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Phytochemical Analysis and Antimicrobial Activity of Peepal, Banyan, Neem, And Sita Ashok Medicinal Plants

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Abstract

The present study describes the phytochemical composition and antimicrobial efficacy of four medicinal plants, namely, Ficus religiosa (Peepal), Ficus benghalensis (Banyan), Azadirachta indica (Neem), and Saraca asoca (Sita Ashok), which are commonly used in traditional medicine. The leaves were extracted with ethanol, and the extracts were subjected to qualitative phytochemical screening indicating the presence of the bioactive compounds alkaloids, flavonoids, tannins, saponins, glycosides, phenols, steroids and terpenoids. Neem had the overall highest concentrations of the bioactive compounds. The extracts were tested for antimicrobial activity against common pathogens, Staphylococcus aureus, Escherichia coli, and Candida albicans, using the agar well diffusion method. Neem extract (high overall concentrations) exhibited the highest antimicrobial activity (largest zones of inhibition and highest percentage efficacy compared to a standard antibiotic), followed by Sita Ashok with less efficacy, then Peepal, and lastly Banyan (least antimicrobial activity). The study's findings support the use of these plants in the traditional medicinal culture and their potential use as natural alternatives and/or supplements to antibiotics, to address the issues of antibiotic resistance. While it is also a call for more research, it emphasizes the need for proper phytochemical as well as antimicrobial methods of screening when developing plant-based therapeutic agents in modern pharmacology.

Keywords: Phytochemical Screening, Antimicrobial Activity, Ficus Religiosa, Azadirachta Indica, Saraca Asoca, Bioactive Compounds, Antibiotic Resistance, Agar Diffusion Method.

1. INTRODUCTION

Medicinal plants have long been the backbone of traditional health care approaches. They serve as tremendous sources of bioactive compounds that can be used therapeutically. Ficus religiosa (Peepal), Ficus benghalensis (Banyan), Azadirachta indica (Neem), and Saraca asoca (Sita Ashok) hold great historical and cultural importance in Ayurveda and other traditional medical systems. All have a reputation for being used for a number of health promoting purposes, including anti-inflammatory, antioxidant, anti-microbial, and wound-healing properties. The phytochemical compositions contribute to these biological effects. The secondary metabolites such as alkaloids, flavonoids, tannins, saponins, glycosides, phenolic compound, steroids, and terpenoids provide these therapeutic effects directly or indirectly. Potentially to many people, the availability of these plants and the ease of use leads to their therapeutic properties being accepted without real evidence. Although there are more uses for these plants then there has been publications, there needs to be more organized scientific validation of these plants looking at phytochemical composition and antimicrobial activity to allow for continued development in therapeutic use in modern medicine.

The present study entails a thorough phytochemical screening and determination of antimicrobial activity of ethanolic extracts of Peepal (Ficus religiosa), Banyan (Ficus benghalensis), Neem (Azadirachta indica), and Sita Ashok (Saraca asoca) plants. Using qualitative and quantitative methodologies, this study aims to determine the concentration and distribution of various phytochemical compounds identified in the aforementioned plants. It also seeks to observe their relative inhibitory effects against some common microbes, such as Staphylococcus aureus, Escherichia coli, and Candida albicans. This study is significant not only to establish the validity of traditional uses of these botanicals but to find suitable plant alternatives or roles for conventional antibiotics, especially as antimicrobial resistance (AMR) continues to challenge global health with an ever-growing list of "superbugs." In addition, the research provides an opportunity for exploration of the pharmacological potential of these three botanical species and supports enhancements for the development of herbal products for therapeutic applications.

2. LITERATURE REVIEW

Dahiya and Purkayastha (2012) conducted a research study to assess the phytochemical composition and anti-microbial study of some the medicinal plants to evaluate the efficacy of the plant extracts against multi-drug-resistant bacteria isolated from clinical specimens. Their results showed that most plant extracts exhibited a significant antimicrobial activity which could be exploited as remedial measures for addressing resistant pathogens. The authors stressed the relevance of traditional medicinal plants in future pharmacology to eliminate the problem of antibiotic resistance.

Khan, Ullah, and Haider (2011) conducted phytochemical screening and antimicrobial studies on medicinal plants found in Khyber Pakhtunkhwa, Pakistan. In their study, they identified many bioactive compounds, including alkaloids, flavonoids, and tannins, from the tested plants. The extracts were also found to demonstrate activity against both gram-positive and gram-negative bacteria. This study shows the therapeutic potential of the local flora and encourages further research on naturally derived compounds for the development of antimicrobials.

Manasi and Raju (2015) examined the cultural importance and preservation issues of sacred trees (especially the Peepal tree) in urban settings. Their investigation studied the socio-cultural attitudes related to the preservation of sacred trees and recognized the important role of cultural beliefs and religious customs to safeguard these trees. They recognized and discussed the decline of cultural respect and conservation with urbanization. This study illustrates the importance of using cultural values in urban ecological planning for the sustainable conservation of sacred trees.

Maneesha et al. (2021) investigated the idea and development of medicinal gardens astrologically designed in India, which are developed from various traditional astrological beliefs about planetary position and nakshatras (lunar mansions). Their research illustrates how plants were chosen and planted based on their astrological relevance which were then intended to promote physical and spiritual well-being. Their study wove together these gardens functioning for therapeutic use and cultural practice that preserved ethnobotanical knowledge. The authors acknowledged the role of these gardens in promoting sustainable healthcare and conservation of medicinal plant species.

Mariappan et al. (2022) conducted a similar study on sacred groves and nakshatravan trees, examining both medicinal characteristics and potentially bioactive volatile compounds that could benefit human health. They conducted phytochemical profiling and identified essential oils that had meaningful therapeutic potential. The study also highlighted the wide diversity of medicinal species found in both sacred groves and nakshatravan trees, which contribute to biodiversity conservation and traditional systems of healthcare. They concluded that sacred groves and nakshatravan trees should be considered in the context of contemporary wellness programs that contribute to public health.

3. RESEARCH METHODOLOGY

In this study, an experimental-comparative research design was performed to explore and compare the phytochemical constituents and antimicrobial activities of four medicinal plants. The study used standard extraction and qualitative testing, with qualitative agar diffusion tests and statistical analyses being done descriptively and expressed with graphs.

3.1. Research Design

This study uses an experimental and comparative design to investigate the phytochemical compounds and antimicrobial activity of four traditionally used medicinal plants: Ficus religiosa (Peepal), Ficus benghalensis (Banyan), Azadirachta indica (Neem), and Saraca asoca (Sita Ashok). The research design includes qualitative and quantitative methods, allowing for a thorough profile of the bioactive compounds and their respective antimicrobial activities. The study seeks to compare the level of efficacy of each plant in phytochemical richness and biological activity against a selection of microbial strains.

3.2. Sample Collection and Preparation

Fresh, healthy leaves of Peepal, Banyan, Neem, and Sita Ashok were obtained from authenticated sources. All samples were identified by a botanist. The plant materials were washed, shade-dried, and finely ground. The powdered samples were extracted in ethanol using a Soxhlet apparatus. The extracts were filtered and concentrated for phytochemical and antimicrobial study.

3.3. Phytochemical Screening:

The presence of major phytochemical groups including: alkaloids, flavonoids, tannins, saponins, glycosides, phenols, steroids, and terpenes were assessed by conventional qualitative biochemical assays. The results were counted and expressed as the percentage occurrence for each compound in all four plants. Data were recorded in a table format and we calculated the mean and standard deviation (SD), to appreciate the variation and concentration values for the plants.

3.4. Antimicrobial Activity Assessment:

The antimicrobial activity of each extract was evaluated by using the agar well diffusion method with three pathogenic organisms: Staphylococcus aureus (Gram-positive); Escherichia coli (Gram-negative); and Candida albicans (fungus). The size of the zones of inhibition was measured in millimeters after 24 hours of incubation at appropriate temperature for the respective organisms. A standard antibiotic was used as a positive control so that the extracts could be compared against it.

3.5. Data Collection and Analysis:

Data were systematically collected and tabulated for each plant extract. Zone of inhibition measurements were averaged for each species across microbial strains. The effectiveness of each plant was calculated as a measure of percentage against the antibiotic control measurement. Descriptive statistical measures, mean and standard deviation, were used to interpret the phytochemical and antimicrobial data. MS Excel was used to visually convey results recorded as bar graphs for the purpose of comparative interpretation.

4. DATA ANALYSIS AND INTERPRETATION

Table 1 gives the percentage presence of eight important phytochemicals (alkaloids, flavonoids, tannins, saponins, glycosides, phenols, steroids, terpenoids) present in four medicinal plants (Peepal, Banyan, Neem, and Sita Ashok). The results were based on the qualitative screening tests performed, and expressed as percentages in Table 1. Mean and standard deviation (SD) for each phytochemical per plant is presented in Table 1. As seen from both Table 1, and represented in Figure 1, the pattern of distribution of phytochemicals showing the presence of the phytochemicals in various concentrations indicates the dramatic differences between the comparison species selected.

Table 1: Phytochemical Composition Analysis

Phytochemical	Peepal (%)	Banyan (%)	Neem (%)	Sita Ashok (%)	Mean (%)	Std. Dev (%)
Alkaloids	75	65	85	70	73.75	8.54
Flavonoids	80	75	90	85	82.5	6.45
Tannins	70	60	80	75	71.25	8.54
Saponins	50	55	65	60	57.5	6.45
Glycosides	65	70	75	65	68.75	4.79
Phenols	85	80	90	88	85.75	4.79
Steroids	40	45	50	42	44.25	4.79
Terpenoids	60	55	70	65	62.5	6.45

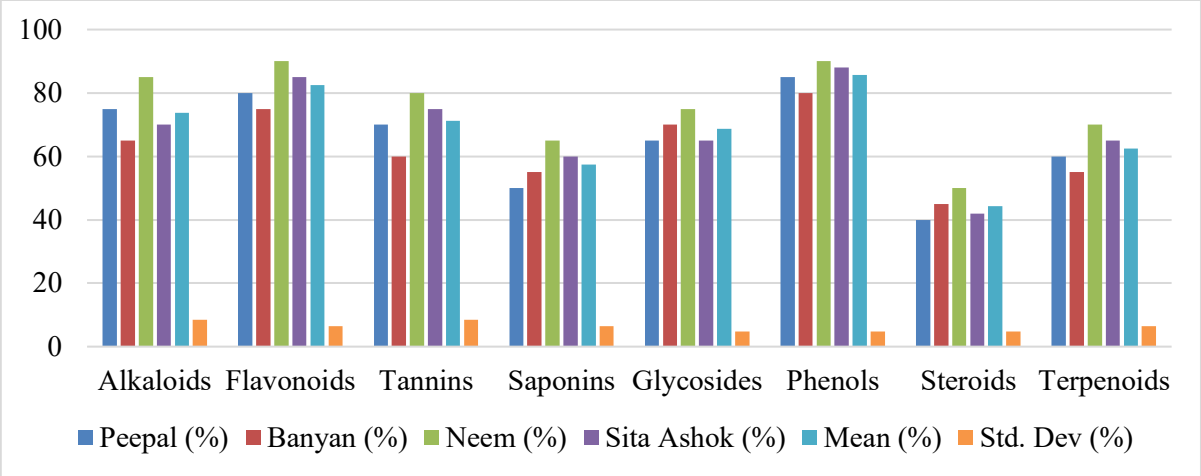

Figure 1: Graphical Representation of Phytochemical Composition Analysis

The results show that phenols and flavonoids were the most prevalent phytochemicals from all the plants studied at average percentages of 85.75% and 82.5%, respectively, and with low standard deviations and mean values, these phytochemicals have relatively high representation across the group. Neem consistently exhibited the highest representations for most phytochemical groupings and showed activity in high concentrations of flavonoids (90%) and phenols (90%), thereby affirming its level of phytochemical richness. Saponins and phytosterols had the mean lowest value, suggesting the lowest presence in these species studied. The standard deviations also show variation with moderate representation across each of the four plants for instance, alkaloids and tannins (SD = 8.54%), indicating variation in the uniqueness of the presence of the phytochemicals across the species. Overall, these results suggest that the four plants studied are all rich in bioactive compounds. Also, the overall results indicate that Neem produced the most potent biodynamic phytochemical profile, and it may provide it with greater therapeutic potential.

Table 2 demonstrates the antimicrobial activity of four medicinal plants, Peepal, Banyan, Neem and Sita Ashok against three microbial strains, Staphylococcus aureus, Escherichia coli and Candida albicans. The activity is measured in millimeters (mm) as the zone of inhibition produced around the plant extracts in an agar diffusion assay. The table includes the average zone of inhibition for each plant extract while a control antibiotic was used to compare the zone of inhibition. Figure 2 serves as a visual (graphical) comparison of the inhibition zones for each plant extracts against the three microorganisms.

Table 2: Antimicrobial Activity Analysis

Plant Extract	S. aureus (mm)	E. coli (mm)	C. albicans (mm)	Average Zone (mm)
Peepal	18	15	12	15
Banyan	16	14	11	13.67
Neem	22	19	17	19.33
Sita Ashok	19	16	14	16.33
Control (Antibiotic)	24	25	24	24.33

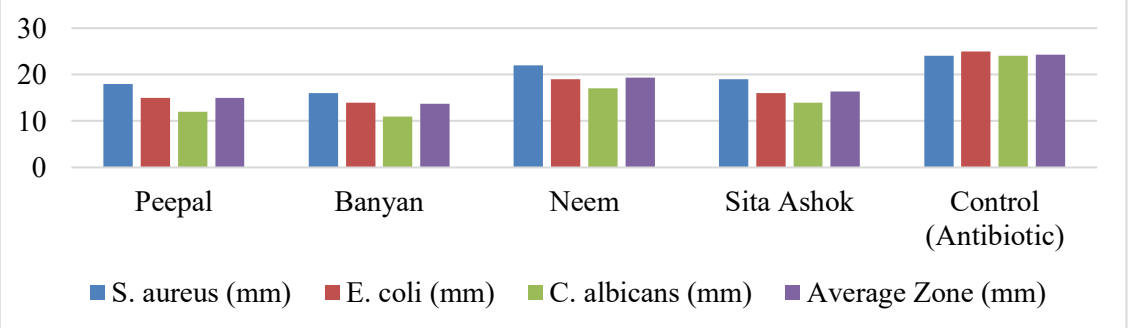

Figure 2: Graphical Representation of Antimicrobial Activity Analysis

The data indicate that Neem extract displays the best antimicrobial activity overall with an average inhibition zone of 19.33 mm, showing good activity on both bacterial and fungal pathogens. Sita Ashok (16.33 mm) and Peepal (15 mm) showed intermediate activity while Banyan had the weakest overall (13.67 mm). All microbes tested showed that S. aureus was the most susceptible to the extracts, with Neem yielding the largest inhibition zone (22 mm). The antibiotics in the control group had the largest zones of inhibition for all microbes, as was expected. Overall, the results suggest that the plants we tested all have affective antimicrobial potential with Neem being the best candidate for pharmacological development.
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Table 3: Percentage Effectiveness Relative to Antibiotic Control

Plant Extract	S. aureus (%)	E. coli (%)	C. albicans (%)	Mean Effectiveness (%)
Peepal	75	60	50	61.67
Banyan	67	56	46	56.33
Neem	92	76	71	79.67
Sita Ashok	79	64	58	67.00

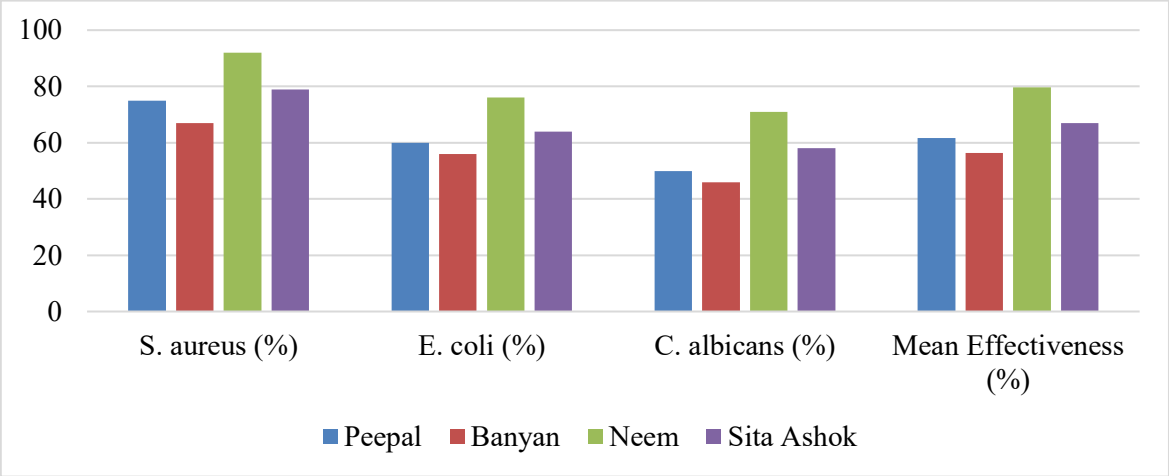

Figure 3: Graphical Representation of Percentage Effectiveness Relative to Antibiotic Control

The data indicates that Neem extract shows the highest average effectiveness, 79.67%, exhibiting strong antibacterial activity with results comparable to the antibiotic control. Sita Ashok follows with an average effectiveness of 67%, suggesting moderate effectiveness. Comparatively, Peepal and Banyan show lower relative activities with average effectiveness of 61.67% and 56.33% respectively. When examining effectiveness against specific pathogens, effectiveness of all extracts is highest against S. aureus, with Neem extract achieving the highest effectiveness, 92%, this reflects its strong anti-bacterial activity. Overall, the data support that Neem has superior effectiveness as a natural antimicrobial agent, demonstrating that Neem has the potential to be a strong alternative or adjunct therapy for conventional antibiotics especially in the context of increasing levels of antibiotic resistance.

5. CONCLUSION

The results of this work clearly show that all four medicinal plants (Peepal, Banyan, Neem, and Sita Ashok) have considerable levels of various phytochemicals with significant composition variability and varying degrees of antimicrobial activity. Of the four primary bioactive compounds, Neem contained the greatest amounts of flavonoids and phenols, which

strongly correlates with its superior antimicrobial activity when compared to the other three plants when tested against the bacterial and fungal pathogens (Staphylococcus aureus, Escherichia coli, and Candida albicans). Clearly, Neem had the greatest zone of inhibition and percentage effectiveness with respect to a standard antibiotic and could be considered the strongest candidate for natural antimicrobial use, followed by Sita Ashok, Peepal, and Banyan. Overall, the results indicate that the historical therapeutic use of these plants was validated, and suggest that they may be useful as viable alternatives or adjuncts to traditional antibiotics, particularly with increasing antibiotic resistance globally. This research highlights the importance of phytochemical profiling combined with antimicrobial assays to identify and develop structurally related plant-based pharmacologically useful compounds, and stimulate further investigations regarding pharmacological application and formulation of these medicinal plants in today's healthcare systems.

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