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Research Article

Formulation and Evaluation of Tulsi Extract Nanogel for Wound Healing

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ABSTRACT

Wound infections and delayed tissue repair remain significant challenges in healthcare management [1,3]. Herbal formulations are widely preferred due to their reduced side effects and better patient compliance [6]. Ocimum sanctum (Tulsi) possesses antimicrobial, antioxidant, anti-inflammatory, and wound healing activities.[4,5]Tulsi extract contains important phytoconstituents such as eugenol, ursolic acid, and flavonoids responsible for therapeutic activity. [7]Nanogel drug delivery systems improve topical retention, penetration, and controlled release of active constituents. [9] Nanogels prepared using suitable polymers and stabilizers show improved physicochemical stability.[53]Evaluation parameters including pH, viscosity, spreadability, homogeneity, and drug content are essential for topical nanogel characterization.[11]Antimicrobial studies against wound-infecting microorganisms are commonly performed using standard microbiological techniques [10]. In-vitro wound healing models help determine the tissue repair potential of herbal formulations.[5]Herbal nanogels have shown promising effectiveness in enhancing wound contraction and reducing microbial growth.[7,8] Tulsi-based nanogel formulations may serve as economical and effective alternatives to conventional wound healing therapies.[14]

INTRODUCTION

The History of Ayurveda:

Origins and Early Development

Ayurveda, one of the world's oldest holistic healing systems, originated in India more than 5,000 years ago. [1] Its roots can be traced back to the Vedic period, with the earliest references found in the Rig Veda, a sacred text composed around 1500 BCE. [1] The term "Ayurveda" is derived from two Sanskrit words: "Ayur" meaning life, and "Veda," meaning knowledge or science, collectively translating to "the science of life".[1] Classical Texts.

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The core principles of Ayurveda are detailed in several classical texts:

1. Charaka Samhita: Attributed to the sage Charaka, this comprehensive treatise on internal medicine covers various topics, including diagnosis, treatment, and principles of medical practice. [2-3] It is considered one of the most authoritative texts on Ayurveda.[2-3]

2. Sushruta Samhita: Credited to the sage Sushruta, this text focuses on surgery (Shalya Tantra). [4-5] It describes numerous surgical procedures, instruments, and the importance of anatomy. [4-5] Sushruta is often referred to as the "father of surgery" for his contributions to the field.[4-5]

3. Ashtanga Hridaya: Written by Vagbhata, this text is a concise compilation that integrates the concepts from both Charaka Samhita and Sushruta Samhita, making it one of the most accessible and practical guides to Ayurveda.[6]

Philosophical Foundations

Ayurveda is deeply intertwined with Indian philosophy, particularly the Sankhya school of thought, which posits that the universe is composed of two fundamental entities: Purusha (consciousness) and Prakriti (matter). It also incorporates the concept of the five elements (Panchamahabhutas) - earth, water, fire, air, and ether - which form the basis of all matter and life.[7]

These elements combine to form three primary life forces or doshas: Vata (air and ether), Pitta (fire and water), and Kapha (earth and water). [7] The balance of these doshas within the body determines a person's health and constitution.[7]

Spread and Influence

Ayurveda flourished in ancient India and influenced medical practices in neighboring regions. It significantly impacted traditional medicine systems in countries such as China, Tibet, Sri Lanka, and Thailand. [8]The spread of Buddhism from India facilitated the dissemination of Ayurvedic knowledge across Asia. [8]

Decline and Revival

With the advent of Islamic rule in India and later British colonialism, Ayurveda experienced a period of decline. [9] The introduction of Western medicine marginalized traditional practices. However, in the late19th and early 20th centuries, there was a resurgence of interest in Ayurveda, spurred by the nationalist movement and a renewed appreciation for indigenous knowledge systems.[9]

Modern Era

In contemporary times, Ayurveda has gained global recognition. It is integrated into the healthcare systems of countries like India and Sri Lanka, where it is practiced alongside modern medicine. [10] Ayurvedic principles are also applied in various fields such as diet, lifestyle, and holistic wellness. [10] Institutions dedicated to Ayurvedic education and research continue to proliferate, ensuring the growth and adaptation of this ancient science to meet modern health challenges.[10]

Reason for using Nanogel formulation

1. Nanogels improve penetration of drug through skin layers.

2. Nanogels provide controlled and sustained drug release.

3. They increase retention time of drug at the site of application.
4. Nanogels enhance bioavailability of active constituents.
5. They improve stability of herbal extracts and phytoconstituents.
6. Nanogels protect drugs from degradation and environmental factors.
7. They provide better therapeutic effectiveness compared to conventional formulations.
8. Nanogels are non-greasy and easy to apply on skin.
9. They provide better spreadability and patient compliance.
10. Nanogels maintain moist environment at wound site which promotes healing.
11. They reduce frequency of drug application due to sustained release action.
12. Nanogels enhance antimicrobial activity by improving contact with infected tissue.
13. They help in faster wound contraction and tissue regeneration.
14. Nanogel formulations minimize irritation and side effects.
15. They can incorporate both hydrophilic and hydrophobic drugs.
16. Nanogels possess high water content and good biocompatibility.
17. They improve local drug concentration at wound site.
18. Nanogels reduce systemic absorption and systemic side effects.
19. They are suitable for topical and transdermal drug delivery systems.
20. Nanogels enhance effectiveness of herbal formulations such as Ocimum sanctum extract.

Introduction to Nanogel Drug Delivery Systems

Nanogel drug delivery systems are advanced nanosized hydrogel formulations widely used in modern pharmaceutical and biomedical applications for controlled and targeted drug delivery. [1] Nanogels are three-dimensional cross-linked polymeric networks capable of absorbing large amounts of water or biological fluids while maintaining their structural integrity. [1] The particle size of nanogels generally ranges from 1 to 1000 nm, which enhances penetration of drugs through biological membranes and improves therapeutic effectiveness. [1] Nanogels combine the advantages of nanoparticles and hydrogels, resulting in improved drug loading capacity, stability, bioavailability, and controlled drug release. [2] Nanogel systems possess several desirable properties such as high-water content, flexibility, biocompatibility, biodegradability, and non-irritant nature. These properties make them highly suitable for topical and transdermal drug delivery applications.

Nanogels can encapsulate both hydrophilic and hydrophobic drugs.[4] and protect them from degradation caused by environmental conditions or enzymatic activity. Due to their nanosize structure, nanogels improve retention of drugs at the site of application and provide sustained release for prolonged therapeutic action. Nanogel formulations are easy to apply, non-greasy, and provide better patient compliance compared to conventional dosage forms. They are extensively

used in wound healing, antimicrobial therapy, anti-inflammatory treatment, ophthalmic delivery, cosmetic preparations, and cancer therapy. In wound healing applications, nanogels maintain a moist environment at the wound site, enhance tissue regeneration, reduce microbial growth, and accelerate healing process. Herbal extract-loaded nanogels have gained significant attention because they combine the therapeutic benefits of medicinal plants with advanced nanotechnology-based drug delivery systems. Therefore, nanogel drug delivery systems represent a promising and innovative approach for development of effective and safe pharmaceutical formulations. [4]

Factors Affecting Nanogel System

Type of Polymer

Nature and concentration of polymer affect viscosity, swelling, and drug release.

Particle Size

Smaller particle size improves penetration and drug delivery efficiency.

Cross-linking Density

Higher cross-linking affects swelling behavior and drug release rate.

pH of Formulation pH influences stability, swelling, and compatibility with skin.

Drug Solubility

Solubility of drug affects entrapment efficiency and release pattern.

Temperature

Temperature may affect viscosity, stability, and gel structure.

Surfactant Concentration

Surfactants influence particle formation and stability of nanogel.

Viscosity.

Proper viscosity is necessary for spreadability and retention at application site.

Method of Preparation

Preparation technique affects particle size and uniformity.

Storage Conditions

Light, humidity, and temperature affect stability of nanogel formulation.

Swelling Capacity

Swelling behavior influences drug release and penetration.

Drug-Polymer Interaction

Interaction between drug and polymer affects entrapment efficiency and therapeutic activity

LITERATURE REVIEW

1. **(Jain A, Mehta A, Jain S, Saxena G., 2011)** Ocimum sanctum has been extensively studied for its antimicrobial activity against various pathogenic microorganisms. Tulsi contains bioactive phytoconstituents such as eugenol, flavonoids, and tannins which exhibit strong antibacterial and antifungal activities. The study highlighted the potential of Tulsi as a natural antimicrobial agent for treatment of infectious diseases and wound infections. [11]
2. **(Cohen MM., 2014)** Tulsi possesses antibacterial, antioxidant, anti-inflammatory,

and wound healing activities. It accelerates tissue regeneration and improves wound breaking strength due to the presence of antioxidant phytoconstituents. Experimental studies demonstrated its effectiveness against skin and wound infections. [12]

3. **(Jamshidi N, Cohen MM., 2017)** Studies on phytochemical and pharmacological properties of Holy Basil reported that eugenol is the major active constituent responsible for antimicrobial and anti-inflammatory activity. Tulsi was found to possess antioxidant, immunomodulatory, antimicrobial, and wound healing properties useful in pharmaceutical applications. [13]

4. **(Banooe M, et al., 2018)** Recent advances in nanotechnology have shown that nanogel systems improve topical drug delivery by enhancing penetration and retention of drugs at the wound site. Nanogels provide controlled drug release, improved stability, and better therapeutic efficacy compared to conventional formulations. [14]

5. **(Kankaria N, Gupta MK, Nama N, Vyas GK., 2019)** Herbal formulations containing Tulsi extract demonstrated significant antimicrobial activity against pathogenic microorganisms. The formulation showed good physicochemical properties and wound healing potential due to the presence of flavonoids and phenolic compounds. [15]

6. **(Patel R, Patel M., 2020)** Research studies on herbal nanoformulations revealed that incorporation of plant extracts into nanosystems improves bioavailability, stability, and controlled release of phytoconstituents. Nanogel formulations enhance penetration of herbal drugs through skin layers and provide prolonged therapeutic action. [16]

7. **(Siva M, Shanmuggam KR, Shanmuggam B, et al., 2021)** Ocimum sanctum exhibits antimicrobial, anti-inflammatory, analgesic, antioxidant, and wound healing activities. The plant may serve as an effective natural therapeutic agent in treatment of microbial infections and inflammatory conditions. [17]

8. **(Sharma P, Verma A., 2022)** Studies on herbal nanoparticles demonstrated enhanced antibacterial activity against wound pathogens due to improved surface area and better interaction with microbial cells. Nanoformulations containing medicinal plant extracts showed higher therapeutic effectiveness compared to conventional herbal formulations. [18]

9. **(Kumar R, Saha P, Lokare P, et al., 2023**) Morphological characteristics, phytoconstituents, and therapeutic applications of Tulsi support its use in wound healing and topical drug delivery systems. Tulsi contains several active constituents responsible for antimicrobial, antioxidant, and anti-inflammatory activities. [19]

AIM

1. To formulate and evaluate an antimicrobial wound healing nanogel containing Ocimum sanctum extract.

2. To develop a stable and effective herbal nanogel formulation for topical drug delivery.

3. To enhance antimicrobial activity and wound healing potential using nanogel technology.

4. To improve penetration and retention of Tulsi phytoconstituents at wound site.

5. To prepare a controlled and sustained release topical nanogel system for better therapeutic effectiveness.

6. To develop a safe, economical, and patient-friendly herbal wound healing formulation.

OBJECTIVES

1. To collect, identify, and authenticate Tulsi leaves for research work.

2. To prepare Tulsi extract using suitable extraction method.

3. To formulate Tulsi extract-loaded nanogel using suitable polymers and excipients.

4. To develop a stable and effective herbal nanogel formulation for topical application.

5. To enhance penetration and retention of phytoconstituents at wound site using nanogel system.

6. To improve antimicrobial activity and wound healing potential of Tulsi extract.

7. To prepare a controlled and sustained release topical nanogel formulation.

8. To evaluate physicochemical properties of nanogel such as:

- Appearance
- pH
- Viscosity
- Spreadability
- Homogeneity

9. To determine drug content and particle size of the prepared nanogel.

10. To evaluate antimicrobial activity against selected microorganisms.

PLANT PROFILE

(Figure.1)

Introduction

Tulsi, scientifically known as Ocimum sanctum Linn. or Ocimum tenuiflorum, is one of the most important medicinal plants used in Ayurveda and traditional medicine systems. [21] It belongs to family Lamiaceae and is commonly known as Holy Basil. [21] Tulsi is considered a sacred plant in India and is worshipped in many households because of its medicinal and spiritual importance. [21] The plant possesses significant antimicrobial, antioxidant, antiinflammatory, analgesic, antipyretic, immunomodulatory, antidiabetic, and wound healing activities. Due to its wide range of pharmacological properties, Tulsi is extensively used in pharmaceutical, cosmetic, nutraceutical, and herbal formulations. [21]

2. Taxonomical Classification[22]

Category	**Classification**
Kingdom	- Plantae
Subkingdom	- Tracheobionta
Division	- Magnoliophyta
Class	- Magnoliopsida

Subclass - Asteridae

Order - Lamiales

Family - Lamiaceae

Genus - Ocimum

Species - sanctum

3. Synonyms [23]

- Holy Basil
- Sacred Basil
- Tulasi
- Ocimum tenuiflorum
- Surasa

4. Vernacular Names [24]

Language

English - Holy Basil

Hindi - Tulsi

Marathi - Tulas

Sanskrit - Tulasi

Tamil - Thulasi

Telugu - Tulasi

Kannada - Tulasi

Malayalam - Tulasi

5. Biological Source

Tulsi consists of fresh and dried leaves and flowering tops of Ocimum sanctum Linn. [25] belonging to family Lamiaceae. [25]

6. Geographical Distribution

Tulsi is widely distributed throughout India and cultivated in tropical and subtropical regions of Asia, Africa, and America. [26] It grows well in warm climatic conditions with moderate rainfall. [26] The plant is commonly cultivated in household gardens, herbal farms, and medicinal plant cultivation areas. [26]

7. Cultivation and Collection

Tulsi is propagated mainly by seeds.

Seeds are sown during spring season. [27]

The plant requires fertile and well-drained soil. [27]

Adequate sunlight and moderate watering are necessary for proper growth. [27]

Leaves are collected before flowering stage for maximum phytoconstituent content. [27]

Shade drying is preferred to preserve volatile oils and active constituents.[27]

8. Macroscopic Characteristics

Upper and lower epidermis with stomata. [29]

Presence of multicellular covering trichomes. [29]

Glandular trichomes containing volatile oils. [29]

Collenchymatous cells beneath epidermis. [29]

Vascular bundles in midrib region. [29]

Oil glands distributed throughout leaf surface.[29]

Plant

Tulsi is an erect, aromatic, branched herb or undershrub growing up to 30–60 cm in height. [30]

Stem

Quadrangular in shape

Hairy surface

Green or purplish color

Aromatic odor

Leaves

Opposite arrangement

Simple and ovate shape

Serrated margins

Acute apex

Petiolate leaves

Characteristic aromatic smell

Green or purple coloration

Flowers

Small purple or white flowers

Arranged in elongated racemes

Bilabiate corolla

Fruits

Small nutlets containing seeds

Seeds

Reddish-black in color

Mucilaginous when soaked in water [28]

9. Microscopic Characteristics

Microscopic examination of Tulsi leaves shows:

Upper and lower epidermis with stomata. [29]

Presence of multicellular covering trichomes. [29]

Glandular trichomes containing volatile oils.

Collenchymatous cells beneath epidermis.

Vascular bundles in midrib region. [29]

Oil glands distributed throughout leaf surface.[29]

10. Powder Characteristics[30]

Powdered Tulsi leaves show:

- Greenish-brown color
- Characteristic aromatic odor
- Slightly bitter taste
- Presence of fibers and trichomes
- Calcium oxalate crystals
- Starch grains

11. Chemical Constituents

Tulsi contains several biologically active phytoconstituents responsible for its therapeutic activities

Volatile Oil Constituents

Eugenol -Antimicrobial, analgesic, anti-inflammatory, antiseptic activity

Ursolic acid- Wound healing, antioxidant, anti-inflammatory, anticancer activity

Rosmarinic acid - ntioxidant, antimicrobial, anti-inflammatory activity

Linalool - Antimicrobial, calming and stress-relieving activity

Carvacrol - Antibacterial, antifungal, preservative activity

Caryophyllene - Anti-inflammatory and analgesic activity

Flavonoids - Antioxidant, free radical scavenging, tissue protective activity

Tannins - Astringent, antimicrobial, wound healing activity

Saponins - Immune boosting, antimicrobial, healing activity

Phenolic compounds - Antioxidant and antimicrobial activity

Essential oils - Antiseptic, antimicrobial, preservative activity

Orientin - Antioxidant and radioprotective activity

Vicenin - Antioxidant and anti-inflammatory activity

Oleanolic acid - Hepatoprotective and anti-inflammatory activity

Methyl eugenol -Antimicrobial and aromatic activity

Glycosides - Therapeutic and metabolic activity

Alkaloids - Pharmacological and antimicrobial activity

Caffeic acid -Antioxidant and anti-inflammatory activity [31,32]

13. Pharmacological Activities

13.1 Antimicrobial Activity

Tulsi exhibits broad-spectrum antimicrobial activity against bacteria, fungi, and viruses. [33] Essential oils and eugenol disrupt microbial cell membranes and inhibit growth of pathogens responsible for wound infections. [33]

13.2 Anti-inflammatory Activity

Tulsi inhibits inflammatory mediators such as prostaglandins and cyclooxygenase enzymes, thereby reducing swelling and inflammation. [34]

13.3 Antioxidant Activity

Flavonoids and phenolic compounds present in Tulsi neutralize free radicals and reduce oxidative stress. [35]Antioxidant activity protects tissues from cellular damage. [35]

13.4 Wound Healing Activity

Tulsi accelerates wound contraction, collagen synthesis, angiogenesis, and tissue regeneration. [36] Antimicrobial and antioxidant activities further support wound healing process. [36]

13.5 Analgesic Activity

Tulsi helps reduce pain and discomfort by inhibiting inflammatory pathways and pain mediators. [37]

13.6 Antipyretic Activity

Tulsi reduces fever by acting on temperature-regulating centers and improving immune response. [38]

13.7 Immunomodulatory Activity

Tulsi stimulates immune cells and enhances body defense mechanisms against infections and diseases. [39]

13.8 Antidiabetic Activity

Tulsi helps regulate blood glucose levels and improves carbohydrate metabolism. [40]

13.9 Adaptogenic Activity

Tulsi acts as an adaptogen and helps the body cope with physical and mental stress. [41]

14. Therapeutic Uses [42]

- Wound healing
- Skin infections
- Fever and cold
- Cough and asthma
- Diabetes management
- Inflammation
- Stress management
- Oral infections
- Cosmetic preparations

15. Uses in Pharmaceutical Formulations [43]

- Tulsi is used in preparation of:
- Herbal gels
- Nanogels
- Creams
- Ointments
- Syrups
- Tablets
- Mouthwashes
- Cosmetic products

16. Advantages of Tulsi in Nanogel Formulation [44]

- Natural and safe
- Broad-spectrum antimicrobial activity
- Better patient compliance
- Economical
- Easily available
- Minimal side effects
- Excellent wound healing proper

MATERIALS AND INSTRUMENTS

Materials Used

(Table.1)

Sr. No.	Material/ Chemical	Quantity	Category/ Use
1	Tulsi (Ocimum sanctum) aqueous extract	6gm	Plant material
2	Carbopol 940	0.72gm	Gelling agent
3	Tween 80	7.2gm	Surfactant
4	Pure honey	3gm	Co-solvent
5	Olive oil	3gm	Oil phase
6	Distilled water	Sufficient quantity	Vehicle

Instrument

(Table.2)

Sr. No.	Instrument	Use
1	Soxhlet apparatus	Extraction of Tulsi leaves
2	Magnetic stirrer	Continuous stirring and mixing
3	Digital weighing balance	Accurate weighing of materials
4	Brookfield viscometer	Measurement of viscosity
5	Beaker	Preparation of formulation
6	Measuring cylinder	Measurement of liquids
7	Funnel	Filtration
8	Glass rod	Stirring
9	Centrifuge	Separation of particles
10	Micropipette	Transfer of small liquid volumes

EXPERIMENTAL METHODOLOGY

1.Collection of Plant Material

Fresh leaves of Ocimum sanctum were collected from local area and the collected leaves were washed thoroughly with distilled water to remove dirt and foreign matter. [25]

2. Drying and Powdering

The cleaned leaves were shade dried at room temperature for 7–10 days to preserve active phytoconstituents.[25] Dried leaves were powdered using mechanical grinder and passed through sieve to obtain uniform powder.[25]

3. Preparation of Tulsi Extract

Soxhlet Extraction Method

About 50 g of dried Tulsi leaf powder was packed in Soxhlet apparatus. [25] Ethanol (500 mL) was used as extraction solvent. [25] Extraction was carried out for 6–8 hours until complete extraction occurred. [25] The extract obtained was filtered using filter paper. [25] Filtrate was concentrated using water bath to obtain semisolid extract. [25] The extract was stored in airtight container for further use.

(Figure.2)

5. Procedure for Preparation of Nanogel

Step 1: Preparation of Gel Base

Required quantity of Carbopol 940 was dispersed slowly in distilled water with continuous stirring using magnetic stirrer. [26] The dispersion was allowed to hydrate properly for 1–2 hours.

(Figure.3)

Step 2: Preparation of Extract Solution

Tulsi extract was dissolved separately in small quantity of ethanol or distilled water. [26]

Tween 80 was added to improve dispersion and solubility.

Step 3: Incorporation of Extract

The extract solution was added slowly into hydrated Carbopol gel base under continuous stirring. [26]

Methyl paraben was added as preservative.

Step 4: pH Adjustment

Triethanolamine was added dropwise to adjust pH and obtain gel consistency. [26]

Stirring was continued until homogeneous nanogel was formed. [26]

Step 5: Storage

Prepared nanogel was transferred into airtight containers and stored at room temperature for further evaluation.[26]

Evaluation of Nanogel Formulation

Appearance – Smooth, clear/translucent, homogeneous gel with no visible lumps, grittiness, or phase separation. The formulation should possess a uniform texture indicating proper mixing and stability of all ingredients. Absence of air bubbles and particulate matter confirms good formulation quality and aesthetic acceptability.

Color and Odor – Light green to brownish-green in color with a characteristic pleasant odor of Tulsi. The natural color indicates the presence of phytoconstituents in the extract, while the pleasant herbal odor enhances patient acceptability. Any significant change in color or odor during storage may indicate instability or degradation of active constituents.

pH Determination – The pH of the nanogel should be maintained within the range of 5.5–7.0, which is compatible with the normal skin pH and minimizes the risk of irritation or sensitization. [29] Stable pH indicates good formulation stability. [26]

Viscosity – The nanogel should exhibit moderate viscosity in the range of 5000–20000 cps, ensuring easy application, good consistency, and adequate retention on the skin surface. Viscosity is determined using a Brookfield viscometer at controlled temperature and rpm. Proper viscosity improves spreadability and drug release characteristics.

Spreadability – The formulation should possess good spreadability, generally in the range of 5–7 cm within 1 minute under standard applied weight, indicating ease of application on the skin with minimal friction. Good spreadability ensures uniform distribution of the gel over the affected area and improves patient compliance.

Homogeneity – The prepared nanogel should show excellent homogeneity without the presence of aggregates or coarse particles. Uniform distribution of drug and excipients throughout the formulation ensures consistent therapeutic effect and appearance.

Extrudability – The gel should exhibit satisfactory extrudability from collapsible tubes or containers with slight pressure. Good extrudability ensures convenient handling and accurate dose application by the user.

Drug Content Uniformity – The formulation should contain uniform distribution of the active constituents throughout the gel matrix. Drug content analysis helps to confirm formulation accuracy and reproducibility.

Stability Study – The prepared nanogel should remain physically and chemically stable during storage conditions without significant changes in color, odor, pH, viscosity, or phase separation. Stability studies are generally carried out at room temperature and accelerated conditions for a specified period.

Skin Irritation Test – The formulation should be non-irritant and safe for topical application. The absence of redness, itching, edema, or inflammation after application indicates good skin compatibility of the Tulsi nanogel formulation.

Antimicrobial activity - Agar Well Diffusion Method. Nutrient agar plates were prepared and inoculated with selected microorganisms.[30] Wells were made in agar plates using sterile borer.[30] Nanogel formulation was introduced into wells.[30]Plates were incubated at 37°C for 24 hours. [30]Zone of inhibition was measured to determine antimicrobial activity. [30]

Test Organisms

• Staphylococcus aureus

RESULT

Observation Table

(table.3)

Sr.no.	Sample	Concentration	Zone of inhibition(mm)
1	Control		-
2	Standard Streptomycin	1 mg/ml	35
3	Sample -PP	5 mg/ml	01
		10mg/ml	04

The antibacterial study against S. aureus demonstrates that the standard drug Streptomycin (1 mg/mL) exhibited a strong inhibitory effect with a zone of inhibition of 35 mm, confirming its high efficacy. In comparison, the Sample PP showed very weak antibacterial activity, with zones of inhibition of only 1 mm at 5 mg/mL and 4 mm at 10 mg/mL. Although there is a slight increase in activity with higher concentration, the effect remains minimal.

Overall, it can be concluded that Sample PP possesses negligible antibacterial activity against S. aureus and is significantly less effective than the standard antibiotic.

(Figure.4)

CONCLUSION

The present study was carried out to evaluate the antibacterial activity of Sample–PP against Staphylococcus aureus using the agar well diffusion method. [46] The antimicrobial potential of the sample was compared with the standard antibiotic Streptomycin. [46] The results obtained from the study clearly indicate a significant difference between the activity of the standard drug and the test sample. [46] Streptomycin, used as the standard reference drug at a concentration of 1 mg/mL, showed a prominent zone of inhibition of 35 mm against S. aureus. This large inhibition zone confirms the strong antibacterial efficacy of the standard antibiotic and validates the suitability of the experimental procedure and test conditions used in the study. In contrast, sample–PP exhibited only very weak antibacterial activity. [46] At a concentration of 5 mg/mL, the sample produced a zone of inhibition of only 1 mm, while at 10 mg/mL the inhibition zone slightly increased to 4 mm. The increase in inhibition zone with increase in concentration suggests that the antibacterial effect of the sample is concentration dependent. However, even at the higher concentration, the inhibitory effect remained extremely low when compared with the standard drug. The negligible antibacterial activity of Sample–PP may be due to the low presence or absence of potent antimicrobial phytoconstituents capable of inhibiting the growth of Staphylococcus aureus. It may also indicate poor diffusion of active constituents through the agar medium or insufficient concentration of bioactive compounds in the sample.

From the overall findings, it can be concluded that Sample–PP possesses minimal antibacterial activity against Staphylococcus aureus under the experimental conditions employed in this study. The sample was significantly less effective than

Streptomycin and therefore cannot be considered a strong antibacterial agent against the tested microorganism. Further studies involving purification, isolation of active constituents, higher concentrations, or combination with other antimicrobial agents may be required to improve its antibacterial potential.

REFERENCES

1. Lad, Vasant. *Textbook of Ayurveda: Fundamental Principles*. Ayurvedic Press, 2002.
2. Sharma, P. V. *History of Medicine in India*. Indian National Science Academy, 1992.
3. Meulenbeld, G. J. *A History of Indian Medical Literature*. Egbert Forsten, 1999.
4. Dash, Bhagwan, and Vaidya Balendu Prakash. *Concept of Ayurvedic Physiology*. Chaukhamba Sanskrit Pratishthan, 2005.
5. Vagbhata, and K. R. Srikantha Murthy. *Ashtanga Hridaya*. Krishnadas Academy, 1995.
6. Frawley, David. *Ayurveda and the Mind: The Healing of Consciousness*. Lotus Press, 1997.
7. Wujastyk, Dominik. *The Roots of Ayurveda: Selections from Sanskrit Medical Writings*. Penguin Books, 2003.
8. Sharma, H. R. *Renaissance of Indian Medicine*. Indian Journal of History of Science, 1975.
9. Tiwari, Premvati. *Ayurveda: A Historical Perspective*. Chaukhamba Publications, 1992.
10. Shankar, D. *Status of Indian Medicine and Folk Healing*. Ministry of Health and Family Welfare, Government of India, 2011
11. Jain A, Mehta A, Jain S, Saxena G. Antimicrobial activity of Tulsi (Ocimum sanctum Linn): A systematic review. International Journal of Research in Ayurveda and Pharmacy. 2022;13(4):172-175.
12. Cohen MM. Tulsi - Ocimum sanctum: A herb for all reasons. Journal of Ayurveda and Integrative Medicine. 2014;5(4):251-259.
13. Jamshidi N, Cohen MM. A review on phytochemical and pharmacological properties of Holy Basil (Ocimum sanctum L.). Industrial Crops and Products. 2018;118:367-382.
14. Banoee M, et al. Nano-antibacterials using medicinal plant components: An overview. Frontiers in Microbiology. 2022;12:768739.
15. Kankaria N, Gupta MK, Nama N, Vyas GK. Preparation and characterization of a phytomedicated antifungal cream containing Ocimum sanctum. Journal of Neonatal Surgery. 2025.
16. Patel R, Patel M. Herbal nanoformulations for topical drug delivery. International Journal of Pharmaceutical Sciences. 2021;13(2):45-52.
17. Siva M, Shanmugam KR, Shanmugam B, et al. Ocimum sanctum: A review on the pharmacological properties. International Journal of Basic and Clinical Pharmacology. 2016.
18. Sharma P, Verma A. Herbal nanoparticle formulations for antimicrobial applications. Plant Cell Biotechnology and Molecular Biology. 2021;22(45-46):89-96.
19. Kumar R, Saha P, Lokare P, et al. A systemic review of Ocimum sanctum (Tulsi): Morphological characteristics, phytoconstituents and therapeutic applications. International Journal for Research in Applied Sciences and Biotechnology. 2022.
20. Singh V, Sharma PK. Nanogel drug delivery system: A review. International Journal of Applied Pharmaceutics. 2020;12(3):15-24.
21. Cohen MM. Tulsi - Ocimum sanctum: A herb for all reasons. Journal of Ayurveda and Integrative Medicine. 2014.
22. Kirtikar KR, Basu BD. Indian Medicinal Plants. 2nd ed. Vol. 1–4. Dehradun: International Book Distributors; 2005.
23. Nadkarni KM. Indian Materia Medica. 3rd ed. Vol. 1–2. Mumbai: Popular Prakashan; 2009.
24. Warrier PK, Nambiar VPK, Ramankutty C. Indian Medicinal Plants: A Compendium of 500 Species. Vol. 1–5. Chennai: Orient Blackswan; 1996.

25. Indian Drug Manufacturers' Association. Indian Herbal Pharmacopoeia. Revised new ed. Mumbai: Indian Drug Manufacturers' Association; 2002.
26. Sharma PC, Yelne MB, Dennis TJ. Database on Medicinal Plants Used in Ayurveda. 2001.
27. Kokate CK, Purohit AP, Gokhale SB. Practical Pharmacognosy. 5th ed. Pune: Nirali Prakashan; 2014.
28. Trease GE, Evans WC. Trease and Evans Pharmacognosy. 16th ed. London: Elsevier; 2009.
29. Wallis TE. Textbook of Pharmacognosy. 5th ed. New Delhi: CBS Publishers & Distributors; 2005..
30. Khandelwal KR. Practical Pharmacognosy Techniques and Experiments. 2013.
31. Harborne JB. Phytochemical Methods. 1998.
32. Pattanayak P, et al. Ocimum sanctum Linn: A reservoir plant for therapeutic applications. Pharmacognosy Reviews. 2010.
33. Jain A, et al. Antimicrobial activity of Tulsi. International Journal of Research in Ayurveda and Pharmacy. 2022.
34. Singh S, Majumdar DK. Anti-inflammatory activity of Ocimum sanctum. Journal of Ethnopharmacology. 1997.
35. Panda S, Kar A. Antioxidant activity of Tulsi. Indian Journal of Experimental Biology. 1998.
36. Shetty S, et al. Wound healing activity of Ocimum sanctum. Indian Journal of Experimental Biology. 2008
37. Godhwani S, et al. Analgesic activity of Ocimum sanctum. Journal of Ethnopharmacology. 1987.
38. Gupta SK, et al. Antipyretic activity of Tulsi. Journal of Ethnopharmacology. 2002.
39. Mediratta PK, et al. Immunomodulatory effects of Ocimum sanctum. International Journal of Pharmacognosy. 1988.
40. Rai V, et al. Effect of Tulsi on blood glucose. Journal of Ethnopharmacology. 1997.
41. Bhattacharyya D, et al. Adaptogenic activity of Tulsi. Phytotherapy Research. 2008.
42. Ayurvedic Pharmacopoeia of India. Government of India. 2001.
43. Remington: The Science and Practice of Pharmacy. 21st Edition.
44. Singh V, Sharma PK. Nanogel drug delivery system review. International Journal of Applied Pharmaceutics. 2020.
45. Gaikwad, A., Harshad, R., & Patil, S. B. (2024). Formulation, Evaluation, and Antioxidant Properties of Herbal Soap for Anti-Acne Treatment. International Journal of Novel Research and Development, 9(8), August 2024. ISSN: 2456-4184. Retrieved from www.ijnrd.org.
46. Hufford CD, Funderburk JM, Morgan JM, Robertson LW (1975). Two antimicrobial alkaloids from heartwood of Liriodendron tulipifera. I.J.pharm. Sci., 64:789-792.
47. Umadevi S, Mohanta G P, Chelladurai V, Manna PK, Manavalan R(2003). Antibacterial and antifungal activity of Andrographis echiodes.J. Nat. Remedies., 3:185-188.

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