

Comparative Review of the Antimicrobial Potential of *Azadirachta Indica* and *Gliricidia Sepium*

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ABSTRACT

Antimicrobial resistance has emerged as a major public health concern, creating an increasing need for alternative sources of antimicrobial agents. Medicinal plants represent an important source of structurally diverse bioactive compounds with potential antibacterial and antifungal properties. *Azadirachta indica* (neem) and *Gliricidia sepium* (Mexican lilac) are multipurpose plants that have traditionally been used for several purposes and have demonstrated antimicrobial activity against a variety of pathogenic microorganisms. This review summarizes the available evidence regarding the phytochemical composition and antimicrobial potential of *A. indica* and *G. sepium*, with particular emphasis on activity against Gram-positive and Gram-negative bacteria. Published studies indicate that neem contains bioactive constituents including azadirachtin, nimbidin, flavonoids and other secondary metabolites, while *G. sepium* contains flavonoids, phenols, alkaloids, tannins, saponins, glycosides and other potentially bioactive compounds. Extracts of both plants have demonstrated antibacterial activity against organisms including *Staphylococcus aureus*, *Escherichia coli* and *Pseudomonas aeruginosa*. However, antimicrobial efficacy varies according to plant part, extraction solvent, concentration, extraction method and susceptibility of the microorganism. The available evidence supports further investigation of these plants as potential sources of natural antimicrobial agents, particularly in the context of increasing antimicrobial resistance.

Keywords: *Azadirachta indica*, *Gliricidia sepium*, antimicrobial activity, antibacterial activity, medicinal plants, phytochemicals, *Escherichia coli*, *Staphylococcus aureus*, antimicrobial resistance.

INTRODUCTION

Antimicrobial resistance (AMR) has become a major global health concern, reducing the effectiveness of commonly used antimicrobial agents and making bacterial infections increasingly difficult to treat. The inappropriate and extensive use of antimicrobial drugs has contributed to the development and spread of resistant microorganisms. Among clinically important bacterial pathogens, *Escherichia coli* and *Staphylococcus aureus* are frequently associated with human infections and have been extensively studied in relation to antimicrobial resistance. *E. coli*, a Gram-negative bacterium, is commonly associated with gastrointestinal, urinary tract and other infections, whereas *S. aureus*, a Gram-positive bacterium, can cause infections ranging from skin infections to serious systemic diseases. The increasing prevalence of resistant strains has encouraged the search for alternative sources of antimicrobial agents.

Medicinal plants have gained considerable attention as potential sources of biologically active compounds because of their rich phytochemical composition and long history of traditional use. Plants contain various secondary metabolites such as alkaloids, flavonoids, tannins, terpenoids, saponins, glycosides and phenolic

compounds, many of which possess antimicrobial and other pharmacological properties. The presence of multiple bioactive constituents in plant extracts may allow them to act through different mechanisms, making medicinal plants valuable candidates for the discovery of new antimicrobial agents.

The antimicrobial activity of plant extracts can vary depending on the plant species, geographical origin, plant part, extraction method, solvent and concentration used. Different solvents extract different groups of phytochemicals, which can significantly influence the biological activity of the resulting extract. Therefore, understanding the relationship between phytochemical composition, extraction conditions and antimicrobial activity is important when evaluating medicinal plants as potential antimicrobial sources.

Azadirachta indica, commonly known as neem, belongs to the family Meliaceae and is widely distributed in tropical and subtropical regions. Various parts of the plant, including leaves, seeds, bark, flowers and fruits, have traditionally been used for medicinal purposes. Neem leaves contain several biologically active phytoconstituents, and numerous studies have reported antimicrobial activity of neem extracts against different bacterial species. In particular, activity against *S. aureus* and *E. coli* has been reported, indicating the potential of neem as a source of antibacterial compounds.

Gliricidia sepium is a tropical leguminous tree belonging to the family Fabaceae. It has been traditionally used for various purposes and has attracted scientific interest because of its phytochemical and biological properties. Studies on its leaves have reported the presence of several classes of secondary metabolites and demonstrated antibacterial activity against both Gram-positive and Gram-negative bacteria. These findings suggest that *G. sepium* may also possess significant antimicrobial potential.

The antimicrobial effects of *A. indica* and *G. sepium* may be associated with their diverse phytochemical constituents. Compounds such as alkaloids, tannins, saponins, glycosides, flavonoids and phenolic compounds may contribute to antimicrobial activity by affecting bacterial cell membranes, inhibiting essential enzymes, altering cellular permeability or interfering with other processes required for bacterial survival. However, the type and concentration of these constituents can differ between plant species and extraction methods.

A comparison of the antimicrobial potential of *A. indica* and *G. sepium* is therefore important for understanding their relative antibacterial activity and possible applications. Differences in the cell-envelope structures of Gram-positive and Gram-negative bacteria may also influence their susceptibility to plant-derived compounds. Although several studies have investigated these plants individually, variations in extraction methods, solvents, concentrations and experimental conditions can result in differences in reported antimicrobial activity.

Considering the increasing problem of antimicrobial resistance and the need for new antimicrobial sources, *A. indica* and *G. sepium* represent promising medicinal plants for further investigation. The present review focuses on the available literature concerning their phytochemical constituents, antimicrobial activity, possible mechanisms of action, comparative antibacterial potential, factors affecting their activity, existing research gaps and future prospects, with particular emphasis on their activity against *E. coli* and *S. aureus*.

***Azadirachta Indica*: Botanical and Medicinal Profile**

Azadirachta indica, commonly known as neem, belongs to the family Meliaceae. It is a multipurpose medicinal tree native to the Indian subcontinent and widely distributed throughout tropical and subtropical regions. The plant is traditionally known by several names, including neem, margosa, Aryaveppu and Vembu. It is a medium-to-large tree with a broad crown and deeply fissured bark.

Neem possesses compound pinnate leaves with numerous leaflets. Its flowers occur in axillary inflorescences and are generally white and fragrant, while the fruit is a smooth, yellowish-green drupe. Different parts of the plant, including leaves, bark, seeds and oil, have been utilized traditionally.

The medicinal importance of neem has been associated with numerous biologically active constituents. Azadirachtin is one of its characteristic constituents, while nimbidin, flavonoids and other secondary metabolites have also been associated with biological activity. Neem has been investigated for antibacterial, antifungal, anti-inflammatory, antioxidant and other pharmacological properties.

Gliricidia Sepium: Botanical and Medicinal Profile

Gliricidia sepium, commonly known as Mexican lilac, is a multipurpose leguminous tree belonging to the family Fabaceae. It is distributed in tropical regions and has traditionally been used for agricultural purposes, insect control and other applications. The plant can grow as a small-to-medium-sized tree with a spreading crown and pinnate leaves.

The leaves are composed of multiple leaflets, while the flowers are generally pink to pale purple and occur in inflorescences. The fruit is a flattened dehiscent pod containing several seeds.

Although comparatively less extensively investigated than neem, *G. sepium* has demonstrated considerable biological activity. Published studies have reported antibacterial activity against Gram-positive and Gram-negative bacteria as well as antifungal activity. Its biological effects have been associated with phytochemicals including phenols, flavonoids, alkaloids, tannins, saponins, glycosides and other secondary metabolites.

Phytochemical Basis of Antimicrobial Activity

The antimicrobial properties of medicinal plants are generally attributed to the presence of multiple secondary metabolites. Phytochemical investigations of neem have identified alkaloids, flavonoids, tannins, glycosides, saponins and other constituents. Studies summarized in the source article suggest that flavonoids may contribute significantly to the antibacterial activity of neem extracts.

Gliricidia sepium also contains a variety of phytochemicals. Studies have reported phenols, flavonoids, alkaloids, tannins, saponins, glycosides and other bioactive constituents in its leaves. Abdulaziz et al. reported flavonoids, saponins, tannins and steroids in ethanolic leaf extracts and identified several compounds using GC-MS.

The antimicrobial activity of a plant extract is unlikely to depend upon a single constituent. Interactions among major and minor phytochemical components may contribute to the overall biological effect. Studies on *G. sepium* have suggested that synergistic interactions between constituents may contribute to antimicrobial activity.

Antimicrobial Activity of Azadirachta Indica

Neem has demonstrated antibacterial activity against a wide range of microorganisms. Herrera-Calderon et al. described the antimicrobial potential of different parts of the plant and highlighted constituents including nimbidin, azadirachtin and flavonoids. Neem extracts have demonstrated activity against both Gram-positive and Gram-negative bacteria, including *S. aureus*, *E. coli* and *Mycobacterium tuberculosis*.

Several investigations have specifically evaluated neem against *S. aureus* and *E. coli*. Francine et al. reported that antibacterial activity was influenced by extraction method, plant material and extract concentration. Ethanol extracts, particularly those prepared from fresh material, generally demonstrated stronger antibacterial effects than aqueous extracts. *S. aureus* was generally more susceptible than *E. coli*.

Sarmiento et al. investigated neem leaf extract against methicillin-sensitive and methicillin-resistant *S. aureus*. The study demonstrated increasing antibacterial activity with increasing extract concentration, with the 100% ethanol extract producing the greatest inhibition.

Aslam et al. evaluated different phytoconstituents obtained from neem leaves against bacterial strains including *S. aureus*, *Corynebacterium bovis* and *E. coli*. Neem extract demonstrated significant antibacterial activity, and flavonoids showed notable activity among the tested phytoconstituents.

The antibacterial activity of neem is not restricted to leaf extracts. Investigations of neem seed oil have demonstrated antibacterial effects associated with fatty acids including linoleic, oleic and stearic acids.

Antimicrobial Activity of *Gliricidia Sepium*

Evidence accumulated over several years indicates that *G. sepium* possesses broad-spectrum antimicrobial properties. Nazli et al. reported antibacterial activity of ethanol extracts of *G. sepium* leaves against several bacterial species, including *E. coli*, *S. aureus* and *Klebsiella* species.

Sunder et al. investigated methanol, ethanol and ethyl acetate extracts of *G. sepium* leaves and reported activity against both Gram-positive and Gram-negative bacteria as well as fungal organisms. Ethanol extracts demonstrated particularly notable activity against organisms including *E. coli* and *S. aureus*.

Kumar and Simon reported antibacterial activity of *G. sepium* leaf extracts against Gram-negative organisms including *E. coli* and *P. aeruginosa*. The activity was associated with secondary metabolites such as glycosides, alkaloids, essential oils and flavonoids.

Ayantola et al. reported activity of *G. sepium* crude extracts against human pathogenic bacteria including *E. coli*, *S. aureus*, *Salmonella typhi* and *Proteus vulgaris*. Antibacterial efficacy varied according to the extraction solvent, while the extracts also demonstrated antioxidant potential.

Abdulaziz et al. reported antibacterial and antifungal activity of ethanolic leaf extracts and identified several potentially important phytochemical constituents. These findings provide additional support for the antimicrobial potential of *G. sepium*.

Comparative Antimicrobial Potential

Both *A. indica* and *G. sepium* demonstrate antibacterial activity against a range of Gram-positive and Gram-negative bacteria. However, the magnitude of activity varies considerably between studies. Such variation may be explained by differences in plant part, geographical origin, phytochemical composition, extraction solvent, extraction procedure, extract concentration and susceptibility of the test organism.

Neem has been more extensively investigated and possesses a comparatively well-characterized phytochemical profile. Its activity has been documented against numerous clinically relevant microorganisms, including *S. aureus* and *E. coli*.

In comparison, the available literature on *G. sepium* is smaller but demonstrates promising broad-spectrum activity. Studies have reported antibacterial effects against *E. coli*, *S. aureus*, *P. aeruginosa*, *Bacillus subtilis* and other organisms.

Studies comparing medicinal plant extracts have also demonstrated that combinations of plant extracts may produce enhanced antimicrobial effects. Kumar et al. reported improved antimicrobial efficacy when neem and tulsi extracts were combined, suggesting that interactions between different plant-derived constituents may be therapeutically relevant.

Effect of Extraction Solvent and Concentration

The extraction procedure is an important determinant of the antimicrobial activity of medicinal plant extracts. Different solvents extract different groups of phytochemicals and therefore produce extracts with different biological activities.

For neem, studies summarized in the source article indicate that ethanol extracts frequently demonstrate greater antibacterial activity than aqueous extracts. Fresh plant material has also been reported to produce stronger activity than dried material in some investigations.

Similar solvent-dependent variation has been observed with *G. sepium*. Methanol, ethanol and ethyl acetate extracts have demonstrated antibacterial activity, with ethanol extracts showing particularly promising effects in several studies.

Extract concentration is another important factor. Several investigations have reported greater inhibition at higher concentrations, suggesting a concentration-dependent antibacterial effect. However, comparison between studies should be performed cautiously because extraction procedures and phytochemical concentrations are not standardized.

Activity Against Gram-Positive and Gram-Negative Bacteria

Both plants have demonstrated activity against Gram-positive and Gram-negative bacteria. *S. aureus*, a Gram-positive pathogen, has frequently shown susceptibility to neem and *G. sepium* extracts. Similarly, *E. coli*, a Gram-negative organism, has been inhibited by extracts of both plants.

However, Gram-negative bacteria may exhibit different susceptibility patterns compared with Gram-positive organisms because of differences in their cellular envelope and permeability. The available studies indicate that *S. aureus* is frequently more susceptible to neem extracts than *E. coli*, although this pattern is not universal and Depends On The Extract And Experimental Conditions.

Potential Mechanisms of Antimicrobial Action

The precise mechanisms responsible for the antibacterial effects of *A. indica* and *G. sepium* are not completely established from the studies included in this review. Nevertheless, the diverse phytochemical composition of these plants suggests that multiple mechanisms may contribute to their activity.

Plant-derived antimicrobial constituents may interfere with bacterial membrane integrity, alter membrane permeability, inhibit essential enzymes, interfere with protein or nucleic-acid synthesis and affect bacterial metabolism. The presence of multiple bioactive constituents may also result in additive or synergistic effects.

The reported synergistic contribution of major and minor constituents in *G. sepium* extracts further supports the possibility that the antimicrobial activity of whole plant extracts may not be attributable to a single compound.

Antimicrobial Resistance and the Potential of Medicinal Plants

The emergence of antimicrobial resistance has increased the importance of identifying alternative antimicrobial sources. Resistant bacteria can persist under antimicrobial selective pressure, particularly when antibiotics are used excessively or inappropriately.

Medicinal plants offer a chemically diverse source of natural compounds that may provide new antimicrobial leads. Studies involving neem have demonstrated activity against susceptible as well as certain resistant bacterial strains, including methicillin-resistant *S. aureus*.

However, demonstrated in-vitro activity of plant extracts should not automatically be considered equivalent to clinical efficacy. Standardization of extracts, identification of active compounds, toxicity evaluation, pharmacokinetic characterization and well-designed clinical studies are necessary before therapeutic applications can be established.

CONCLUSION

The available literature demonstrates that *Azadirachta indica* and *Gliricidia sepium* possess significant antimicrobial potential. Both plants contain diverse phytochemicals that may contribute to their antibacterial effects against Gram-positive and Gram-negative microorganisms. Neem has a comparatively extensive evidence base, with activity reported against organisms including *S. aureus* and *E. coli*, while *G. sepium* has also demonstrated promising broad-spectrum antibacterial activity.

The antimicrobial activity of both plants is influenced by several factors, particularly the plant part, extraction solvent, extraction method, concentration and susceptibility of the microorganism.

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