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Antimicrobial Activity of Selected Medicinal Plants from Around Ujjain City, India

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Abstract: Ayurveda, an ancient Indian medical system, emphasizes the use of natural elements to treat diseases and promote a balanced, healthy life. Polyherbalism—the practice of combining multiple herbs—enhances therapeutic efficacy and reduces toxicity. In this study, three medicinal plants, *Moringa oleifera*, *Withania somnifera*, and *Acorus calamus*, were examined for their antimicrobial and antioxidant properties. Phytochemical screening of these plants identified active compounds like alkaloids, tannins, saponins, and flavonoids. Solvent extractions using methanol, chloroform, petroleum ether, and water were conducted, and antimicrobial activity was tested against *Staphylococcus aureus*, *Escherichia coli*, *Bacillus subtilis*, *B. cereus*, and *Pseudomonas aeruginosa* using the disc diffusion method. Additionally, antioxidant properties were measured with the DPPH radical scavenging assay. This research highlights the potential of these plants to combat microbial infections and oxidative stress-related disorders.

Keywords: Antimicrobial Activity, Antioxidant Activity, Phytochemical Screening, Polyherbal Formulation, Traditional Medicine.

1 INTRODUCTION

1.1 Importance of Traditional Medicine and Herbal Therapy

For centuries, plants have served as an essential source of medicine. Across various cultures, traditional medicine systems have utilized plant-based remedies to treat a range of health conditions. The World Health Organization estimates that nearly 80% of the world's population relies on herbal medicine for primary healthcare. This widespread usage highlights the growing acceptance of phytotherapy, which offers natural alternatives with fewer side effects than synthetic drugs [1].

In India, Ayurveda is deeply ingrained in cultural practices and emphasizes a holistic approach, integrating mind, body, and environment. Given the country's vast biodiversity, India has identified over 45,000 plant species, with 15,000 recognized for their medicinal properties. These plants serve as a resource for developing treatments not only for common infections but also chronic diseases and disorders like diabetes, arthritis, and cancer [2]-[4].

1.2 Polyherbalism and Its Clinical Significance

Polyherbalism is a distinctive concept in Ayurveda that involves combining multiple herbs to maximize therapeutic outcomes. Individual herbs may contain beneficial phytochemicals, but combining several plants increases potency by leveraging their synergistic effects. For instance, some plants provide antioxidants, while others exhibit antimicrobial properties, leading to improved treatment efficiency when used together. Polyherbal formulations also reduce the toxicity associated with high doses of a single herb, ensuring safer treatments for patients [5].

Given the rise of antibiotic-resistant bacteria, there is a pressing need to explore natural alternatives like polyherbal formulations. This study examines the antimicrobial and antioxidant potential of *Moringa oleifera*, *Withania somnifera*, and *Acorus calamus*—plants widely known for their therapeutic properties [6]-[7].

2 MATERIALS AND METHODS

2.1 Selection of Plants

The plants chosen for this study—*Moringa oleifera*, *Withania somnifera*, and *Acorus calamus*—have established reputations in traditional medicine for their health benefits.

1. Moringa oleifera: Known for its high nutrient content, *Moringa* has antibacterial and anti-malarial properties.
2. Withania somnifera: Often referred to as Ashwagandha, this plant is valued for its anti-inflammatory and neuroprotective effects.
3. Acorus calamus: Used for treating digestive disorders, *Acorus* also acts as a stimulant and has antibacterial properties.

2.2 Extraction Procedures

Different solvents—methanol, chloroform, petroleum ether, and water—were used to extract bioactive compounds from various parts of the plants (leaves, roots, and bark) [6]. These solvents target a range of phytochemicals, ensuring that both polar and non-polar compounds are extracted effectively [8]-[9].

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1. Methanol: Extracts alkaloids and phenols.
2. Chloroform: Targets terpenoids and saponins.
3. Petroleum Ether: Extracts non-polar compounds, including fats and essential oils.
4. Water: Isolates water-soluble compounds like tannins and flavonoids.

The extracted samples were stored at 4°C to preserve the compounds' integrity until further analysis.

Fig. 1 Moringa oleifera

Fig. 2 Withania somnifera

Fig. 3 Acorus calamus

3 PHYTOCHEMICAL SCREENING

Phytochemical screening helps identify active compounds responsible for therapeutic properties. The presence of tannins, alkaloids, saponins, phenols, flavonoids, and terpenoids was confirmed through qualitative analysis. These compounds contribute to the plants' antimicrobial and antioxidant effects [10].

- Alkaloids: Known for their antimicrobial and analgesic properties.
- Tannins: Act as natural astringents with antibacterial effects.
- Flavonoids: Function as antioxidants, neutralizing free radicals.
- Saponins: Exhibit both antimicrobial and anti-inflammatory properties.

4 ANTIMICROBIAL ACTIVITY

The antimicrobial activity of the extracts was tested using the disc diffusion method. The selected bacterial strains—*S. aureus*, *E. coli*, *B. subtilis*, *B. cereus*, and *P. aeruginosa*—represent both Gram-positive and Gram-negative bacteria, ensuring comprehensive testing [11]-[13].

4.1 Procedure and Results

Sterile discs impregnated with plant extracts were placed on agar plates inoculated with bacterial cultures. The plates were incubated at 37°C for 24 hours, and the zone of inhibition was measured. Larger inhibition zones indicated stronger antibacterial activity [4].

- *Moringa oleifera* extract showed the highest activity against *S. aureus* and *B. subtilis*.
- *Withania somnifera* demonstrated moderate activity, particularly against *E. coli*.
- *Acorus calamus* exhibited significant activity against *P. aeruginosa*, a notoriously drug-resistant bacterium.

These findings confirm the plants' potential to combat microbial infections, especially in an era of increasing antibiotic resistance [14].

5 ANTIOXIDANT ACTIVITY

The antioxidant properties of the extracts were evaluated using the DPPH radical scavenging assay. Antioxidants neutralize harmful free radicals, reducing oxidative stress that contributes to chronic diseases like cancer and neurodegenerative disorders [15].

5.1 Procedure and Results

The extracts were mixed with DPPH, a stable free radical, and incubated in darkness. The reduction of DPPH, indicated by a color change from purple to yellow, was measured spectrophotometrically.

- *Withania somnifera* showed the highest antioxidant activity, followed by *Moringa oleifera*.
- *Acorus calamus* exhibited moderate antioxidant potential, supporting its traditional use in treating oxidative stress-related conditions [3].

The results validate the antioxidant properties of these plants, highlighting their potential for use in therapies targeting oxidative damage.

6 DISCUSSIONS

This study highlights the therapeutic potential of *Moringa oleifera*, *Withania somnifera*, and *Acorus calamus* for their antimicrobial and antioxidant properties, demonstrating that these plants could provide effective alternatives to synthetic drugs, especially in addressing antibiotic resistance and oxidative stress-related disorders. The findings reinforce the value of traditional medicine in modern healthcare, where natural products are increasingly viewed as reliable, cost-effective solutions with fewer side effects than conventional pharmaceuticals.

6.1 Implications of Antimicrobial Activity

The antimicrobial activity observed in these extracts shows promise for treating infections caused by Gram-positive and Gram-negative bacteria, including drug-resistant strains such as *Pseudomonas aeruginosa*. This result is crucial given the global rise in antibiotic resistance, which has limited the effectiveness of many synthetic drugs. The study suggests that polyherbal formulations involving these plants could enhance treatment outcomes by targeting pathogens through multiple mechanisms, thus reducing the likelihood of resistance development. The ability of *Moringa oleifera*, *Withania somnifera*, and *Acorus calamus* to inhibit multiple bacterial strains indicates broad-spectrum antimicrobial potential, which could benefit patients suffering from infections resistant to standard antibiotics.

The findings open avenues for using these plant extracts as natural preservatives in pharmaceuticals, cosmetics, and food products, where microbial contamination is a concern. Developing topical formulations from these extracts could also help prevent wound infections, making them useful in dermatology and healthcare settings.

6.2 Role of Antioxidant Properties in Disease Prevention

The antioxidant activity demonstrated by the plant extracts, particularly by *Withania somnifera*, suggests that these herbs can play a preventive role in chronic diseases caused by oxidative stress. Oxidative stress is a contributing factor to a range of health conditions, including cancer, cardiovascular diseases, neurodegenerative disorders (e.g., Alzheimer's and Parkinson's), and diabetes. Antioxidants neutralize free radicals, thereby preventing cellular damage and slowing the progression of these diseases. The results imply that incorporating these plants into daily diets or herbal supplements could improve overall health by reducing oxidative damage.

They also present opportunities for developing plant-based antioxidant therapies as supportive treatments for patients with chronic conditions. Polyherbal formulations combining these extracts could offer synergistic benefits, enhancing antioxidant protection and improving patient outcomes.

6.3 Future Research and Applications

While the study confirms the antimicrobial and antioxidant potential of these plants, further research is essential to maximize their therapeutic value. Isolation and characterization of the individual bioactive compounds responsible for these effects could lead to the development of new drugs. Clinical trials will be necessary to validate the safety and efficacy of these extracts for human use. Exploring the synergistic effects between these plants and existing antibiotics could reveal new ways to enhance drug effectiveness. Identifying optimal dosages and combinations will also be critical in formulating safe, effective polyherbal treatments. Additionally, advances in biotechnology and pharmaceutical sciences could improve the extraction and purification processes, ensuring that herbal formulations maintain consistent quality and potency.

6.4 Relevance to Modern Medicine

This research aligns with the increasing global interest in integrating traditional medicine with modern healthcare practices. As the demand for natural therapies grows, plants like *Moringa oleifera*, *Withania somnifera*, and *Acorus calamus* will play a more significant role in treating infections, managing chronic diseases, and promoting wellness. Their natural origin, reduced toxicity, and wide availability make them ideal candidates for use in resource-limited settings where access to synthetic drugs may be restricted. The study also underscores the need to preserve biodiversity and traditional knowledge, as many medicinal plants hold untapped potential for drug discovery. Governments and healthcare institutions should support research initiatives aimed at exploring these natural resources and integrating them into public health strategies.

7 CONCLUSIONS

This study demonstrates the significant antimicrobial and antioxidant potential of *Moringa oleifera*, *Withania somnifera*, and *Acorus calamus*. The phytochemical screening confirmed the presence of active compounds such as alkaloids, flavonoids, tannins, and saponins, which contribute to the therapeutic effects observed. The antimicrobial activity, especially against drug-resistant strains like *Pseudomonas aeruginosa*, highlights the potential of these plants in addressing bacterial infections, offering a natural alternative to synthetic antibiotics. Similarly, the antioxidant activity of these plants suggests their utility in mitigating oxidative stress, which plays a role in chronic conditions like cardiovascular diseases and cancer. The findings emphasize the value of polyherbal formulations, where the combined effects of multiple herbs enhance therapeutic outcomes and reduce toxicity. These results align with the growing preference for natural therapies that offer safety and efficacy with minimal side effects.

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ETHICS STATEMENT

This study did not involve human or animal subjects and, therefore, did not require ethical approval.

STATEMENT OF CONFLICT OF INTERESTS

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

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