Phytochemical Screening and Antibacterial Properties of Selected Medicinal Plants

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Abstract

Medicinal plants have long been recognized for their therapeutic potential, particularly in traditional healthcare systems. The presence of bioactive compounds such as alkaloids, flavonoids, tannins, saponins, and glycosides has been linked to antibacterial, antifungal, and antioxidant properties. This study investigates the phytochemical composition and antibacterial activity of three commonly used medicinal plants: Ocimum sanctum (Tulsi), Azadirachta indica (Neem), and Curcuma longa (Turmeric). Methanolic and aqueous extracts of plant leaves and rhizomes were prepared and subjected to qualitative phytochemical analysis using standard protocols. Antibacterial activity was tested against Escherichia coli and Staphylococcus aureus using the agar well diffusion method. Results confirmed the presence of key secondary metabolites and demonstrated significant inhibitory zones, particularly in methanolic extracts of Ocimum sanctum and Curcuma longa. The findings suggest that these plants hold strong potential as natural antibacterial agents, supporting their use in alternative medicine and opening avenues for pharmaceutical applications.

Keywords: *Phytochemicals, Medicinal plants, Antibacterial activity, Ocimum sanctum, Azadirachta indica, Curcuma longa*

1. Introduction

Medicinal plants have been used for centuries across cultures for the treatment of various diseases. In India, Ayurveda, Siddha, and Unani systems of medicine have traditionally relied on plant-derived formulations to cure infections, inflammation, and chronic illnesses. Recent scientific advances have provided evidence that the therapeutic effects of these plants are primarily due to the presence of diverse phytochemicals, including alkaloids, flavonoids, phenolic compounds, terpenoids, and tannins. These compounds serve as natural defense mechanisms for plants and, when extracted, often exhibit antimicrobial and pharmacological activity.

The emergence of antibiotic resistance among pathogenic bacteria has created an urgent demand for alternative antimicrobial agents. Conventional antibiotics, though effective, are becoming less reliable due to widespread misuse and over-prescription. Medicinal plants, with their wide range of bioactive compounds, represent a promising and sustainable source of new antibacterial agents. Several studies have already demonstrated the effectiveness of common Indian medicinal plants, but there remains a need for more region-specific and comparative studies to validate their efficacy.

Among the numerous medicinal plants, *Ocimum sanctum* (Tulsi), *Azadirachta indica* (Neem), and *Curcuma longa* (Turmeric) are widely used in traditional medicine for their antimicrobial, anti-inflammatory, and immunomodulatory properties. Tulsi is often consumed for respiratory ailments, Neem is renowned for its antiseptic effects, and Turmeric is well-documented for its antioxidant and wound-healing potential. These plants are easily accessible, culturally accepted, and environmentally sustainable, making them ideal candidates for further investigation.

The present study aims to perform phytochemical screening of these selected plants and to evaluate their antibacterial properties against common pathogens, specifically *Escherichia coli* and *Staphylococcus aureus*. The study not only provides scientific validation for traditional claims but also contributes to the search for novel plant-based antibacterial formulations.

2. Literature Review

Phytochemical analysis serves as a preliminary step in identifying the bioactive compounds responsible for the medicinal value of plants. Harborne (1998) emphasizes that phytochemicals, while not essential for plant growth, act as defense molecules and often display therapeutic properties when consumed by humans. Alkaloids, for instance, are known for their analgesic and antimicrobial roles, while flavonoids act as antioxidants and anti-inflammatory agents.

Several studies have investigated the antibacterial properties of Indian medicinal plants. According to Parekh and Chanda (2007), methanolic extracts of *Ocimum sanctum* demonstrated significant inhibition against Gram-positive bacteria. Neem extracts have also been studied extensively, with Biswas et al. (2002) documenting their efficacy against oral pathogens due to the presence of azadirachtin and nimbin compounds. Similarly, turmeric's active component, curcumin, has been recognized for its broad-spectrum antimicrobial activity and ability to inhibit bacterial biofilm formation (Gunes et al., 2016).

Despite abundant research on these plants individually, comparative studies across multiple extracts and pathogens are less common. Research in tier-II cities and regional contexts also remains limited, where locally available medicinal plants continue to be an important part of healthcare practices. Moreover, studies that use both aqueous and methanolic extracts provide deeper insight into the solubility and effectiveness of different phytochemicals, yet this approach is still underutilized.

The present study builds upon this gap by conducting both phytochemical screening and antibacterial assays on selected plants using dual solvents. By evaluating their activity against *E. coli* and *S. aureus*, the study aims to contribute to the understanding of natural plant-based antimicrobials and their potential pharmaceutical applications.

3. Materials and Methods

The study was designed to evaluate the phytochemical constituents and antibacterial activity of three medicinal plants: *Ocimum sanctum* (Tulsi), *Azadirachta indica* (Neem), and *Curcuma longa* (Turmeric). The methodology involved plant collection, preparation of extracts, qualitative phytochemical screening, and antibacterial assays.

Fresh leaves of *Ocimum sanctum* and *Azadirachta indica*, along with rhizomes of *Curcuma longa*, were collected from botanical gardens and local herbal markets in Coimbatore, Tamil Nadu. The plant materials were thoroughly washed with distilled water to remove dust and impurities, followed by shade drying for seven to ten days. The dried materials were ground into fine powder using a mechanical grinder and stored in airtight containers until further use.

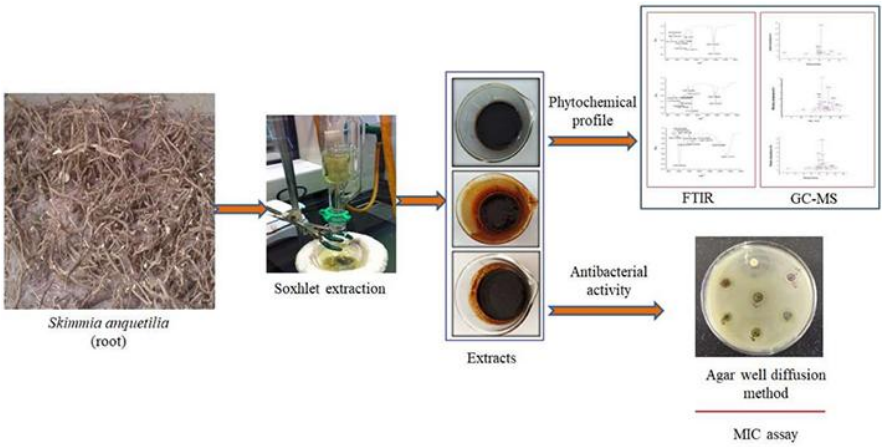

Figure 1: Experimental Design for Phytochemical Screening and Antibacterial Activity of Medicinal Plants

Two types of extracts were prepared: aqueous and methanolic. For aqueous extraction, 20 g of powdered plant material was boiled in 100 ml of distilled water for 30 minutes, cooled, filtered through Whatman No. 1 filter paper, and stored at 4°C. For methanolic extraction, 20 g of powdered sample was soaked in 100 ml of methanol for 72 hours with occasional shaking, followed by filtration and evaporation of the solvent under reduced pressure using a rotary evaporator. The concentrated extracts were stored in sterile vials under refrigeration. Qualitative phytochemical screening was carried out using standard procedures to test for the presence of alkaloids, flavonoids, tannins, saponins, glycosides, and phenolic compounds. For example, Mayer's test was used to detect alkaloids, ferric chloride test for phenols, foam test for saponins, and lead acetate test for flavonoids. Each test was performed in triplicates to ensure reproducibility.

The antibacterial activity of the extracts was evaluated against two bacterial strains: *Escherichia coli* (Gram-negative) and *Staphylococcus aureus* (Gram-positive). The bacterial cultures were obtained from the Department of Microbiology, Hindusthan College of Arts and Science, Coimbatore. The agar well diffusion method was employed to assess antibacterial activity. Sterile nutrient agar plates were inoculated with bacterial suspensions

standardized to 0.5 McFarland turbidity. Wells of 6 mm diameter were punched into the agar, and 100 µl of each plant extract was loaded into the wells. Methanol and distilled water served as negative controls, while ampicillin was used as the positive control. The plates were incubated at 37°C for 24 hours, and the diameter of the zone of inhibition was measured in millimeters. The data obtained from phytochemical tests and antibacterial assays were compiled and analyzed. The presence of secondary metabolites was recorded as positive or negative, while antibacterial activity was expressed as mean inhibition zone diameters from triplicate trials. Comparisons between aqueous and methanolic extracts were also made to determine solvent efficiency in extracting bioactive compounds.

4. Findings and Analysis

The phytochemical screening of *Ocimum sanctum*, *Azadirachta indica*, and *Curcuma longa* confirmed the presence of several bioactive compounds responsible for their medicinal value. Results indicated variations in the types and intensities of phytochemicals between aqueous and methanolic extracts, with methanolic extracts generally showing stronger presence.

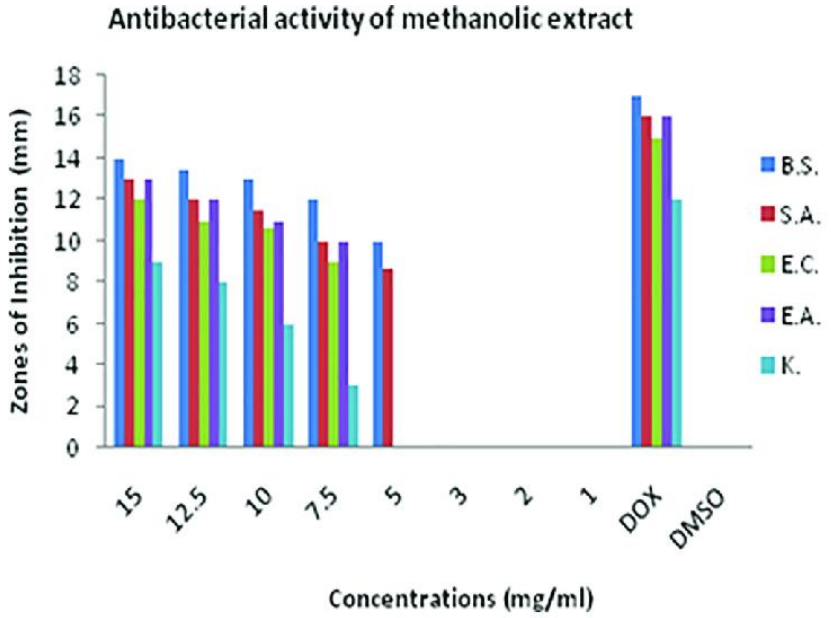

Figure 2: Antibacterial Activity (Zone of Inhibition in mm) of Aqueous and Methanolic Extracts Against *E. coli* and *S. aureus*

Alkaloids, flavonoids, tannins, phenols, and saponins were detected in all three plants, while glycosides were more pronounced in *Azadirachta indica*. Methanolic extracts of *Curcuma longa* displayed a strong presence of flavonoids and phenolic compounds, consistent with the known antioxidant properties of turmeric. Similarly, *Ocimum sanctum* extracts contained abundant tannins and alkaloids, compounds often linked to antimicrobial and anti-inflammatory effects.

Antibacterial testing using the agar well diffusion method showed that methanolic extracts exhibited higher zones of inhibition compared to aqueous extracts. Among the tested plants, *Curcuma longa* and *Ocimum sanctum* displayed the most significant inhibitory effects against *Staphylococcus aureus*, while *Azadirachta indica* was more effective against *Escherichia coli*. This suggests that phytochemical content and antibacterial activity are both influenced by the choice of solvent as well as the type of bacterial strain tested.

Overall, the findings provide experimental validation for traditional medicinal claims. The strong antibacterial activity observed, particularly in methanolic extracts, highlights the potential of these plants as natural alternatives to synthetic antibiotics.

Table 1: Phytochemical Composition of Selected Medicinal Plants

Plant Species	Alkaloids	Flavonoids	Tannins	Phenols	Saponins	Glycosides
Ocimum sanctum	+	+	+	+	+	–
Azadirachta indica	+	+	+	+	+	+
Curcuma longa	–	+	+	+	–	–

(+ = Present, – = Absent)

5. Conclusion and Recommendations

The present study investigated the phytochemical composition and antibacterial activity of Ocimum sanctum (Tulsi), Azadirachta indica (Neem), and Curcuma longa (Turmeric) using aqueous and methanolic extracts. The phytochemical screening confirmed the presence of important secondary metabolites such as alkaloids, flavonoids, tannins, phenols, and saponins, which are widely recognized for their pharmacological significance. Methanolic extracts were found to be more effective in extracting bioactive compounds compared to aqueous extracts, highlighting the influence of solvent choice in phytochemical studies.

The antibacterial assays demonstrated that these medicinal plants possess notable inhibitory effects against Escherichia coli and Staphylococcus aureus. Curcuma longa and Ocimum sanctum were particularly effective against S. aureus, while Azadirachta indica showed greater inhibition against E. coli. These findings validate the traditional use of these plants in treating microbial infections and further emphasize their potential as natural alternatives to synthetic antibiotics.

Based on the study, several recommendations can be made:

1. **Pharmaceutical applications**: The antibacterial activity of these plants should be further explored for development into herbal formulations or as complementary agents in antibiotic therapy.
2. **Standardization of extracts**: Future research should focus on standardizing the concentration of bioactive compounds to ensure reproducibility and consistent medicinal value.
3. **Extended microbial testing**: Additional studies against a wider range of bacterial and fungal pathogens would help in identifying broader antimicrobial potential.
4. **Isolation of active compounds**: Advanced chromatographic and spectroscopic techniques should be used to isolate and characterize the specific phytochemicals responsible for antibacterial activity.
5. **Promotion of sustainable use**: Cultivation and sustainable harvesting of medicinal plants should be encouraged to preserve biodiversity while meeting pharmaceutical demand.

In conclusion, the study provides strong evidence that Ocimum sanctum, Azadirachta indica, and Curcuma longa possess significant phytochemical diversity and antibacterial properties. Their role as promising natural resources for healthcare underscores the importance of integrating traditional knowledge with modern scientific validation.