Case (f(r) < 0)

$$R(t,r) = \frac{F}{2}(-f)^{\frac{3}{2}}\ (1 - cos\eta), \tag{21}$$

$$t - a^0 = \frac{F}{2}(-f)^{-\frac{3}{2}}(\eta - sin\,\eta). \tag{22}$$

Density and Curvature Analysis

The density profile in the Tolman-Bondi spacetime is given by:

$$8\pi\,\rho(t,r) = \frac{F'(r)}{R'(t,r)R^2(t,r)} \tag{23}$$

The Kretschmann scalar $K = R^{hijk}R_{hijk}$ takes the form:

$$K = 12\left(\frac{F^2}{R^6}\right) - 8\,\frac{FF'}{R^5R'} - 3\,\frac{F'^2}{R^4R'^2}. \tag{24}$$

Physical Interpretation

The functions $a_0(r), f(r)$, and $F(r)$ play fundamental roles in determining the behavior of the Tolman-Bondi model:$a_0(r)$ represents the local time at which $R(t,r) = 0$, distinguishing between big-bang and big-crunch regions.$F(r)$ is the Misner-Sharp mass function, which corresponds to twice the effective mass m. Since $F(r)$ is a mass function, it must satisfy the condition:

$$F(r) \geq 0 \tag{25}$$

Conditions for Shell-Crossing Singularity

Shell-crossing singularities are characterized by the conditions:

$R' = 0$, and $R > 0$.

For a general ($f(r) < 0$) Tolman-Bondi solution, the evolution of the system can be described using parametric equations. From equation (22), we obtain:

$$(t - a_0) = \left(\frac{F}{2}\right)(-f)^{-\frac{3}{2}}(\eta - \sin\eta), \tag{26}$$

$$R(t,r) = \left(\frac{F}{f}\right) sin^2\eta/2\ , \tag{27}$$

where $0 < \eta \leq \pi$ (elliptic case), and a_0 is an arbitrary constant of integration determined from initial conditions.

For initial data $\dot{R}(0,r) \equiv \varphi(r) = a_0(r)$, equation (26) simplifies to:

$$a_0 = \left(\frac{F}{2}\right)(-f)^{-\frac{3}{2}}(\eta_0 - \sin\eta_0). \tag{28}$$

Using equation (27):

$$f\left(csc^2\left(\frac{\eta}{2}\right) + 1\right) = \dot{R}^2, \tag{29}$$

which leads to

$$f^{-\frac{3}{2}} = \frac{\left(\left(csc^2\left(\frac{\eta}{2}\right)+1\right)^{-\frac{3}{2}}\right)}{\dot{R}^3}. \tag{30}$$

Substituting equation (30) into equation (28) at $t = 0$ gives:

$$a^0(r) = \left(\frac{F}{2}\right)\frac{\left(csc^2\left(\frac{\eta_0}{2}\right)+1\right)^{-\frac{3}{2}}}{\dot{R}^3}\ (\eta_0 - \sin\eta_0). \tag{31}$$

Defining $\dot{R}^3(0,r) = \nu(r)$, we obtain:

$$a_0(r) = \left(\frac{F}{2}\right)\nu^{-3}\frac{\left(\left(csc^2\left(\frac{\eta}{2}\right)+1\right)^{-\frac{3}{2}}\right)}{\dot{R}^3}\ (\eta_0 - \sin\eta_0). \tag{32}$$

For a time-symmetric initial condition, $v(r) = t_0(r) = 0$ leads to $f = -F\ /\ R$, and the initial area radius is fixed as $R(0,r) = r$.Using these in equations (26) and (27):

$$t(\eta,r) = \left(\frac{r^3}{4F}\right)^{\frac{1}{2}}(\eta - \sin\eta), \tag{33}$$

$$R(\eta,r) = r\,sin^2\left(\frac{\eta}{2}\right). \tag{34}$$

The time required for complete collapse is:

$$t_{collapse(r)} = \pi\sqrt{\frac{r^3}{4F}}. \tag{35}$$

Differentiating equation (5.16) with respect to r:

$$t'_{collapse(r)} = \left(\frac{\pi}{4}\right)\left(\frac{3}{r} - \frac{F'}{F}\right). \tag{36}$$

Shell-crossing occurs when the outer shells move faster than the inner shells, leading to a temporary density singularity. The necessary and sufficient condition for shell-crossing is that $t_{collapse(r)}$ be a decreasing function:

$$t'_{collapse} < 0 \tag{37}$$

which leads to the condition:

$$\frac{F'}{F} > \frac{3}{r}. \tag{38}$$

In the marginally bound ($f(r) = 0$) Tolman-Bondi model, the energy function vanishes. The solution simplifies to:

$$R(t,r) = r\left[1 - \frac{t}{a_c(r)}\right]^{\frac{2}{3}}, \quad (39)$$

where

$$a_{c(r)} = \sqrt{\frac{4r^3}{9F}}. \quad (40)$$

The shell-crossing condition requires:

$$\frac{F'}{F} > \frac{3}{r}, \quad (41)$$

which coincides with the time-symmetric ($f(r) < 0$) case. This singularity occurs at $R(t,r) > 0$ and $R'(t,r) = 0$, indicating a weak singularity, rather than a strong curvature singularity.

Such shell-crossing singularities do not necessarily lead to curvature singularities where the Kretschmann scalar diverges. However, in regions where $R \to 0$ globally, the singularity becomes strong, marking the end of classical evolution. Studies (e.g., Newman Clarke 1981, Nolan 1999) have explored the nature of these singularities and their implications for cosmic censorship.

Curvature vs. Time and Curvature vs. Radius

The behaviour of curvature plays a crucial role in understanding the dynamics of collapsing matter in the Tolman-Bondi model. The two graphs presented illustrate the variations of curvature with respect to time and radius.

Curvature vs. Time

The first graph demonstrates how curvature $\boldsymbol{K}$ evolves as a function of time. Initially, at $\boldsymbol{t = 0}$, the curvature starts at a maximum value and gradually decreases as time progresses. This trend suggests that as the collapse proceeds, the spacetime curvature weakens, which is consistent with the structure of the Tolman-Bondi solution. However, as the matter shells approach the singularity, the curvature diverges, leading to a shell-crossing singularity.

Curvature vs. Radius

The second graph shows the dependence of curvature on the radial coordinate r. At the centre$\boldsymbol{r = 0}$, the curvature is at its highest value, indicating strong gravitational effects in the core. As we move outward to larger radii, the curvature decreases, implying that the outer shells experience weaker gravitational influence. This aligns with the expectation that the central region undergoes more intense collapse compared to the periphery.

Interpretation and Physical Implications

The occurrence of shell-crossing singularities in gravitational collapse is governed by the relationship between the Misner-Sharp mass function F(r)F(r) and the radial coordinate rr. Specifically, the condition

$$\frac{F'}{F} > \frac{3}{r} \quad (42)$$

serves as a necessary and sufficient criterion for the development of these singularities. Physically, this condition implies that the mass distribution within the collapsing cloud plays a crucial role in determining whether the evolution of the system will lead to shell-crossing, where neighbouring shells of matter overlap, resulting in regions of diverging density. Unlike strong curvature singularities, where the Kretschmann scalar or other curvature invariants diverge, shell-crossing singularities are typically considered weak in the sense that they do not necessarily lead to geodesic incompleteness. The study of curvature behavior as a function of both time and radial coordinate provides deeper insights into the nature of these singularities. By analyzing how the curvature evolves with time, we can determine the critical moments during collapse when density and tidal forces reach extreme values. Similarly, the dependence of curvature on radial distance highlights the spatial distribution of singular behavior within the collapsing cloud. This analysis aids in distinguishing between central singularities, where all collapsing shells converge to a point, and shell-crossing singularities, which form due to the differential infall of mass shells. For the specific case of marginally bound collapse, where the energy function $f(r) = 0$, the system follows a parabolic trajectory, leading to a finite collapse time. This scenario corresponds to the critical boundary between hyperbolic and elliptic collapse dynamics and is particularly significant in astrophysical modeling. The existence of weak singularities in such cases depends on the initial density profile and the velocity distribution of the collapsing matter.

revious studies on spherically symmetric dust collapse, such as those based on the Tolman-Bondi model, have demonstrated that certain initial conditions can lead to shell-crossing, reinforcing the results obtained in this analysis. These findings have important implications for the study of gravitational collapse and black hole formation. In realistic astrophysical scenarios, deviations from perfect spherical symmetry and the inclusion of pressures or other stresses could alter the onset of shell-crossing singularities. Moreover, the impact of quantum effects, such as vacuum polarization, on these singularities remains an open question in theoretical physics. Future work could extend these results to include more general initial conditions, higher-dimensional models, or alternative gravity theories to explore their influence on shell-crossing behavior.

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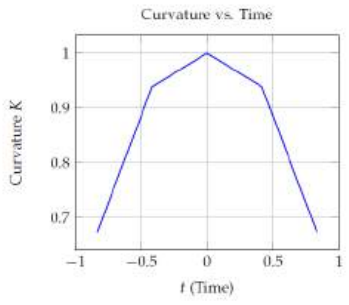


FIG. 1. Curvature vs. Time at Fixed Radius

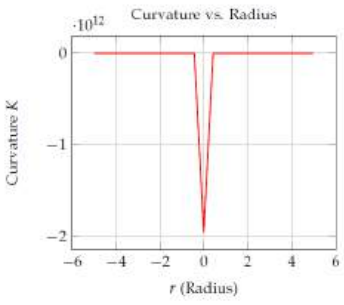


FIG. 2. Curvature vs. Radius at Fixed Time

Fig 1 & 2

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RESEARCH ARTICLE

Dermasorption -the Interconnectedness of Iontophoresis with Lepa

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ABSTRACT

Alepa kalpana as per ayurveda is topical medication suitable for external application on skin. From the beginning of time, as documented by the vedas and samhitas. Lepas are used to treat a variety of illnesses, including inflammation, skin whitening, wound cleaning, and wound healing. Topical applications in Ayurveda include malahara, upanaha, and lepa. The lepa incorporates herbal medications, they should be made and applied within 24 hours as the medications break down otherwise causing skin damage. The base that the medications are combined with to make a lepa determines how long the shelf life will be. Iontophoresis is a technique used in old textbooks for medicine as medicated plasters like salyclic acid patch .the article reviews both the systems of their potential merits and demerits of both the treatment modalities

Keywords: Lepa Kalpana, Upanaha, Malahara, Iontophoresis

INTRODUCTION

The potential of using the intact skin as the port for drug delivery has been recognized for over several decades as evidenced by the development of medicated plasters, ointments, and complex inunctions. Historically, the medicated plasters could be viewed as the first development of human's idea of transdermal drug delivery. Medicated plasters such as salicylic acid plaster have also been used in western medicine for several decades [1]. The

skin being the largest organ would be a best option for delivery of drugs. Acharya Susrutha was keen on understanding twak as a media to infuse drug in the body. Chikitsa can be classified as Antah Parimarjana and Bahir Parimarjana. Bahir Parimarjana means, the medicine intended for external use like Lepa, Upanaha, Udavartana, Abhyanga, Malahara [2].Historically, the medicated plasters could be viewed as the first development of human's idea of transdermal drug delivery. Medicated plasters such as salicylic acid plaster have also been used in western medicine for several decades but mostly for local effect at site. The transdermal drug-delivery system has several advantages, particularly avoidance of gastrointestinal incompatibility and hepatic "first-pass" effect. However, it is also associated with some specific limitations arising mainlyfrom the excellent barrier properties of the stratum corneum, the outermost (dead) layer of the epidermis. The conventional topical delivery systems are therefore restricted to either substances for local effects or to highly potent, small, and lipophilic substances for systemic effects [3]. It is also difficult to deliver ionic and higher-molecular-weight drugs in therapeutically sufficient amount by conventional system. Skin being the largest organ can be made use to deliver drug into the body. Iontophoresis and poultice application in Ayurveda represent two distinct approaches to treatment—one rooted in modern medical science and the other in ancient holistic practices. This article reviews these two methods, exploring their mechanisms, applications, benefits, and potential drawbacks.

LEPA

DEFINITION OF LEPA

लिप्यतेअनेनइतिलेपनं॥ (ShabdakKalpa Druma)4

Means the act of coating or smearing is called as lepana

द्रव्यमआर्द्रमशिलापिष्टंशुष्कवसद्रवमभजेत|

देहेप्रलेपनार्ऽथतल्लेपइत्युच्यतेबुधे॥ (Dravyaguna vigyan , yadvaji)5

According to this referencewet drugs are made into paste for by grinding it. If the drugs are in dry state they are converted into paste by adding sufficient quantity of water (milk or Sneha dravyas depending on the need). The paste so applied is called as lepa. From pharmacological point of view lepa is from of kalka Kalpana. The therapeutic use of applying over gave kalka the name lepa. Acharya Susrtuha explains Sneha according to dosha.

TYPES OF LEPA

As per Susrutha Samhita the types of lepas are 3types[6]

सत्रिविधः-प्रलेपः,प्रदेह,आलेपश्च

PROCEDURE

PREPARATION OF AGNI CHIKITSA

Fine powder of all the dry drugs(Lashuna, Lavanga, Marica, Sarshapa, Haridra) was prepared using a mixer. All the wet drugs(fresh leaves of Kshudra Agnimantha, Vana Tulasi, Nirgundi, Papata, Bhandha) were washed and the veins present in the leaves were removed and chopped into small pieces using a knife. These were then mixed with the powder of dry drugs and fine paste was prepared with help of a grinder by adding small quantity of water. Fresh paste of Agni Chikitsa was prepared daily just before application during the course of treatment.

INTERVENTION

Patients were asked to take hot water bath. 5 gram of Agni Chikitsa was given internally, in the morning and 5grams in the evening. 10 grams of Agni Chikitsa was applied over the anterior frontanelle. Rest of the Agni Chikitsa was applied in opposite direction of the hair follicle to the whole body below the neck in thickness of approximately 2.6 mm. Patients were asked to retain it till next morning. Paste falls off from the body of the patient when it gets dried. It was not removed manually.

INOTOPHORESIS

Iontophoresis is a process of transdermal delivery by use of a voltage gradient on the skin[7]. Molecules are transported from stratum corneum to deeper layers by electrophoresis and electroosmosis and the electric field can also increase the permeability of the skin. Average adult human covers a surface area of nearly 2 m^2 and receives about one-third of the blood circulating through the body[8]. Transdermal drug delivery technologies are divided into passive and active methods [9]. Iontophoresis is an active technique that delivers charged or neutral drugs across the skin by the application of a small electric current which enhances the permeation of drug through the skin non- invasively. Amongst the many benefits of the transdermal drug delivery method are the avoidance of gastrointestinal incompatibility and the hepatic "first-pass" impact. The stratum corneum, the outermost (dead) layer that makes up the epidermis, possesses strong barrier qualities, which is one of the technique's unique drawbacks. Percutaneous absorption can transpire via two distinct pathways: transepidermal (across the stratum corneum intracellularly and intercellularly) and transfollicular (by hair follicles, sweat ducts, and secretory glands). Passive iontophoresis is an advanced method of transdermal drug delivery that leverages the principles of iontophoresis to enhance the permeability of the skin for therapeutic agents. Unlike active iontophoresis, which requires an external electric field to drive ions through the skin, passive iontophoresis relies on naturally occurring electrochemical gradients and the inherent properties of the skin and drug molecules [10]. The process of percutaneous absorption can be defined as the mass movement of substance from the skin surface to the general circulation. It includes penetration by gradient through the stratum corneum, diffusion through each layer of the skin, uptake by the capillary network at the dermo-epidermal junction, and finally transportation to the target tissues to achieve therapeutic action [11].

Factors affecting the rate of absorption

May be divided into two main types

Skin factors

- Area
- Character of skin
- Keratinisation

Drug factors

- Concentration
- Meyer Overton theory
- Attributes of drug

Area of skin

The amount of drug absorbed at constant concentration is greater when applied over a large area. The area of skin has a direct correlation with the amount of drug absorbed. The medication applied tropically in a small area need to be in good concentration to get absorbed and to create and systemic effect

Skin character

Areas with more keratinsed tissue decreases absorption of the drug through the skin as stratum corneum reduces absorption. Normal non keratinised tissue helps in better absorption than keatinised tissue. The absorbability also changes with age.

Meyer

Overton theory of absorption states that the substances soluble in lipids pass through the cell membrane owing to its lipid content while water-soluble substances pass after the hydration of the protein portion of the cell wall which render the cell permeable to water soluble substances. [12]

Drug concentration

The amount of drug absorbed per unit surface area with more concentration of drug. A high concentration of drug applied locally can help in better absorption provided the drug is easily diffusible with low molecular weight.

Addition of perfusion enhancers and some of them are lauric acid and oleic acid and water[13]. They are substances that increase the absorption of the drug thought skin. The addition of Sneha dravyas into the lepa Kalpana may be considerd here with due significance

CONCLUSION

Agni Chikitsa Lepa exemplifies the convergence of ancient wisdom and modern science. By drawing parallels with passive iontophoresis, this Ayurvedic practice underscores the timeless relevance of natural healing mechanisms. The medication applied on skin due to the concentration and surface area would seep into deeper layers. The addition of Sneha dravyas into lepa increases the penetration coefficient of the drug. The permeation enhancers like lauric acid and oleic acid may also add to the efficacy of the preparation. Continued exploration and validation of these methods can lead to more effective and holistic healthcare solutions.

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Table:1

NAME	DOSHIC INVOLMENT	SPECIFICATIONS
प्रलेपः		Cold thin any may be allowed to dry up on the body
प्रदेह	VATA KAPHA	Can be applied warm or cold and may be dry or non drying on body
आलेपश्च	RAKTA PITTA	

Table:2 Sneha added as per dosha prevalence

	vata	Pitta	Kapha
Sneha	1/4th of lepa	1/6th of lepa	1/8th of lepa

Table:3 AGNILEPA

Sanskrit name	Botanical name	Part used
DRY DRUGS		
Lashuna	*(Allium sativum)*	10 buds
Lavanga	*(Syzygium aromaticum)*	10gm
Maricha	*(Piper nigram)*	10gm
Sarshapa	*(Brassica campestris)*	5gm
Haridra	*(Curucuma longa)*	5gm
Wet drugs		
Kshudra agnimantha	*(Clerodendrum phlemoidis)*	Leaves of these drugs are used. Each drug is taken in equal quantity Quantity sufficient enough to prepare a paste to apply all over the body of the patient Quantity varies according to the patient
Vanatulasi	*(Ocimum basilicum)*	
Nirgundi	*(Vitex nigundo)*	
Papata	*(Pavetta indica)*	
Bandha	*(Bradelta scandes)*	

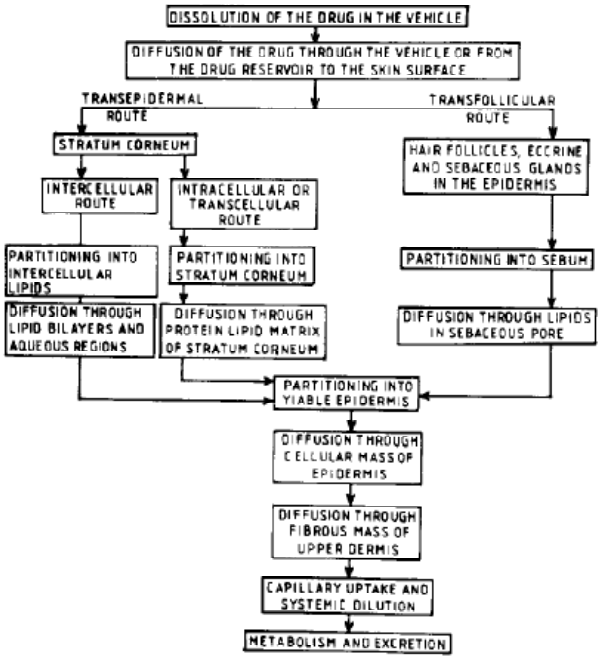


Figure:1

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RESEARCH ARTICLE

An Isolated Connected Domination in Random Graphs

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ABSTRACT

An <S> is a union of a connected Random graph (non isolated Random graph) with some (at least one) isolated vertices. An isolated connected dominating set of a connected Random graph G(n,p) is a dominating S $\subseteq$ V($G_{n,p}$) set in this way. The smallest cardinality of an isolated connected dominating set of G is represented by an isolated connected domination number of G(n,p), denoted by $\gamma_{ic}\, G(n,p)$. We examine a few characteristics and provide an isolated connected dominance number for a few families of random graphs in this research.

Keywords: Random Graph($G_{n,p}$), Connected Random Graph$G_c(n,p)$,Domination number in $G_{n,p}$, connected domination number in $G_{n,p}$,Isolated Connected domination $G_{n,p}$.
Mathematics Subject Classification (2010): 05C69, 05C80

INTRODUCTION

In the 1960s Erdos and Renyi , two great Mathematicians , established the Random graph theory and initiated the systematic study of it[1] . Random Graph($G_{n,p}$) lies in the intersection of Graph theory and Probability theory, has always been the basic theory for studying complex networks. Domination is a central topic in graph theory, with a number of application in computer science and engineering. A dominating set S in a graph G has that each node not is S is joined to some node of S. The minimum order of a dominating set is the domination number of G denoted$\gamma(G)$.The book [8][9]supply a introduction to theoretical and applied results of domination in graphs. Relatively little work has been done on domination in Random graph models. The domination number of ER Random Graph ($G_{n,p}$) was determined by Wieland and Godbole in [7].Dreyer[17] analyse some basic results of

proves with q=1/(1-p)(p fixed) and set of cardinality $(1+\varepsilon)\log_q n$ is a dominating set with probability tends to 1 as n tends to infinity. And sets of order$(1-\varepsilon)\log_q n$ dominate with probability approaching zero as n tends to infinity.May instead take $\varepsilon = \varepsilon_n$tends to zero so that $\varepsilon_n \log_q n$ tends to infinity.we analyse the some properties of Isolated connected domination of $(G_{n,p})$.

PREMILIARIES

Definition:2.1:($G_{n,p}$)

When we are given a graph G is a random graph, this is wrong. Already Existing graph is fixed, there is nothing random to it. What we mean though through this term abuse is that this graph was sampled out of a set of graphs according to a probability distribution. An Random Graph $G_{n,p}$ has two parameters , the number of vertices n and a probability parameter$0 \leq p \leq 1$. Let $\mathcal{G}$ be the family of all possible labelled graphs on the vertex set [n]. Note that $|\mathcal{G}| = 2^{\binom{n}{2}}$.The $G_{n,p}$Model assign to a graph G$\epsilon\mathcal{G}$ satisfy the probability

Probability [G]=$P^{|E(G)|}(1-P)^{\binom{n}{2}-|E(G)|}$

Definition: 2.2: ($G_{n,m}$)

An Uniform Random graph($G_{n,m}$) has two parameters , the number of vertices n and the number of edges m, where $0 \leq m \leq \binom{n}{2}$. This model assigns to all labelled(named) graphs on the vertex set [n] with exactly m edges equal probability. Therefore,

Probability [G]=$\begin{cases} \frac{1}{\binom{\binom{n}{2}}{m}} & if\ |E(G)| = m \\ 0 & \end{cases}$

Definition: 2.3: $G_c(n,p)$

An Connected Random Graph$G_c(n,p)$, a pair of u and v is chosen from the vertex set V(G) of the graph G. Here each pair of vertices $\{v_i, v_j\}$, where $v_j \epsilon$ V(G) - v_i. There exist an edge between v_i *and* $v_j$in a graph iff the random number generated for the pair v_i *and* v_j is at most the edge probability p of the graph G.Its is denoted by $G_c(n,p)$.

Definition:2.4: γ ($G(n,p)$)

An Random Graph $G(n,p)$ with fixed parameter p_n=p>0 and the number vertices n tending to infinity. Then a.a.s the domination number of $G(n,p)$ satisfies ,

$\gamma\left(G(n,p)\right) = (1+o(1))log_q n$

Where q=$\frac{1}{1-p}$.

Definition:2.5 γ_c ($G(n,p)$)

An Connected Domination Random Graph γ_c $(G(n,p))$ with fixed parameter p_n=p>0 and the number vertices n tending to infinity. Then a.a.s the connected domination number of γ_c $(G(n,p))$ satisfies ,

$\gamma_c\left(G(n,p)\right) = \lceil log_q n + a_n \rceil$

Where a_n be any sequence of $G_c(n,p)$.

An Isolated Connected Domination in Random Graphs:

Definition:3.1 $\boldsymbol{\gamma_{ic}}$ $(\boldsymbol{G(n,p)})$

An Isolated connected dominating set S of a $G(n,p)$ is a dominating set

S C V($G(n,p)$) such that <S> is union of a connected $G(n,p)$ and some (at least one) isolated vertices. An Isolated connected dominating number of $G_c(n,p)$ is denoted by γ_{ic} $(G(n,p))$.

Propositions:3.2

A Connected Random Graph γ_c $(G(n,p))$ with m(fixed) edges is equally likely to be any of the $\binom{\binom{n}{2}}{m}$ graphs with m edges.

Proof:

Let any graph with m edges(fixed), its G.

Probability $[G_c(n,p)]$=G[$|E(G_c(n,p))|$=m]

$$=\frac{\text{Pro}[G_c(n,p)=G]}{\text{Pro}[|E(G_c(n,p))|=m]}$$

$$=\frac{P^{|E(G)|}(1-P)^{\binom{n}{2}-|E(G)|}}{\binom{\binom{n}{2}}{m}P^{|E(G)|}(1-P)^{\binom{n}{2}-|E(G)|}}$$

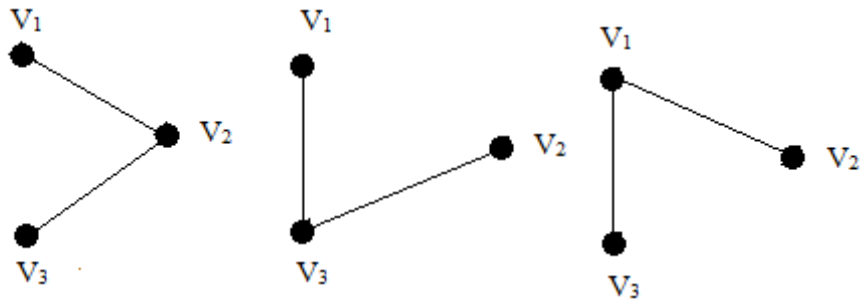
$$=\frac{P^{m}(1-P)^{\binom{n}{2}-m}}{\binom{\binom{n}{2}}{m}P^{m}(1-P)^{\binom{n}{2}-m}}$$

Probability $[G_c(n,p)]$ $=\frac{1}{\binom{\binom{n}{2}}{m}}$

Example:3.2.1

A Connected Random Graph$G_c(n,p)$ on 3 vertices with 2 edges (fixed)

Is given by



Above G(n,p) figure having same Probability $=\frac{1}{3}$.

Theorem:3.3

In connected Random Graph $G_c(n,p)$, consider *P is a monotone increasing property and* $0\leq p_1 < p_2 \leq 1$, G $\sim G_c(n,p_i)$, i=1,2.

Propability $[G_1 \in p_1]\leq$ Propability $[G_2 \in p_2]$

Propositions:3.4

If a Random Graph G(n,p) admits isolated connected vertex set ,then

diam (G(n,p))≥ 2. (a.a.s)

Proof

Let X be the eccentricity of vertex v.

$\Pr(x = 1) = P^{n-1}$, which goes to 0 as n →∞

$\Pr(X > 2)$indicates that there is a vertex u such that u is not connected (isolated vertex) to v or any of the vertices that is directly connected to v.

So, $\Pr(X > 2) = (n-1)(1-p)^{(|S|+1)}$

Where S is the set of vertices connected to v. Since $|S| = np + o(1)$ when n is sufficiently large, $\Pr(X > 2)$also goes to zero as n goes to infinity.

Just an approximation $|S| = (n-2)p, the$ probability that a given pair of vertices is not connected by a path of length 2 is $(1-p^2)^{(n-2)}$.Since all edges forming these potential paths are distinct.

Thus the expected number of pair not thus connected is $\binom{n}{2}(1-p^2)^{(n-2)}$,which goes to zero as n→∞ at fixed p>0.

The probability for the diameter to exceed 2 is less than this expected number and thus also goes to 0.

Example:3.4.1

If$G_c \sim G_{ic}\left(n, n^{\frac{-1}{3}}\right)$ prove that $G_{ic}\left(n, n^{\frac{-1}{3}}\right)$ has diameter 2 almost surely.

Solution

Let X_{uv} be the indicator for the event .A_{uv} that no other vertex in G(n,p) is adjacent to u or v.

Show that :E[X]→0 as n →∞ (ie) (it has diameter 2 almost surely)

$E[X]=E[\sum_{(u,v)u,v\epsilon v(G)} X\text{uv}]$

$=\sum_{(u,v)u,v\epsilon v(G)} E[X\text{uv}]$

$=\sum_{(u,v)u,v\epsilon v(G)} P[A\text{uv}]$

$=\binom{n}{2}(1-p)(1-p^2)^{(n-2)}$

In this situation given above problem $p=n^{\frac{-1}{3}}$

$\binom{n}{2}(1-p)(1-p^2)^{(n-2)} = \binom{n}{2}(1-n^{\frac{-1}{3}})(1-n^{\frac{-2}{3}})^{(n-2)} \cong \binom{n}{2}(1-n^{\frac{-1}{3}})exp(-n.n^{\frac{-2}{3}})n \to \infty = \binom{n}{2}(1-n^{\frac{-1}{3}})\exp(-n^{\frac{1}{3}})$

→ 0.

Propositions:3.5

If a Random Graph$G(n,p)$ admits Isolated connected set then

$\gamma\left(G(n,p)\right) \leq \gamma_{ic}\left(G(n,p)\right) \to 1 \text{as } n \to \infty$

Proof

There is no relationship between $\left(G(n,p)\right) and\ \gamma_{ic}\left(G(n,p)\right)$.

The domination number of G(n,p)= $(1+o(1))log_q n$ where q=$\frac{1}{1-p}$.

Case(i)

$\gamma\left(G(n,p)\right)$ is no larger than $\lceil log_q n + a_n \rceil$ with probability approaching unity.

$P([D \leq \lceil log_q n + a_n \rceil]) = P(\exists\ a\ dominating\ set\ of\ size\ r := \lceil log_q n + a_n \rceil)$

$\geq P$ ({1,2,…….,r} is a dominating set) [$\therefore$ p = p^{n-r+r}

$= (1-(1-p)^r)^{n-r} = (p^r)^{n-r}$

$\geq 1-(n-r)\,(1-p)^r \quad = (1-(1-p)^r)^{n-r}]$

$=1-n\,(1-p)^r + n\,(1-p)^r \geq 1-n\,(1-p)^{log_q n + a_n}$

$= 1\text{-}n(1-p)^{log_q n}.(1-p)^{a_n} = 1\text{-}n.(q)^{log_q n}(1-p)^{a_n}$

$= 1 - (1-p)^{a_n} = 1\text{-}1 + p^{a_n} = p^{a_n} \rightarrow 1$

Case(ii)

$p(\gamma_{ic}(G(n,p))) \leq \lceil log_q n + a_n \rceil \rightarrow 1\ as\ n \rightarrow \infty.$

Let a_n be any sequence approaching infinity then,

$p(\gamma_{ic}(G(n,p))) \leq \lceil log_q n + a_n \rceil = P\ (\exists\ a\ dominating\ set\ of\ size\ r := \lceil log_q n + a_n \rceil) \geq P$ (vertices {1,2,…….,r} form a dominating set)

Now a set consisting of r vertices which we will call M_r. Let N_r be the set with the remaining (n-r) vertices and some (at least one) isolated vertices. It becomes the vertices {1,2,…,r} forming a dominating set is connected to every vertex in N_r having at least one neighbour in M_r (i.e) $M_r \cup N_r = V(G(n,p))$.

$p(\gamma_{ic}(G(n,p))) \leq \lceil log_q n + a_n \rceil \geq p(vertex\ v\ in\ Mr\ is\ adjacent\ to\ u\ in\ Nr)^{n-r}$

Now use that the probability of vertices forming an edge is independent .Then probability if a vertex v in N_r not having any neighbour in M_r.

$p(\gamma_{ic}(G(n,p))) \leq \lceil log_q n + a_n \rceil \geq (1 - p(vertex\ v\ in\ Nr\ has\ no\ neighbour\ in\ Mr)^{n-r} = (1-(1-p)^r)^{n-r}$

Where to the fact that edge from a vertex v in N_r to a vertex u in $M_r$with probability 1-p and having r possibilities for vertices u in M_r .then,

$\geq 1-(n-r)\,(1-p)^r \quad = 1-n\,(1-p)^r + n\,(1-p)^r \geq 1-n\,(1-p)^r \geq 1-n\,(1-p)^{log_q n + a_n}$

$= 1 - n(1-p)^{\frac{log n}{\log(1-p)} + a_n}$

$= 1 - n.(e)^{\frac{\log(1-p)}{\log(1-p)} + a_n}$

$= 1 - (1-p)^{a_n}$

$= 1\text{-}1 + p^{a_n}$

$= p^{a_n} \rightarrow 1$

We assumed that $a_n \rightarrow \infty$ as $n \rightarrow \infty$ and since p>0 we have that 1-p<1 .

This results in (1-p) $\rightarrow 0\ as\ n \rightarrow \infty.$

$p(\gamma_{ic}(G(n,p))) \leq \lceil log_q n + a_n \rceil \geq 1 - (1-p)^{a_n} \rightarrow$ 1-0=1.

From the case(i) &(ii), $\gamma\left(G(n,p)\right) \leq \gamma_{ic}(G(n,p)) \rightarrow 1 as\ n \rightarrow \infty.$

Example:3.2.1

Here n=3, p=1/3, $\gamma\left(G(n,p)\right) = (1+o(1))log_q n$

$\gamma\left(G(3,1/3)\right) = \lceil(1+2)log_{1.5}3\rceil = \lceil 1.43136\rceil = 1.$

Here n=3, p=1/2 ,$\gamma_{ic}\left(G(n,p)\right) = (1+o(1))log_q n$

$\gamma_{ic}\left(G(n,p)\right) = \lceil(1+1)log_2 3\rceil = \lceil 0.954\rceil = 1.$

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RESEARCH ARTICLE

A Case Study on Managing Tinea (Dadru) - Skin Disorder: An Ayurvedic Approach

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ABSTRACT

Tinea, commonly known as Ringworm, is a highly contagious fungal infection that primarily affects the skin, nails, and hair. In Ayurveda, it is classified under Kushtha (skin diseases), with Dadru being a subtype of Kshudra Kushtha**.** It is typically caused by the imbalance of Kapha and Pitta doshas. This case study investigates the Ayurvedic approach to treating Dadru through a Shaman Chikitsa. A 29-year-old male patient, who developed severe itching and erythematous lesions with raised borders in the groin, thigh, genital, and buttock regions, was diagnosed with Tinea**.** The infection spread progressively over four months and was exacerbated by poor hygiene and improper dietary practices. The Ayurvedic treatment plan focused on restoring balance in the doshas, particularly Kapha and Pitta**,** through a combination of internal and external therapies. Arogyavardhini Vati**,** Gandhak Rasayana**,** Krumikuthar Ras**,** Mahamanjishthadi Kashaya**,** and Nimba Taila were prescribed for systemic purification, blood cleansing, and local application. In addition, the patient was advised to maintain strict hygiene, wear loose cotton clothing, avoid daytime sleep, and follow a diet free from oily, spicy, and heavy foods. The internal medicines worked to address the underlying dosha imbalances and fungal infection, while the topical treatments targeted local inflammation and itching. The treatment plan was followed for six months, resulting in significant improvement in skin appearance, reduction in itching, and resolution of lesions. This study concludes that Ayurvedic interventions, focusing on both internal and external treatments, provide a safe and effective solution for managing Dadru (Tinea), offering an alternative to conventional antifungal therapies with fewer side effects.

Keywords: Tinea, Dadru, Kushtha, Skin disease

INTRODUCTION

Tinea, commonly known as Ringworm, is a type of highly contagious fungal infection that presents as circular lesions, typically characterized by distinct edges and raised borders, often appearing as single patches. While it is possible to observe multiple lesions, they usually remain separate or can merge. The method of diagnosis may differ depending on where the infection appears.[1]According to Ayurveda, the skin comprises seven layers that derive their nutrients from the underlying muscles. Additionally, the skin is considered a secondary product of blood, reflecting the characteristics of both blood and plasma, leading to the adage that "healthy plasma and blood produce glowing skin." According to Ayurveda, imbalances in the three doshas, particularly the aggravation of Pitta and Kapha, lead to fungal skin conditions.[2]The skin disorders described by the Acharyas under the category of kushtaroga are classified into two types: Mahakushta and kshudraroga, also referred to as 'Dadrukushta.[3] Skin diseases are primarily triggered by various microorganisms, with Tinea being one of them. Tinea, commonly known as ringworm, results from a specific group of fungi that live in the keratin layer of the skin, nails, and hair. However, these fungi do not penetrate the living epidermis. The serum's antifungal factors in the extravascular space help inhibit their growth. The invasion of fungi into living tissue can be influenced by various factors, including inadequate nutrition, unsanitary conditions, hot and humid climates, occupations that lead to sweating and skin maceration, diabetes, chronic illnesses, the use of corticosteroids and immunosuppressive medications, and close contact with infected individuals, animals, and contaminated surfaces, all of which increase the risk of ringworm. In Ayurveda, skin diseases are categorized as Kushtha, one of the Ashta-Mahagada, characterized by causing skin discoloration and vitiation. Kushtha is primarily divided into Mahakushtha and Kshudra Kushtha. While Acharya Sushruta and Vaghbata place Dadru under Mahakushtha,[4] Acharya Charaka designates it as Kshudra Kushtha.[5]Clinical symptoms include Deergapratana, Utsanna Mandala, Kandu, Raaga, Pidakas, and Anusangi. Ayurvedic texts recognize every form of Kushtha as a Tridoshaja condition. Acharya Vaghbata and Charaka attribute Dadru to imbalances in Kapha and Pitta doshas, whereas Acharya Sushruta attributes it solely to Kapha. In modern medicine, Dadru kushtha is equated with the fungal infection known as Tinea. Treatment for Tinea typically involves topical or systemic antifungals and corticosteroids, which can have potent side effects such as headaches, dizziness, nausea, vomiting, or abdominal pain. This highlights the need for effective treatments with minimal side effects. Consequently, this case study was conducted, viewing Ringworm as Dadru kustha and designing an Ayurvedic treatment plan accordingly.

MATERIAL & METHODS

Patient History

A 29-year-old male patient was apparently healthy before 4 Months. He gradually developed itching multiple erythematous lesions with Sharp border and round red colour big patches at abdominal region and buttocks region.

Local examination

Site of the lesion (Pidika Sthana) – Abdomen and Buttocks
Distribution (Vaypti) – Asymmetrical
Itching (Kandu) - Present
Inflammation (Raga) - Moderate present
Elevated circular skin lesion (Utsanna mandala) - Present

Sampraptighatak

Dosha–Tridoshaja.
Dushya–Twaka, Rakta, Mamsa and Ambu.
Strotas–Rasavaha, Raktavaha.
Strotodushti–Sanga.
Adhishthan–Twaka.

Swabhav–Chirkari.
Rogmarga–Bahya

RESULTS

After Treatment Kandu (Itching), Utsanna mandala (Elevated circular skin lesion), Pidika (Eruptions), Raaga (Erythema) was reduced.Ayurvedic therapies target the underlying cause of the infection by restoring balance to the doshas and cleansing the blood, providing lasting relief from recurring fungal infections.

Advice
To ensure proper local hygiene, the patient should wash the area twice daily, keep it dry, and wear loose-fitting cotton clothing. Additionally, it was recommended for the patient to sleep without undergarments to prevent irritation in the groin area. Avoiding daytime sleep was also suggested. Furthermore, incorporating cow ghee into the diet twice a day was advised to help soothe Rookshta. The patient was recommended to steer clear of oily, fried, spicy, junk, and heavy foods, which include curd, milk, and non-vegetarian options.

DISCUSSION

Arogyavardhini Vati Vata-Rakta Dushti and Kleda are key factors in Kushtha Vyadhi. The blood-purifying and anti-skin disease properties of Arogyavardhini are enhanced due to the specific combination of herbs in the formulation, which undergo a Bhavana with Kandughna and Kushthaghna Nimba. Arogyavardhini effectively eliminates stagnant Doshas and cleanses the body.[6]

Gandhak Rasayana is a widely recognized formulation primarily used for Kushtha Roga, serving as a blood purifier while alleviating itching (Kandu) and burning sensations (Daha). It possesses properties such as Raktashodhak, Vranaropak, Twachya, and Krumighna, and helps maintain a balance among Vata, Pitta, and Kapha Doshas, making it a suitable choice for this study.[7]

Krimikuthar Ras is a significant herbo-mineral formulation that includes Karpura, Kutaja, Trayamana, Ajamoda, Vidanga, Hingula Bhasma, and Vatsanabha Palasha Beeja. It is particularly effective in treating skin disorders caused by Krimi. Acharya Susrutha describes the transmission factors for Kustha, identifying Dadru as a communicable disease. The prevalence of Dadru is rising due to poor hygiene and practices such as sharing clothing. These contagious diseases can be transmitted through Krimi via sweat. This communicable aspect is another reason for including it in this study.

Mahamanjishthadi Kwatha was utilized to enhance and maintain blood quality due to its properties such as reducing inflammation, combating skin diseases, promoting wound healing, purifying blood, alleviating pain, and relieving itching, as indicated in the treatment of Kushtharoga.[8]

Nimba Taila Known for its **antifungal** and **anti-inflammatory** properties, **Nimba** (neem) oil helps reduce the inflammation, itching, and fungal growth associated with **Dadru**. It also has antiseptic properties, making it effective for local application.

CONCLUSION

Dadru, whether in its acute or chronic form, poses physical and mental challenges to individuals, as the itching and other symptoms persist throughout the day. Ayurvedic medicine offers a permanent solution through the use of internal and external remedies with properties that can alleviate skin conditions, itching, and parasitic infestations, effectively and safely treating those affected by Dadru.

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Table:1 Treatment Plan

No.	Medicine	Matra	Dosage	Kala	Anupana	Duration
1.	Arogyavardhini vati	250 mg	BD	Before Food	Koshnajala	6 Months
2.	Gandhak Rasayan	250mg	BD	Before Food	Koshnajala	6 Months
3.	Krumikuthar ras	250mg	BD	Before Food	Koshnajala	6 Months
4.	Mahamanjishthadi kashaya	20ml	BD	Before Food	Koshnajala	6 Months
5.	Nimba Taila		BD	For Local Application		6 Months



Fig :1



Fig :2

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RESEARCH ARTICLE

Chloride Concentration in Drinking Water of Slum Dwellers: Implications for Public Health

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ABSTRACT

Slums, known for poverty, overpopulation, and insufficient substructure, are often deprived of safe drinking water. Chloride, a universal anion in water, is an important indicator of water quality. While essential in small amounts, high chloride concentrations in drinking water can pose serious health risks. This study investigated the chloride concentration in drinking water sources within slum communities, examining the potential health risks associated with elevated levels. Chlorination of drinking water is an important procedure for disinfection. As a result, the concentration of chloride ions was determined in randomly collected drinking water samples from slum areas in Surat City, Gujarat, India. Analysis was done following Mohr's method. The results were between 315.2 to 576.4 mg/L. The data indicated a consistent increase in chloride levels after the monsoon season across all locations. This trend suggests a further deterioration of water quality after the rains, possibly due to runoff or changes in water composition The findings highlight the urgent need for interventions to ensure slum dwellers have access to clean and safe drinking water, safeguarding their health and well-being.

Keywords: Mohr's method, water quality, health, impacts, contamination

INTRODUCTION

The first prerequisite for the existence of life is water. Water's total physical and chemical characteristics determine the water's quality[1]. Important water resources have drastically decreased due to the unrestrained use of water for industrial, drinking, and irrigating purposes [2]. Water quality degradation has emerged as a critical global concern for human sustainability. Water supplies are severely threatened by pollution brought on by human activity and

improper agricultural drainage from water bodies [3]. Worldwide, industrialization and urbanization in the 20th century have given rise to an increased population in slums, resulting in a disadvantaged population with many health disparities compared with urban non-slum residents. Hence, this proportion is expected to increase to 68%, reaching 6.3 billion people by 2050, adding 2.3 billion more people to urban areas [4]. The proportion of the slum population in the country's urban population was 18.3 percent in 2001, compared with 17.4 percent in 2011 [5]. As per provisional reports of Census India, the population of Surat in 2011 was 4,467,797. Although Surat City has a population of 4,467,797, its urban/metropolitan population is 4,591,246. The total no. of Slums in Surat City numbers 100,038, with a population of 467,434. This is around 10.46% of the total population of Surat [6]. Globally, 785 million people lack access to even the most basic drinking water services, which can significantly affect their health and well-being [7]. Most residents in slums are poor, water insecure, and regularly deal with overcrowded and risky environmental conditions [8]. Water quality parameters that help to measure water quality include physical, chemical, and biological parameters. Water quality deteriorates when these parameters are not within the standard limit. Chlorine, in one form or another, is the most used chemical to disinfect water supplies. It is also active for other water treatment and supply purposes, such as preventing algal, bacterial, and general slime growths in treatment plants and pipeworks, controlling tastes and odours, and removing iron, manganese, and colour [9]. Chlorine is added to drinking water as elemental chlorine (chlorine gas), sodium hypochlorite solution, or dry calcium hypochlorite to purify the water on a large scale. When applied to water, each of these forms "free chlorine," which destroys pathogenic (disease-causing) organisms [10]. Chlorination is relatively inexpensive and readily available, making it suitable for large-scale and small-scale water treatment. When added to water, chlorine forms hypochlorous acid (HOCl) and hypochlorite ion (OCl-), both powerful oxidizing agents. When chlorine reacts with organic matter in water, it can form DBPs, such as trihalomethanes (THMs) and haloacetic acids (HAAs). Some DBPs have been linked to potential health risks, such as an increased risk of cancer with long-term exposure. The Canadian drinking water quality guideline for chloride is an Aesthetic Objective (AO) of less than or equal to 250 milligrams per liter (mg/L). At concentrations higher than 250 mg/L, the sodium associated with chloride may concern people on sodium-restricted diets [12,13]. The United States Environmental Protection Agency (EPA) has a secondary drinking water standard for chloride of 250 mg/L. This is not a legally enforceable limit but is recommended to avoid aesthetic issues like salty taste [14]. The Bureau of Indian Standards (BIS) has a desirable limit of 250 mg/L for chloride in drinking water, with a permissible limit of up to 1000 mg/L without an alternate source [15]. This research aims to determine chloride ion concentration in drinking water in slum areas due to its impact on health in higher concentrations

MATERIALS AND METHODS

Samples collection

A total of 60 drinking water samples were randomly taken from five selected slums of Surat city. The samples were analyzed on the same day they were brought from selected sampling sites(Fig. 1)

Method of analysis

Mohr's method (precipitation titration) is used to determine chloride ions in water samples. This method determines the chloride ion concentration of a solution by titration with 0.02N silver nitrate and the indicator (5%) potassium chromate solution [16,17].

RESULTS AND DISCUSSION

In the study, chloride ion concentration was determined in all the samples of drinking water collected from five slums of Surat City. The concentration and variation of chloride ions are depicted in Fig. 2, and 3 & 4. Fig. 2 displays chloride concentrations (mg/L) across various studied locations during pre-monsoon and post-monsoon periods. It was observed that chloride levels increased during post-monsoon across all locations. Govalak and Banjaravas samples consistently showed the highest chloride concentrations. Halpativas has the lowest chloride levels among all

locations. Chloride concentrations ranged from ~300 mg/L (Halpativas during pre-monsoon) to ~550 mg/L (Govalak, Banjaravas SMC, and Banjaravas Boring during post-monsoon). Concerning the acceptable chloride limit of 250 mg/L, the graph revealed that all measured samples exceeded the safe threshold significantly. Since all sites exceed the safe limit of 250 mg/L, the water at these locations is not acceptable for direct drinking without treatment. Prolonged exposure to such high chloride levels can affect water taste, may impact plumbing corrosion, and potentially cause health issues if consumed regularly. The data indicated a consistent increase in chloride levels after the monsoon season across all locations. This trend suggests a further deterioration of water quality after the rains, possibly due to runoff or changes in water composition (Fig. 3). The graph demonstrated that water quality is compromised in terms of chloride content across all measured locations, and additional treatment or water management interventions would be necessary to bring the levels within acceptable limits. The radar graph has multiple axes radiating from the centre, each representing a category. The axes are labelled with values ranging from 0 to 600, indicating the measurement scale. Each series forms a polygon connecting the data points for each category. The radar graph helped toidentify patterns and compare the concentration of different samples across different periods (Fig.4). The data suggests variability in the measured parameters across locations and periods (pre-monsoon vs. post-monsoon). According to the study of Raval and Malik, the concentration of chloride ion in analyzed samples exceeded the limit except for Kawas and Chalthan. High chloride reacts with sodium and makes water salty, which is unacceptable for human consumption. It also increases the TDS values thereby affecting the quality of water[18].A study in Bangladesh found that an increase of 1,000 mg/l in drinking water salinity led to a 2.2 mm Hg rise in systolic blood pressure [19]. Studies have also documented seasonal increases in hypertension, heart attack, and stroke during winter months that might be related to elevated levels of sodium in drinking water [20].The present study also found elevated levels of chloride in drinking water. Interaction with the slum dwellers revealed a bad taste and odour of water for the first half an hour to one when water was received from municipal taps. The study confirmed that the salty taste and odour might be due to the elevated level of chloride ions in the water samples studied.

CONCLUSION

Chlorination is a very popular method of water disinfection that has been used for many years. It is effective in killing bacteria and viruses. Although chlorination does have some drawbacks, it continues to be the most popular, dependable, and cost-effective method of water disinfection. This study showed that the concentration of chloride ion in drinking water exceeded the accepted limit. This requires strict and continuous control of the levels of these anionic ions in drinking water. Alternative disinfection methods like UV treatment and ozone are increasingly relevant. However, drawbacks such as installation costs, operational energy requirements, and the fact that these methods do not provide residual protection in the distribution system limit their use.

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Table1. Chloride ion levels in drinking water and its acceptability [11]

Chloride levels expressed in mg/L	Acceptability
0 – 250	Acceptable
250 – 500	Lessthan desirable
500 – 1000	Undesirable
Over 1000	Unsatisfactory









Fig 1: Sampling sites

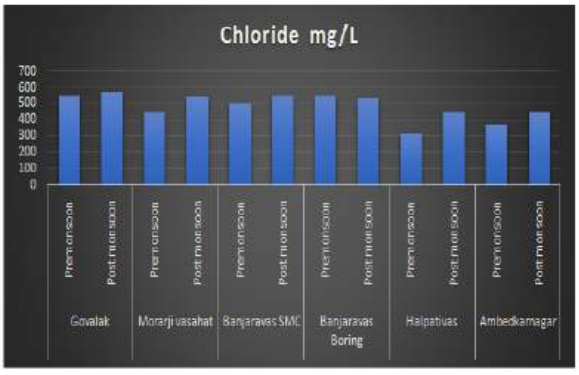


Fig.2 Chloride ion concentration in different sites and seasons

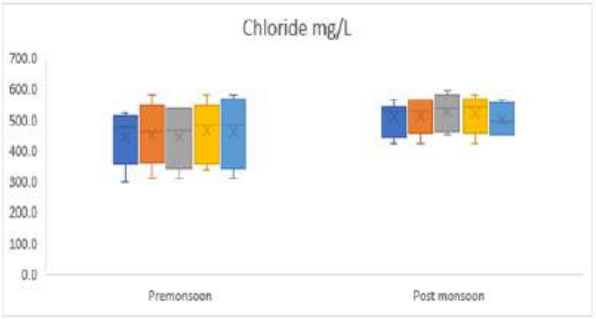


Fig.3 Box plot showing variations in pre monsoon and post monsoon

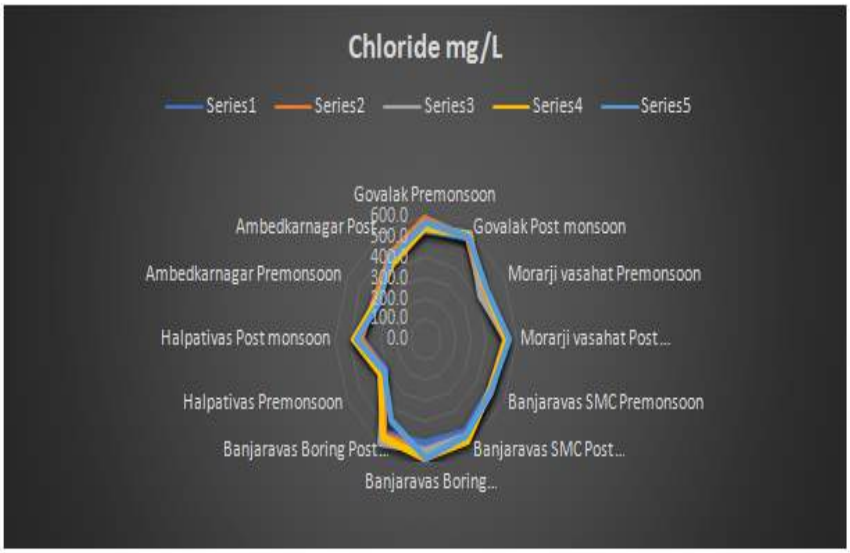


Fig. 4 Radar plot

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RESEARCH ARTICLE

Cow: A Treasure Trove of Nutrition and Wellbeing

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ABSTRACT

The *Cow* was revered as a sacred animal in ancient India because of her maternal qualities, which led to its treatment as a mother. *Cow*s and the products they produce are also very helpful to humans because they are used in agriculture, the painting and cosmetics industries, and medicine for a variety of ailments since ancient times. Because of its antibacterial qualities, *Cow* dung is utilized by many villagers to paint their hut walls and clean the surrounding area. It also keeps the temperature of the room cool in the summer. As a result of this property, organic *Cow* dung paint is being produced with a high business potential. Due to the agnihotra, the two families were spared the damaging effects of the methyl isocyanide gas that was discharged from the Union Carbide Plant in Bhopal on the evening of December 3, 1984.The panchagavya therapy uses five *Cow* products to treat a variety of illnesses and ailments, including the flu, allergies, colds, cough, arthritis, leukoderma, leucorrhoea, alopecia, and asthma. These products can be taken alone or in combination with other medications of herbal, animal, or mineral origin. Amith Vaidhya, a person, was able to survive cancer by include *Cow* products in his diet, demonstrating the potential of *Cow* products to combat cancer. This is evidence that *Cow* products have anticancer properties. A type of animal-assisted therapy known as "*Cow* cuddling or hugging" includes brushing, caressing, or simply just talking with your new, reliable psychologists which was believed to reduce anxiety and stress.

Keywords: Panchagavya, Bhopal gas tragedy, *Cow* cuddling therapy, *Cow* dung paint.

INTRODUCTION

The *Cow* was revered as a sacred animal in ancient India because of her maternal qualities, which led to its treatment as a mother. The name "gaumata" or "kamdhenu" refers to a sacred *Cow* in India that is thought to grant wishes. Our Indian economy is built on *Cow*s. The sacredness of *Cow* s Hinduism holds that *Cow*s are products of nature and divine beneficence, and as such, they should be worshipped[1].When we think of *Cow*s as a source of milk, dung, urine, ghee, and curd, we see more benefits than when we think of killing them for meat. *Cow*s and the products they produce are also very helpful to humans because they are used in agriculture, the painting and cosmetics industries, and medicine for a variety of ailments since ancient times. Numerous studies have been conducted on products derived from *Cow*s, and the results have shown that these products are beneficial in a variety of fields, including agriculture, paper manufacturing, and pollution management due to their natural and environmentally favorable nature. They can be used for a variety of medical purposes as well Panchagavya treatment is the name given to the practise of using *Cow* products—milk, curd, ghee, dung, and urine to treat various diseases and problems. Another animal-assisted therapy that uses *Cow*s as a key character to help patients with anxiety and depression is called " *Cow* hugging" or " *Cow* cuddling" therapy.

COW PRODUCTS

***COW* MILK:** The component found in *Cow* 's milk that is comparable to mothers' milk *Cow* milk's low calorie, low cholesterol, and high content of protein, calcium, and vitamins make it a healthy food. It has complex C, vitamin A, and carotenoids. It is readily absorbed, making it highly nourishing for both adults and children[2]. Among other dairy products, *Cow* milk is special because it contains enough nutrients in a concentrated enough way to suit human demands for both physical and cognitive development[3]. *Cow* milk has a PH of 6.6 to 6.7.While other breeds produce milk of the A1 kind, Indian breed *Cow*s produce milk of the A2-type. India's *Cow* milk has a high content of nutrients and only 4.6% lactose. 0.59% minerals and 4.65% fat 3.4% of proteins 86% water. 27 % beta casein, 9 % k-casein, 36% alpha casein, and 27 % peptides are found in *Cow* milk protein**[4].** The constituents of *Cow* milk and colostrums was described in table.1**.**

BENEFITS OF *COW* MILK

Strengthening of bones and teeth

The calcium and phosphorus found in *Cow*'s milk helps to strengthen large teeth and bones.

Healthy heart

potassium, calcium, and phosphorus keep the heartbeat stable.

Low cholesterol

fat content in milk is essential for both mental and physical development.

Energy

It is provided by lactose and vitamins, riboflavin, and keeps the immune system, brain, and digestive systems functioning.

Boost your vision

It Improve vision because it has 250 milliliters of *Cow* milk and vitamin A-carotene. Due to the presence of vitamin K, it controls the blood clotting process. Breastfeeding is one way to treat baby anemia. It encourages the growth of healthy gut flora and inhibits the growth of dangerous gut bacteria, milk-based enzymes

Bovine milk and the corona virus

when substantial quantities of the virus coated in mucous discharge are consumed, the BIM inactivates the virus. The ingested antibodies attach to some shared antigenic structure of SARS-COV2, which is duplicated and distributed into the GIT[5].

COW GHEE

Cow ghee has been used for religious rituals and as a therapeutic substance in Ayurveda from ancient times in India. Traditional methods of preparing *Cow* ghee are said to be helpful in healing and in promoting health. Compared to ghee made from the milk of other exotic *Cow* species, it has greater health benefits.

BENEFITS OF _COW_ GHEE

It has long been believed that ghee improves speech, memory, vision, IQ, and the body's ability to fight off illnesses. Ayurvedic practitioners think that ghee and *Cow*'s milk improve memory. It enhances digestion and is beneficial for those with impaired vision[6].

Ghee-based formulations

which are designed to improve the bioavailability and targeted delivery of hydrophobic botanicals. As an illustration, consider Brahmi Ghrita for mental clarity, Vasa Ghrita for the respiratory system, Shaptadhatu Ghrita for skin conditions, Bhallatakadi Ghrita for wound healing, and Kaamdev Ghrita for sexual dysfunctions, among others. A combination of *Cow* ghee, honey, vitamins, and the non-fat portion of *Cow* milk were tried as micronutrients[7].

Anti cancer activity

A study comparing the effects of *Cow* ghee vs soya bean oil on rats' mammary glands showed that *Cow* ghee has anticancer potential. The study also found that *Cow* ghee produced mammary carcinogenesis and that the expression of cox-2 and peroxisome proliferators activated receptors-γ (PPAR-γ) in the rats' mammary glands. *Cow* ghee composition & medicinal properties were described in figure.1.

COW CURD

It's sometimes referred to as "yogurt" or "Dahi" is consumed all over the world because of its great nutritional content and health advantages. Probiotics, or good live microorganisms, are abundant in curd and provide a variety of health benefits when taken orally. Lactic acid-producing bacteria in curd produce metabolites like cyclic dipeptides. Phenyl Lactate's antifungal properties[8]. Composition and calories of *Cow* products is described in table.2.

BENEFITS

It is an excellent probiotic that includes beneficial bacteria that are known to enhance intestinal activity, which in turn helps with digestion and soothes upset stomachs.

Boost immunity

Curd contains living bacteria that can combat pathogenic microorganisms and safeguard the gut and intestinal health. There is evidence to support the notion that curd, a probiotic has a strong immune-boosting effect.

For skin that is healthy

curd helps to support gut health, which results in skin that is vibrant and healthy. It is an excellent ingredient since it contains a lot of lactic acid, which acts as fantastic exfoliant that removes all imperfections and dead cells.

Strengthen bones and joints

The minerals calcium, magnesium and phosphorous found in curd help to strengthen teeth and bones. A tiny amount of curd in our diet strengthens our connective tissues and lowers our risk of developing weakening diseases like osteoporosis and arthritis.

Reduces hypertension

Potassium helps the body eliminate extra salt, which eases the strain on the heart muscle and lowers high blood pressure. Regularly eating a specific amount of non-fat yogurt with meals reduces the symptoms of hypertension and promotes heart health[9].

Regarding vaginal infections

Curd's multitude of beneficial microorganisms not only improve digestion by guaranteeing ideal gut flora, but also treat female vaginal yeast infections. By producing hydrogen peroxide, a specific microbe called Lactobacillus acidophilus, which is found in large amounts in yogurt, kills the dangerous yeast growth that is close to the vagina. This relieves pain and discomfort while suppressing the contagious bacteria in the vagina. *Cow* curd benefits and composition was described in figure.2.

***COW* DUNG**

In India's natural regions, dried *Cow* dung cakes are used as a cooking fuel, which reduces reliance on external energy sources, is completely environmentally benign, and ensures air purification by eliminating airborne bacteria. *Cow* dung is better than other dung because it contains preventive and antibacterial qualities. The amount of curd fiber (90%) and carbohydrates(20%), ash (10.5%), crude protein (7%), crude fat (4%), and moisture (18.5%) in dung are all dependent on the grain and forage that *Cow*s are given during domestication. *Cow* dung has a pH between 6.5 and 7.1.

BENEFITS OF *COW* DUNG

Soil fertility enhancer

Cow dung, used as a bio fertilizer, can replenish the mineral states of the soil, giving plants resistance against pests and immune system development, as well as sulphoxidation and phosphorus solubilization. *Cow* manure was used to make African deserts fertile. With 1 kg of manure, 15–16 kg of biomass, and soil of comparable grade, we can create 3 kg of high-quality compost .Out of every kilogram of excrement, a healthy *Cow* yields about ten kilograms. It yields 33 kg of manure, also referred to as organic manure. This has also been accepted by the "NATIONAL BANK OF AGRICULTURE AND RURAL DEVELOPMENT (NABARD)" this. It has been demonstrated that manure from dung provides the cultivation soil with 18 micronutrients, including calcium, iron, cobalt, manganese, phosphate, and potassium[10].

Fuel

Dung as fuel is well known or rural kitchen. *Cow* dung patties [goottе] are used for cooking. Cooking foods using dung cakes is traditional practice followed in village of our country. it has advantage, when food is cooked by using dung patties, the temperature never rise beyond a certain point that prevents overheating and doesn't destroy nutrient in food[11].

Seed protector

Covering seeds in dung before planting, protect the seed against pest so it is an excellent conditioner for soil.

Gobar gas

Dung is best valuable source of energy as it produces biogas [methane] and also generate electricity. Biogas is a form of renewable energy for cooking, lighting of homes and street light. The self-combustion engines can be driven by using this biogas. Example: Running generator to produce electricity.

Petrol making

According to Japanese scientist 'sukae shibusawa' at Tokyo university of agriculture and technology, cattle dung is new source of petrol [gasolin],extracted from dung by application of high pressure and heat.

Floor coating
Mixed with mud and water serves to coat the walls of mud houses. it has antiseptic property.

Mud brick additive
It is proven that mud huts plastered with dung keep insects and reptiles away.

Mosquito repellent
Smoldering of *Cow* patties keeps away mosquitoes form the houses.

Pot cleaner
Pots can be cleaned by dung. So, it is good cleaning agent for utensils.

As a container
By using containers made of *Cow* dung, the grains can be stored for long time.

PH balancer
As dung neutralize acid content in water when thrown into ponds.

Resistant to radiation
Several scientific studies have been proved that the *Cow* dung is resistant to solar radiation by applying thick layer of *Cow* dung on walls houses prevent incidence of gamma rays as it absorbs rays emitted from solar emission.

Dhoop sticks preparation
By mixing fine powder of nagarmutha, ral, lalchandhan, jatamachi, Kapoor kajuri & ghee in *Cow* dung produces oxygen when burnt.

Environmental protection
Dung from single *Cow* in its life span can produce 4,500litres of biogas which is equal to burning 6,80,00,000 tons of wood. This will help us to have 14 crore trees from cutting and burning& thus gives protection to environment. 1 spoon of ghee on burning *Cow* dung evolves 1 ton of oxygen[12].

BHOPAL GAS TRAGEDY
On the evening of December 3, 1984, a deadly gas known as methyl isocyanide (MIC) spilled from the Union Carbide plant in Bhopal. This catastrophe demonstrated the potency and significance of ghee. Two families, the families of Shri Sohan Lal S. Khushwaha and Shri M.L. Rathore, who lived around one mile away from the facility, escaped unharmed although hundreds of people died and thousands were hospitalized. These families practiced Agnihotra (Havan) on a regular basis. Despite being in the region most severely impacted by the deadly gas leak, none the members of these families passed away or were even admitted to the hospital. The published article of newspaper was depicted in figure.3. This suggests that agnihotra is a well-established remedy for pollution. On that fatal night, the intense smoke emitted by these *Cow* dung cakes served as an effective antidote to the hazardous Methyl Isocyanate (MIC) gas. Ghee, being one of Agnihotra's key ingredients, played an important role in detoxifying the noxious vapors surrounding it. Havan made with elements such as dry *Cow* dung, wood, ghee, rice grains, etc., when lit in fire, eliminates microorganisms and purifies the region.

COMMERCIAL PRODUCT OF *COW* DUNG
Cow dung paint is a commercial product also known as "khadi prakritik paint" or "vedic paint." Because of its antibacterial qualities, *Cow* dung is utilized by many villagers to paint their hut walls and clean the surrounding area. It also keeps the temperature of the room cool in the summer. As a result of this property, organic *Cow* dung paint is being produced with a high business potential. The paint is free of metals such as lead, mercury, chromium, arsenic, cadmium, and others. Khadi pratikrit distemper and emulsion paints were evaluated at three reputable laboratories,

including the National Test House in Mumbai, Shri Ram Institute of Industrial Research, New Delhi, National Test House, Ghaziabad. Khadi pratikrit emulsion paint meets BIS 15489:2013 specifications, and khadi Pratikrit distemper paint meets the BIS 428:2013 standards[13].

Why is *Cow* dung used in the paint?

Boost air quality by as much as 50%qualities that are antiseptic, resistant to heat, economical (7–10/-per dung cake), Dried manure has no smell. It serves as an insulator, keeping heat inside during the winter and preventing it from escaping in the summer. It eradicates bacteria efficiently, It is extremely valuable and used to purify the air. Radium, which shields against UV radiation, is present in it. use of *Cow* dung has an inverse relationship with paint costs. serves as a coolant, removing the need for application[14]. HVAC up to 40,000/-in savings, reduces the requirement for heating by providing insulation, it produces a uniform, smooth surface after drying in less than 4 hours. Paint can be used on walls that are indoors or outdoors. The picture of vedic and pratikrit paint was given in figure.4.

***COW* URINE**

Cow urine has various helpful effects, particularly in the fields of agriculture and healthcare. *Cow* pee is typically considered as safe since 95% is water, 2.5% is urea, and the remaining 2.5% is a mixture of the aforementioned minerals, hormones, and salts[15]. The composition of cow urine and their functions are given in table.3.

Benefits of *COW* urine: **Agriculture**

Distillation waste and *Cow* dung can be used to produce vermin compost. The use of vermin compost in pots increases the yield of "Medicago sativa". *Cow* urine acts as a disinfectant, purifies the environment, and improves land fertility[16].

Bio pesticides

2kg of neem leaves are soaked in 10kgs of urine and mixed with other vegetable waste [1:50] before spraying. *Cow* urine combined with neem leaves acts as a pest repellant due to its insecticidal, fungicidal, and pesticidal characteristics. Urine utility can generate modest amounts of power to power electronic clocks and kitchen appliances.

Medicinal uses include

Analgesia: it was discovered that the animals given *Cow* urine had comparable analgesic effects to the standard drug group given Diclofenac Sodium, reinforcing the recommendations of Ayurvedic texts to use *Cow* urine as a reasonably safe, easily available, and cost-effective natural analgesic.

Anti-diabetic activity

Streptozotocin (50 mg/kg) diluted in citrate buffer (0.1 M, pH 4.5) was administered to diabetic rats in a study on the utilization of *Cow* urine distillate. Compared to the diabetic control group, the increased levels of blood glucose, serum cholesterol, and serum triglycerides were significantly ($P<0.05$) reduced by the *Cow* urine distillate. The diabetic rats given *Cow* urine distillate also had a notable increase in body weight and HDL levels[17].

Anti hemorrhoids activity

In both Grade I and Grade II hemorrhoids, a clinical evaluation of the efficacy of *Cow* urine demonstrated a significant reduction in pain during defecation, bleeding, and itching. This indicates that oral supplementation with *Cow* urine can prevent the time-consuming, painful, and costly complications associated with hemorrhoids of Grade I and Grade II.

Antimicrobial & fungal activity

Analyzed against pathogenic microbes, the antibacterial activity of *Cow* Urine Distillate (5, 10 and 15µl) was found to be maximal against Pseudomonas aeruginosa and Salmonella typhi. An analysis was conducted on the antifungal activity of *Cow* urine distillate against Aspergillus niger and Aspergillus flavus.

Immunomodulatory activity

It has been discovered that *Cow* urine distillate has an immune modulatory impact since it promotes T and B lymphocyte proliferation, blastogenesis, and elevated IgG levels in mice and chicks (avian species)[18].

As a bioenhancer

Rifampicin, a first-line treatment for tuberculosis, exhibits bio-enhancing activity for pharmaceuticals or medicines in *Cow* urine. Increase its effectiveness against Escherichia coli by seven times and against Gram-positive bacteria by eleven times as an Anti-tubercular medication. Additionally, it improves the transfer of antibiotics by a factor of two to seven-For instance: ampicillin, tetracycline, and rifampicin through artificial membranes and the gut wall.

The patents granted on cow products were described in table.4[19].

ECONIMICS OF *COW* PRODUCTS

***COW* URINE**

The average healthy *Cow* yields three liters of gaumutra. Now let's discuss gau mutra, or *Cow* dung. A *Cow* can yield two to two and a quarter liters of pee daily. Approximately 48 different ailments can be treated with urine, including diabetes, arthritis, bronchitis, bronchial asthma, TB, osteomyelitis and more! One liter of urine sells for approximately 500/- in the market; this may also be the case for the Indian market. However, a liter of urine can fetch more in international markets. The American government imports *Cow* urine from India each year to manufacture medications for diabetes, cancer, and other conditions. Therefore, if we base our calculations on the American market, a liter of *Cow* urine can fetch between 1,200 and 1,300/-. That implies just out. A healthy *Cow* may live for approximately 20 years, thus if we assume we can make $10,95,000/-a year, we can make $219,00,000/-millions from selling urine in 20 years.

***COW* DUNG**

In the global market, a kilogram of organic manure sells for roughly six rupees. Thus, 10 kg of *Cow* dung sells for between 1800 and 2000 rupees each day [330 kg of manure for every 10 kg of dung, which is worth 6 rupees]. Thus, we can earn 657000/-year of *Cow* dung in 365 days of the year. *Cow*s are 20 years old on average, and they excrete manure every day till the end. We could so make millions of dollars, or 1,31,40,000/-. Because *Cow* dung is high in nitrogen, it is the most effective crop nutrient. Additionally, using *Cow* dung and pee, scientists created specialized bio fertilizers that, when sprayed on crops, increased plant growth and productivity. It yielded nutrient-dense fruits that promote long life

***COW* MILK**

A *Cow* can yield 28 liters of milk a day, with each liter valued at roughly 50 cents. It can therefore make 1400/-per day, 42000/-per month, 511000/-per year, 1400×365/-per year, and 10,220,000/-(511000×20) during the course of its 20-year life span for 28 liters of milk. Over the course of their 20-year existence, we can make a total of 6,700/-per day, 2,01,000/-per month, 24,45,500/-per year, and 48,910,000/- from *Cow* products, which also include *Cow* manure, urine, and milk. The economics of cow products was given in table.5.

PANCHAGAVYA

The Sanskrit terms "gavya-means *Cow* derivatives" and "panch-means five" are the roots of the word "panchagavya." A mixture of five *Cow* products, including milk, dung, urine, curd, and ghee (two indirect and three direct products, respectively), is called panchagavya. Scriptures on vruksh ayurvedha (plants and health system) and the vedas honor the panvchagavy [20].*Cow* pathy, also known as Panchagavya chikitsa or therapy, is the term used to describe the panchagavya treatment. The panchagvya therapy uses five *Cow* products to treat a variety of illnesses and ailments, including the flu, allergies, colds, cough, arthritis, leuco-derma, leucorrhoea, alopecia, and asthma. These products can be taken alone or in combination with other medications of herbal, animal, or mineral origin [21].

BENEFITS

When Panchagavya is sprayed on plants, they always develop more leaves and a denser canopy. For optimal biological efficiency, the photosynthetic system is active, allowing for the synthesis of photosynthates and metabolites. It is possible for the Panchagavya to raise agricultural yield levels again. For every crop, the harvest is advanced by fifteen days. It extends the shelf life of fruits, vegetables, and cereals while also enhancing their flavor. Through the replacement or reduction of expensive chemical inputs, Panchagavya guarantees greater profit margins and releases organic farmers from debt. The plants' large, deep roots enable them to endure protracted dry spells. and so ensuring harsh hardiness while lowering the irrigation water consumption by thirty percent[22]. Panchagavya is the living essence of numerous microorganisms, including bacteria, fungus, protein, carbohydrates, vitamins, and enzymes, as well as known and unknown growth-promoting agents, micronutrients, trace elements, antioxidants, and immunity-enhancing agents[23]. The living microorganisms in Panchagavya, when consumed orally by humans or animals, stimulate the immune system and generate a large amount of antibodies against the eaten bacteria. It functions similarly to a vaccination. This physiological reaction boosts immunity in both humans and animals, assisting in the prevention and treatment of disease [24].

THE LIVING PROOF

Amit vaithya, a US-born individual, holds a Ph.D. in economics and works in the entertainment industry's business department in the US. His father passed away from cancer at the age of 27. For around two years, he had been receiving various treatments, but they had been ineffective. His mother also passed away from cancer two months after the death of his father. Subsequently, his health records were examined prior to the death of his parents, and it was revealed in 2011 that he was also afflicted with cancer that had spread to his liver and lungs. Then, before he passed away, he made the decision to visit India. A few days later, he recalled his friend's recommendation to have an ayurvedic therapy. Afterwards, he began doing yoga, meditation, and consuming *Cow*'s milk, curd, and ghee in addition to using *Cow* urine as a medicinal combination. His scan data showed that his body had conquered cancer after a few days. Afterwards, he kept consuming foods associated with *Cow*s, built a cattle shed, and tamed the *Cow*s. He also works with the nonprofit organization "HEALING VAIDHYA" to offer free services to cancer sufferers.

The book "HOLY CANCER-HOW A *COW* SAVED MY LIFE" was also written by Amit Vaidhya. This served as evidence for the products made from *Cow*s having a miraculous ability to treat cancer. Amith Vaidhya served as a living example of how *Cow*'s milk products might prevent cancer. The image of amith vaidhya was given in figure.5.

***COW* HUGGING THERAPY**

The Dutch word "koeknufflen" translates to "*Cow* cuddling." It's customary in the Netherlands to take a trip from the city to the countryside and spend time with farm animals as a way to unwind and rebalance one's emotions. This practice is known as animal-aided interaction, or AAI, and it falls under the category of bovine assisted therapy [25].

Research from a wide range of studies has shown that interactions between animals and people improve social support and overall well-being while lowering anxiety, depression, and loneliness [26]. A type of animal-assisted therapy known as "*Cow* cuddling or hugging" includes brushing, caressing or simply just talking with your new, reliable psychologists. It's a custom that dates back to the Dutch village of Reuver[26]. The image of cow cuddling is given in figure.6.

Amazing advantages of giving *Cow* hugs

Provide instantaneous respite from mental strain; Disseminate good energy wherever Feel good hormones are released; hyper-vigilance and social isolation are eliminated; high blood pressure is avoided; spinal pain is effectively treated; a sense of calm and serenity is experienced; depression is effectively managed; and respiratory disorders are effectively treated. February 14 is designated as "*Cow* Hugging Day," as proclaimed by the Animal Welfare Board of India. A "Horse& *Cow* experience" at a mountain horse farm in upstate New York aims to provide participants with the opportunity to "bring relaxation, healing, and awareness About body language" through *Cow* snuggling. Additionally, it encourages ease, mindfulness, assertiveness, confidence building, fear-reduction, playfulness, and boundary-setting. It continued by saying that the people hugging the *Cow*s had slower heart rates and shown outward manifestations of relaxation[27].

CONCLUSION

According to the study's findings, cows are an extremely useful natural resource for a sustainable way of life because of the high quality of the items they provide. This study has shown a number of facts about cows and their products that are advantageous to agriculture since they increase soil fertility and serve as fertilizers and pesticides. Several studies and experiments have confirmed it. The cow adds to our riches as well since, when its products are exploited appropriately, it yields 4,89,10,000. Many individuals don't know this knowledge or how much cows are worth. Cow ghee creates oxygen, which is good for cleaning the atmosphere, as the Bhopal gas tragedy shows. It also treats a wide range of illnesses, including epilepsy, TB, cancer, and cow huggings in anxiety. Additionally, there is living evidence of cow products' anticancer effects. The aforementioned information led to the conclusion that cows are an invaluable resource for human well-being and success. Therefore, we believe that this evaluation will increase people's awareness of the advantages of cows.

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Table 1: Constituents of milk and colostrums

Milk and colostrum constituents	**Protein**	Caseins (α S1,α S2, β& α) (β-LG,α -LA,BSA&LF)
	Fat	Triacyl glycerol, diacyl glycerol, phospholipids, free fatty acid.
	Vitamins	Vit A, Vit B1,B2,B3,B6,B12,folate, Vit D
	Enzymes	Lacto peroxidase, thioyanate, Xanthine oxidase, lysozyme & peroxidase
	Minerals	Calcium, phosphorous, magnesium, potassium
	Immuno-globulins	IgGI,IgG2,IgA,IgM,Ige and IgD
	Cytokines	IL-β, IL-8,IL-10,IL-12,IL-18,IFN-γ, TGF-β.
	Immune & other factors	PRP,G-GSF,M-CSF AND GM-GSF.

Table 2: Composition and calories of the *Cow* products

Name of the *Cow* product	Composition in %	Calories per 100 ml
Milk	Carbohydrates-4.75,fats-3.7,proteins-3.2,minerals-0.7	68
Ghee	Fats-98,cholesterol-30,kerotine-3.2, free fatty acids-2.8	900
Curd	Fat-4.2,protein11.75,carbohydrates-3.4,vitaminA-42.	98
Paneer	Proteins-23,fat-25,minerals-2	265-323
Butter	Fat-82,minerals-2,vitamins-8.6	717
Cheese	Fat-29	272
Dung	Nitrogen 0.6,carbon-10	3500

Table 3: *Cow* urine composition and benefits

Bio-component of *Cow* urine	Functions
Nitrogen, N2 NH2	Remove blood abnormalities & toxins, stimulant of UT & kidney.
Sulphur	Support motion in large intestine, cleanses blood
Ammonia	Stabilize bile, mucus and air of body, stabilizes blood
Iron	Maintain blancce and help in production of R.B.C, and hemoglobin
Urea	Affects urine formation and removal ,has germicidal properties
Uric acid	Remove swelling or inflammation it is diuretic so destroys the toxin
Sodium, potassium	Purifies blood, increase appetite, removes muscular weakness
Calcium	Blood purifier ,bone strengthen, germicidal
Copper	Control unwanted fat, iron help to produce hemoglobin.

Table 4: Patents Granted on *Cow* Products[19]

1.US patent no.6410059	For the antibiotic, antifungal, bio-enhancer effect of *Cow* urine by USFDA to CSIR, India.
2.US patent no.6896907	For the anti-allergic, anti-infective, nutrient, anticancer activity of gomutra.
3.US patent no.7718360	For antioxidant and apoptosis properties on May 18, 2010.
4.US patent no.7235262	*Cow* urine distillate as a bio-enhancer of anti-infective, anticancer agents and nutrients.
5.US patent no.7297659	For synergistic fermented plant growth promoting& bio-control composition.
6. US patent no.6602537	For its enhanced nutritive and health value
7.Chinese patent no. 100475221	For *Cow* urine as DNA protector on April 8,2009.

Table 5: Economics of *Cow* Products

Cow products	Per day income	Per month income	Per annum income	Throughout its life span income
330 kilos of *Cow* dung manure(10 kilos of dung)	1800/-	54,000/- (1800x 30)	6,57,000/- (1800x365)	1,31,40,000/- (6,57,000x20)
Cow urine liter	in India 500/- in America 3000/-	15,000/- (500x30) 90,000/- (3000x30)	1,82,500/- (500x365) 10,95,000/- (3000x365)	3,650,000/-(182,500x20) 2,19,00,000/-(10,95,000x20)
Cow milk 1 liter	1400/-	42000/- (1400x30)	511000/- (1400x365)	10,220,000/-(511000x20)
Total income	6700/-	2,01,000/-	24,45,500/-	48,910,000/-

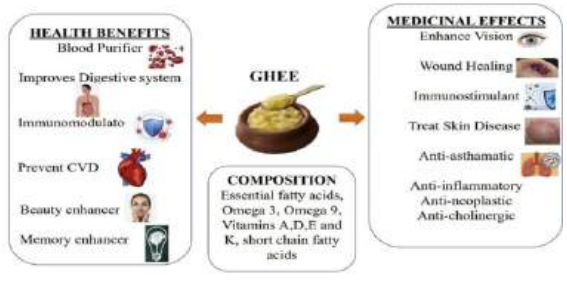


Figure 1: *Cow* ghee composition and medicinal properties

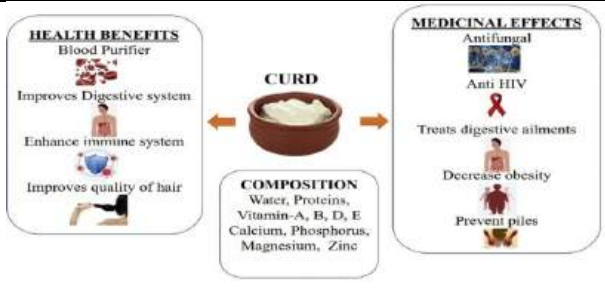


Figure 2: *Cow* curd benefits and composition



Figure 3: The incident of Bhopal gas tragedy published in newspaper article



Figure 4: vedic and prakrit paint



Figure 5: Amit Vaidhya, the cancer survivor who used *Cow*'s milk products



Figure 6: *Cow* cuddling therapy