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Avicennia officinalis L.: A Comprehensive Review of Its Ethnomedicinal Importance, Phytochemical Profile, Pharmacological Activities, and Future Therapeutic Prospects

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ABSTRACT:

Avicennia officinalis L. is a medicinal mangrove species widely distributed throughout tropical and subtropical coastal ecosystems. Traditionally, the plant has been utilized for the management of numerous ailments, including inflammatory disorders, diabetes, gastrointestinal diseases, skin infections, ulcers, rheumatism, and microbial infections. Increasing scientific interest in this species has led to extensive investigations into its phytochemical composition and pharmacological properties. Various plant parts, including leaves, bark, roots, fruits, and aerial roots, contain diverse bioactive compounds such as flavonoids, iridoid glycosides, terpenoids, triterpenoids, steroids, phenolic acids, tannins, and polyphenols. These phytochemicals contribute to a wide range of biological activities including antioxidant, antimicrobial, anti-inflammatory, antidiabetic, anticancer, antiulcer, antiviral, analgesic, antipyretic, neuroprotective, and hepatoprotective effects. In addition to its medicinal value, A. officinalis plays a significant ecological role in coastal protection and environmental remediation by accumulating heavy metals and supporting biodiversity. The plant also serves as a valuable source of endophytic microorganisms capable of producing novel therapeutic metabolites. This review critically summarizes current knowledge regarding the taxonomy, botanical characteristics, geographical distribution, traditional applications, phytochemistry, pharmacological activities, and environmental significance of A. officinalis. Furthermore, existing research gaps and future opportunities for phytochemical isolation, molecular investigations, preclinical evaluation, and clinical validation are highlighted. Continued multidisciplinary research may facilitate the development of standardized herbal formulations and novel drug candidates derived from this important mangrove species

Keywords: Avicennia officinalis, Indian mangrove, medicinal plant, phytochemicals, pharmacological activity, antioxidants, traditional medicine, mangrove ecosystem.

INTRODUCTION:

Mangrove ecosystems represent one of the most productive and biologically important coastal environments worldwide. These specialized plant communities survive under extreme environmental conditions, including high salinity, tidal inundation, fluctuating oxygen levels, and elevated temperatures. Apart from stabilizing shorelines and protecting coastal ecosystems from erosion, mangrove species provide valuable ecological services while serving as reservoirs of biologically active natural products.

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Among the various mangrove species, Avicennia officinalis L. has emerged as an important medicinal plant due to its extensive traditional applications and diverse pharmacological properties. The species is predominantly distributed along the coastal regions of India, Bangladesh, Sri Lanka, Myanmar, Thailand, Malaysia, Indonesia, and several other tropical countries. Indigenous communities have utilized different parts of the plant for centuries to manage diabetes, ulcers, inflammatory disorders, skin diseases, rheumatism, asthma, diarrhea, microbial infections, and wound healing.

Recent phytochemical investigations have demonstrated that A. officinalis contains numerous secondary metabolites, including flavonoids, iridoids, triterpenoids, phenolic compounds, steroids, tannins, alkaloids, and glycosides. These constituents are responsible for various experimentally validated biological activities such as antioxidant, antimicrobial, anti-inflammatory, antidiabetic, anticancer, antiviral, antiulcer, analgesic, neuroprotective, and hepatoprotective effects. Furthermore, the plant exhibits remarkable environmental applications through phytoremediation and biosynthesis of metal nanoparticles.

Despite significant progress in pharmacological research, many bioactive constituents remain insufficiently characterized, and clinical evidence supporting therapeutic use remains limited. Therefore, an updated review integrating ethnomedicinal knowledge with modern scientific findings is essential to facilitate future drug discovery and evidence-based utilization of this valuable mangrove species.

AIM AND OBJECTIVES

Aim:

To comprehensively review the ethnomedicinal significance, phytochemical composition, pharmacological properties, environmental applications, and future therapeutic potential of Avicennia officinalis L. based on available scientific evidence.

Objectives

To summarize the botanical characteristics and geographical distribution of A. officinalis.

To compile traditional and ethnomedicinal uses reported across different regions.

To review the major phytochemical constituents isolated from various plant parts.

To critically evaluate experimentally validated pharmacological activities.

To discuss ecological importance and industrial applications of the species.

To identify current research gaps and recommend future directions for pharmacological and clinical investigations.

MATERIALS AND METHODS

Literature Search Strategy

This review was developed through a systematic evaluation of published scientific literature concerning Avicennia officinalis L. Relevant

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articles were identified using internationally recognized electronic databases, including PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, SpringerLink, and other peer-reviewed sources. Standard botanical references, pharmacognosy textbooks, ethnomedicinal literature, and reports related to mangrove biodiversity were also consulted.

Keywords employed during the literature search included "Avicennia officinalis", "Indian mangrove", "ethnomedicine", "phytochemistry", "secondary metabolites", "pharmacological activities", "antioxidant", "antimicrobial", "anti-inflammatory", and "medicinal mangroves". Studies focusing on botanical characterization, phytochemical investigations, biological activities, and traditional medicinal applications were critically evaluated. Duplicate publications and studies lacking sufficient scientific evidence were excluded to improve the quality of the review.

RESULTS

Botanical Characteristics

Avicennia officinalis L. belongs to the family Acanthaceae and is one of the most important mangrove species found in coastal ecosystems. It is a medium- to large-sized evergreen tree that generally reaches a height of 10–20 m. The plant possesses greyish bark, opposite leathery leaves, orange-yellow flowers arranged in clusters, and characteristic pencil-shaped pneumatophores that facilitate gaseous exchange under waterlogged conditions.

The leaves exhibit salt-secreting glands that enable the plant to tolerate highly saline environments. Flowers are bisexual and insect-pollinated, while fruits contain a single seed that undergoes rapid germination under suitable environmental conditions.

Distribution and Habitat

The species is naturally distributed throughout tropical and subtropical coastal regions, including India, Bangladesh, Sri Lanka, Myanmar, Thailand, Malaysia, Indonesia, Vietnam, the Philippines, and northern Australia. Within India, A. officinalis occurs predominantly in the Sundarbans, the eastern and western coastal belts, estuaries, river deltas, and tidal marshes.

The plant thrives in saline, muddy, and oxygen-deficient soils subjected to regular tidal inundation. Its extensive root system contributes significantly to shoreline stabilization, sediment deposition, and protection against coastal erosion.

Ethnomedicinal Importance

Traditional medicinal systems have long recognized A. officinalis as a valuable therapeutic plant. Different plant parts are employed for the treatment of numerous disorders.

Leaves are commonly used for inflammatory conditions, skin diseases, wounds, ulcers, and

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diabetes. Bark preparations have been administered for rheumatism, fever, diarrhea, and microbial infections. Fruits and seeds have traditionally been applied to abscesses, boils, and chronic skin lesions. Root preparations have been reported for aphrodisiac and tonic purposes in certain traditional systems.

Several indigenous communities also utilize decoctions and herbal formulations prepared from different plant parts to manage asthma, hepatitis, dyspepsia, paralysis, leprosy, and gastrointestinal disorders.

Phytochemical Constituents

Phytochemical investigations have revealed that A. officinalis contains a broad spectrum of biologically active secondary metabolites.

Major phytochemical groups include:

- Flavonoids
- Iridoid glycosides
- Triterpenoids
- Terpenoids
- Steroids
- Polyphenols
- Phenolic acids
- Tannins
- Alkaloids
- Saponins
- Glycosides

Several important compounds isolated from different plant parts include betulinic acid, ursolic acid, lupeol, taraxerol, β-amyrin, α-amyrin, avicennioside, loganin derivatives, geniposidic acid derivatives, chrysoeriol glycosides, luteolin glycosides, velutin, stigmasterol, β-sitosterol, campesterol, and numerous phenolic antioxidants.

These compounds collectively contribute to the plant's extensive pharmacological activities.

Pharmacological Activities

Antioxidant Activity

Leaf, bark, and fruit extracts exhibit remarkable free radical scavenging activity through DPPH, ABTS, FRAP, and superoxide radical assays. The antioxidant potential is primarily attributed to flavonoids, phenolic compounds, and tannins that reduce oxidative stress.

Antimicrobial Activity

Extracts prepared using methanol, ethanol, ethyl acetate, and chloroform demonstrate inhibitory activity against numerous Gram-positive and Gram-negative bacteria as well as pathogenic fungi. Several isolated compounds possess significant antibacterial properties against Staphylococcus aureus, Bacillus subtilis, Escherichia coli, and other clinically relevant microorganisms.

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Anti-inflammatory Activity

Experimental studies demonstrate that leaf extracts significantly suppress acute and chronic inflammatory responses.

Antidiabetic Activity

Experimental animal studies have shown significant reductions in blood glucose concentrations following administration of bark and leaf extracts. The proposed mechanisms involve inhibition of α-amylase and α-glucosidase enzymes, improved glucose utilization, and antioxidant protection.

Anticancer Activity

Methanolic extracts exhibit cytotoxic activity against experimental cancer cell models. Several phytoconstituents have demonstrated antiproliferative effects through induction of apoptosis and inhibition of tumor cell growth.

Antiulcer Activity

Experimental investigations indicate that ethanolic leaf extracts provide gastroprotective effects by reducing gastric acid secretion, enhancing mucosal defense, and promoting ulcer healing.

Antiviral Activity

Preliminary investigations suggest inhibitory effects against viral targets, including HIV-associated proteins, indicating potential antiviral applications that require further validation.

Neuroprotective Activity

Extracts possess cholinesterase inhibitory activity and exhibit central nervous system depressant effects in experimental models. These findings indicate possible applications in neurodegenerative disorders such as Alzheimer's disease.

Analgesic and Antipyretic Activities

Leaf extracts significantly reduce experimentally induced pain and fever through mechanisms associated with suppression of inflammatory mediators and prostaglandin synthesis.

Environmental and Industrial Applications

Beyond its medicinal value, A. officinalis contributes substantially to environmental sustainability. The species efficiently accumulates heavy metals from contaminated soils and aquatic environments, making it an effective candidate for phytoremediation

DISCUSSION

Avicennia officinalis has attracted considerable scientific attention because of its diverse phytochemical composition and broad spectrum of pharmacological activities. Traditional medicinal systems have long utilized various parts of the plant for managing inflammatory disorders, infectious diseases, gastrointestinal complications, skin ailments, diabetes, and wound healing. Modern pharmacological investigations have largely supported many of these ethnomedicinal

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claims, indicating that the species represents a promising source of bioactive compounds for future therapeutic development.

The pharmacological properties of A. officinalis are primarily attributed to the synergistic effects of flavonoids, iridoid glycosides, triterpenoids, phenolic compounds, tannins, steroids, and other secondary metabolites. These phytochemicals exhibit potent antioxidant activity by scavenging reactive oxygen species, reducing oxidative stress, and protecting cellular components from oxidative damage. Since oxidative stress contributes to the pathogenesis of chronic disorders such as diabetes, cardiovascular disease, neurodegenerative disorders, and cancer, the antioxidant potential of A. officinalis may have significant therapeutic implications.

Several experimental studies have demonstrated notable antimicrobial activity against both Gram-positive and Gram-negative bacteria as well as pathogenic fungi. These findings support the traditional use of the plant in treating skin infections, wounds, ulcers, and gastrointestinal diseases. Furthermore, anti-inflammatory investigations indicate that the extracts inhibit inflammatory mediators and reduce tissue damage in experimental animal models, thereby validating their use in inflammatory disorders and rheumatic conditions.

The antidiabetic activity of A. officinalis is particularly noteworthy. Experimental evidence suggests that plant extracts inhibit carbohydrate-metabolizing enzymes, improve glycemic control, and reduce oxidative stress associated with diabetes mellitus. Similarly, promising anticancer activity has been demonstrated in laboratory studies through inhibition of tumor cell proliferation and induction of apoptosis. However, these findings remain largely confined to in vitro and preclinical investigations.

In addition to its medicinal value, A. officinalis possesses considerable ecological and industrial importance. Its capacity to accumulate heavy metals from contaminated environments makes it an effective candidate for phytoremediation. Moreover, recent studies involving green synthesis of silver nanoparticles using plant extracts have opened new avenues in nanomedicine and antimicrobial research.

Despite encouraging scientific evidence, several limitations remain. Most available studies have focused on crude extracts rather than purified bioactive molecules. Information regarding pharmacokinetics, molecular mechanisms, toxicity profiles, dosage standardization, and clinical efficacy remains limited. Therefore, future investigations should emphasize advanced phytochemical characterization, molecular pharmacology, standardized extract development, and well-designed clinical trials to facilitate the

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translation of laboratory findings into therapeutic applications.

CONCLUSION

Avicennia officinalis is an important medicinal mangrove species with significant ethnopharmacological, phytochemical, ecological, and pharmaceutical value. Scientific investigations have confirmed the presence of numerous biologically active constituents responsible for antioxidant, antimicrobial, anti-inflammatory, antidiabetic, anticancer, antiviral, antiulcer, neuroprotective, analgesic, and other therapeutic activities. The accumulated evidence strongly supports many of its traditional medicinal applications while highlighting its potential as a valuable source of novel drug candidates.

Beyond its medicinal significance, the species contributes substantially to coastal ecosystem conservation, environmental remediation, and sustainable utilization of natural resources. Nevertheless, further multidisciplinary research involving advanced phytochemical isolation, molecular target identification, toxicity assessment, pharmacokinetic evaluation, formulation development, and controlled clinical studies is essential before widespread therapeutic application can be recommended.

Overall, Avicennia officinalis represents a promising medicinal resource deserving continued scientific exploration for the discovery of safe, effective, and evidence-based phytopharmaceutical products

REFERENCE:

1. Bandaranayake WM. Traditional and medicinal uses of mangroves. Mangroves Salt Marshes. 1998;2:133-148.
2. Bandaranayake WM. Bioactivities, bioactive compounds and chemical constituents of mangrove plants. Wetl Ecol Manag. 2002;10:421-452.
3. Duke NC. A systematic revision of the mangrove genus Avicennia. Aust Syst Bot. 1991;4:299-324.
4. Das SK, Samantaray D, Thatoi H. Pharmacological activities of Avicennia officinalis. Clin Phytosci. 2018;4:13.
5. Das SK, Samantaray D, Sahoo SK, et al. Bioactivity-guided isolation of antidiabetic compounds from Avicennia officinalis. S Afr J Bot. 2019;125:109-115.

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