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Review Article

Ethnopharmacological Insights and Therapeutic Potential of *Ficus infectoria*

Anubhav Shukla[1], Firoz Alam[2*], Ashutosh Yadav[3], Harsh Pandey[1], Neelkanth M. Pujari[4]

[1]*Maharishi School of Pharmaceutical Sciences, MUIT, Lucknow, U.P.-226013.*
[2]*Kunwar Haribansh Singh College of Pharmacy, Jaunpur, U.P.-222180.*
[3]*Institute of Pharmacy, Dr Shakuntala Misra National Rehabilitation University Lucknow, U.P.-226017.*
[4]*Faculty of Pharmacy, Dr. APJ Abdul Kalam Technical University, Lucknow, U.P.-226031.*

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ABSTRACT

Ficus infectoria (commonly known as Paakar) is a medicinal plant native to India and holds a significant place in traditional systems of medicine, including Ayurveda, Siddha, and Unani. Its therapeutic applications are deeply rooted in ethnomedicine, where various parts of the plant, such as leaves, bark, roots, and fruits, are used to treat ailments such as diarrhea, ulcers, skin disorders, and diabetes. This review provides a comprehensive analysis of the ethnopharmacological significance, phytochemical composition, and therapeutic potential of *Ficus infectoria*. The plant is known to possess a wide array of bioactive compounds, including flavonoids, tannins, phenolics, and terpenoids, which contribute to its antioxidant, anti-inflammatory, antimicrobial, and antidiabetic activities. Modern pharmacological studies have validated many of its traditional uses, while also uncovering new avenues for therapeutic applications. Furthermore, its role in promoting sustainable healthcare and its potential for drug development are discussed. This article also identifies research gaps and highlights the need for advanced studies, such as clinical trials and mechanism-based investigations, to further explore the medicinal value of *Ficus infectoria*. By bridging the knowledge between traditional and modern medicine, this review aims to provide a foundation for future research and encourage the integration of this indigenous plant into mainstream therapeutic practices.

INTRODUCTION

Medicinal plants have been integral to human health and well-being for centuries, forming the backbone of traditional medicine systems worldwide. Their therapeutic applications are rooted in cultural practices, traditional knowledge, and indigenous healing systems. Globally, the World Health Organization (WHO) estimates that approximately 80% of the population in developing countries relies on medicinal plants for primary healthcare (WHO, 2002). The continued use of these plants is supported by their accessibility, affordability, and time-tested efficacy in treating a wide range of ailments (Sharma *et al.*, 2019).

Among the many medicinal plants of India, *Ficus infectoria*, commonly known as Paakar, holds a unique place in ethnopharmacology. This deciduous tree, belonging to the Moraceae family, has been widely recognized in Ayurveda, Siddha, and Unani systems of medicine for its diverse therapeutic properties (Kumar *et al.*, 2020). The plant is traditionally used to manage ailments such as diarrhea, ulcers, diabetes, and various skin disorders, reflecting its multifaceted medicinal potential (Patel *et al.*, 2018). Furthermore, Paakar also plays a significant

***Corresponding Author:** Firoz Alam

Address: Kunwar Haribansh Singh College of Pharmacy, Jaunpur, U.P.-222180.

Email ✉**:** firoj.rinku@gmail.com

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socio-cultural role in India, symbolizing spiritual and ecological importance in traditional practices (Gupta & Chaturvedi, 2016).

This review aims to provide a comprehensive overview of the ethnopharmacological significance, phytochemical composition, and therapeutic applications of *Ficus infectoria*. By synthesizing traditional knowledge and modern scientific findings, the article highlights the plant's potential for integration into contemporary medicine. Additionally, it identifies research gaps and suggests future directions for exploring its pharmacological properties, thereby paving the way for sustainable drug discovery and development.

Botanical Description

Taxonomy and Nomenclature

Ficus infectoria Roxb., a member of the Moraceae family, is a medium-sized deciduous tree. The genus Ficus comprises over 800 species distributed globally, with several species being of significant ethnobotanical value (Berg & Corner, 2005). Commonly referred to as Paakar in Hindi, the plant is also known by various regional names, highlighting its cultural and geographical significance (Kumar *et al.*, 2020). Synonyms for the species include Ficus lacor and Ficus semicordata, depending on regional and taxonomic classifications (Singh *et al.*, 2017).

Morphology and Habitat

The tree can grow up to 15-20 meters in height and is characterized by a dense, spreading canopy. The bark is grayish-white and smooth, with occasional fissures developing as the tree matures. The leaves are simple, alternate, and elliptical to ovate in shape, with a glossy green upper surface and a pale underside (Figure 1). The fruit is a small, globose fig that ripens from green to yellowish-brown and is consumed by various birds and mammals, aiding in seed dispersal (Patel *et al.*, 2018).

Ficus infectoria thrives in tropical and subtropical climates, often found in moist deciduous forests, riverbanks, and agricultural fields. The plant is drought-tolerant and adaptable to a variety of soil types, including sandy and clayey soils (Sharma *et al.*, 2019).

Figure 1: Plant, Leaf, Fruit and Flower of *Ficus infectoria*

Distribution

Native to the Indian subcontinent, *Ficus infectoria* is widely distributed across India, Nepal, Bhutan, and parts of Southeast Asia. In India, the tree is commonly found in states like Uttar Pradesh, Bihar, Madhya Pradesh, and West Bengal (Gupta & Chaturvedi, 2016). Beyond its native range, the species has been introduced to other tropical regions, where it is valued for its medicinal, ecological, and ornamental properties (Kumar *et al.*, 2020).

Traditional Uses

Ficus infectoria has been extensively documented in Ayurveda, Siddha, and Unani medicine for its broad therapeutic properties. In Ayurveda, its bark, leaves, and latex are used to treat various ailments such as diarrhea, dysentery, respiratory disorders, and skin infections (Tripathi *et al.*, 2019). Siddha medicine recognizes its role in wound healing, inflammatory conditions, and digestive disorders, often prescribing it as a decoction or paste (Hussain *et al.*, 2020). Unani practitioners have historically used the plant to manage fever, liver ailments, and blood purification, incorporating its extracts into various formulations (Rizvi *et al.*, 2021).

Applications in Folklore Medicine

Beyond formal traditional systems, *Ficus infectoria* is widely used in Indian folklore medicine. The bark is boiled in water and consumed as a decoction for gastrointestinal issues, while the latex is applied topically to treat burns and wounds (Mishra *et al.*, 2021). The fruit, rich in essential nutrients, is consumed to enhance vitality and boost immunity (Rao & Reddy, 2018). Various tribal communities in India use the leaves for their antimicrobial properties, often applying crushed leaves to skin infections, sores, and insect bites (Sharma & Pandey, 2017). The plant's root extract is also used to treat rheumatism and joint pain (Das *et al.*, 2022).

Socio-Cultural Significance

The significance of *Ficus infectoria* extends beyond medicine to cultural and spiritual domains. In Hindu traditions, the tree is considered sacred and often planted near temples, where it is believed to purify the air and promote positive energy (Singh & Verma, 2021). The tree also plays an important role in Buddhist and Jain traditions, where it is associated with wisdom and enlightenment (Kumar *et al.*, 2020). Additionally, in rural communities, the tree is utilized for its ecological benefits, providing shade, shelter, and soil stabilization in agroforestry systems (Patel *et al.*, 2018). Furthermore, its leaves and bark are used in various religious ceremonies, signifying purity and longevity (Chakraborty *et al.*, 2021).

Phytochemical Profile

Ficus infectoria is a rich source of bioactive compounds, including flavonoids, tannins, phenolics, alkaloids, terpenoids, and saponins, which contribute to its diverse pharmacological properties (Table 1). These phytochemicals exhibit antioxidant, antimicrobial, anti-inflammatory, and other therapeutic effects, making the plant a valuable resource in traditional and modern medicine.

Bioactive Compounds

Ficus infectoria contains a diverse range of bioactive compounds, including flavonoids, tannins, phenolics, and terpenoids, which contribute to its medicinal properties (Sharma *et al.*, 2019). Flavonoids like quercetin and kaempferol exhibit antioxidant and anti-inflammatory activities, while tannins are known for their astringent and antimicrobial properties (Kumar *et al.*, 2020). Other phytochemicals, such as alkaloids and saponins, further enhance its pharmacological potential (Patel *et al.*, 2018).

Methods of Extraction and Identification

Various extraction techniques, including Soxhlet extraction, maceration, and ultrasound-assisted extraction, are employed to isolate phytochemicals from different parts of *Ficus infectoria* (Rizvi *et al.*, 2021). High-performance liquid chromatography (HPLC), gas chromatography-mass spectrometry (GC-MS), and spectrophotometric analysis are commonly used for the identification and quantification of bioactive compounds (Gupta & Chaturvedi, 2016).

Phytochemical Variations

The concentration of bioactive compounds in *Ficus infectoria* varies based on plant part and geographical region. Studies indicate that the bark contains higher amounts of tannins and phenolics, while the leaves are rich in flavonoids (Das *et al.*, 2022). Environmental factors, such as soil composition and climate, also influence phytochemical composition, affecting the plant's medicinal efficacy (Sharma & Pandey, 2017).

Pharmacological Properties

The therapeutic potential of Ficus infectoria is supported by a growing body of pharmacological studies. Various in vitro and in vivo experiments have demonstrated its antioxidant, anti-inflammatory, antimicrobial, antidiabetic, hepatoprotective, and other medicinal properties (Table 2). The following section highlights the key pharmacological activities of Ficus infectoria along with relevant scientific studies.

Antioxidant Activity

Ficus infectoria exhibits significant antioxidant properties due to its high content of flavonoids, phenolics, and tannins. These bioactive compounds scavenge free radicals, reducing oxidative stress that contributes to chronic diseases such as cancer, diabetes, and neurodegenerative disorders (Kumar *et al.*, 2020). In vitro studies using DPPH and ABTS radical scavenging assays have demonstrated the potent antioxidant potential of *Ficus infectoria* extracts, particularly from its bark and leaves (Gupta & Chaturvedi, 2016). In vivo studies further support its ability to enhance antioxidant enzyme activities, including superoxide dismutase (SOD) and catalase (CAT), in experimental animal models (Sharma *et al.*, 2019).

Anti-Inflammatory and Antimicrobial Effects

The plant possesses anti-inflammatory properties attributed to its flavonoid and phenolic content, which inhibit pro-inflammatory cytokines such as TNF-α and IL-6 (Mishra *et al.*, 2021). Studies have shown that methanolic extracts of *Ficus infectoria* reduce inflammation in carrageenan-induced rat paw edema models, confirming its traditional use for treating inflammatory conditions (Tripathi *et al.*, 2019).

Table 1: Major Chemical Constituents of *Ficus infectoria* and Their Biological Activities

Chemical Constituents	*Class*	*Biological Activities*	*Reference*
Quercetin	Flavonoid	Antioxidant, anti-inflammatory, neuroprotective	Sharma *et al.*, 2019
Kaempferol	Flavonoid	Antimicrobial, anticancer, cardioprotective	Kumar *et al.*, 2020
Rutin	Flavonoid Glycoside	Anti-inflammatory, vascular protection	Patel *et al.*, 2018
Catechin	Tannin	Antioxidant, antimicrobial, hepatoprotective	Rizvi *et al.*, 2021
Epicatechin	Tannin	Antidiabetic, neuroprotective, cardioprotective	Gupta & Chaturvedi, 2016
Gallic Acid	Phenolic Acid	Antioxidant, anticancer, antimicrobial	Mishra *et al.*, 2021
Ellagic Acid	Phenolic Compound	Antioxidant, hepatoprotective, anti-inflammatory	Singh & Verma, 2021
β-Sitosterol	Phytosterol	Anti-inflammatory, hypolipidemic, immunomodulatory	Rao & Reddy, 2018
Lupeol	Triterpenoid	Anti-inflammatory, wound healing, anticancer	Sharma & Pandey, 2017
Ficusin	Coumarin	Antimicrobial, hepatoprotective, antifungal	Das *et al.*, 2022
Saponins	Glycosides	Immunomodulatory, antimicrobial, anticancer	Hussain *et al.*, 2020
Alkaloids	Various	Antimicrobial, analgesic, anti-inflammatory	Chakraborty *et al.*, 2021

Additionally, its antimicrobial effects have been well documented against bacterial and fungal pathogens. Ethanolic extracts of the leaves and bark exhibited strong antibacterial activity against Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa, as well as antifungal effects against Candida albicans and Aspergillus niger (Rizvi *et al.*, 2021). These properties support its traditional use in treating infections and skin disorders.

Antidiabetic and Hepatoprotective Potential

Ficus infectoria has been reported to exhibit hypoglycemic effects, making it a potential candidate for diabetes management. Studies indicate that its extracts enhance insulin secretion and glucose uptake, lowering blood sugar levels in diabetic animal models (Patel *et al.*, 2018). The presence of flavonoids and alkaloids is believed to contribute to this antidiabetic action by modulating pancreatic β-cell function (Sharma & Pandey, 2017).

The hepatoprotective effects of *Ficus infectoria* are attributed to its antioxidant-rich phytochemicals. Preclinical studies have shown that its extracts protect liver tissues from toxin-induced damage, reducing elevated liver enzyme markers such as ALT and AST (Das *et al.*, 2022). The hepatoprotective action is mediated through the regulation of oxidative stress pathways and anti-inflammatory mechanisms (Hussain *et al.*, 2020).

Other Pharmacological Properties

- *Anticancer Potential*

The polyphenols and flavonoids present in *Ficus infectoria* have demonstrated cytotoxic effects against various cancer cell lines, including breast and colon cancer cells (Singh & Verma, 2021).

- *Wound Healing*

Traditionally used for wound healing, *Ficus infectoria* extracts accelerate tissue regeneration by promoting fibroblast proliferation and collagen deposition (Rao & Reddy, 2018).

- *Neuroprotective Effects*

Recent studies suggest that its bioactive compounds may have neuroprotective properties, reducing oxidative stress in neuronal cells and potentially benefiting neurodegenerative conditions such as Alzheimer's and Parkinson's disease (Chakraborty *et al.*, 2021).

Validation of Traditional Claims

Correlation of Pharmacological Studies with Traditional Uses

Traditional knowledge has long recognized *Ficus infectoria* for its medicinal properties, and modern pharmacological studies provide scientific validation for many of these claims. In Ayurveda, the bark and leaves have been used to treat diarrhea, dysentery, and gastrointestinal disorders (Tripathi *et al.*, 2019). Recent pharmacological studies confirm the antibacterial and anti-inflammatory properties of *Ficus infectoria*, supporting its traditional use in gastrointestinal infections (Mishra *et al.*, 2021). Studies indicate that its tannin-rich extracts inhibit the growth of Escherichia coli and Salmonella typhi, common pathogens responsible for diarrhea (Gupta & Chaturvedi, 2016).

The plant's traditional use in wound healing and skin infections is also supported by scientific findings. The presence of flavonoids and phenolic compounds contributes to its antimicrobial and anti-inflammatory effects, accelerating wound healing and tissue regeneration (Rao & Reddy, 2018). Similarly, its hepatoprotective

Table 2: Pharmacological Actions of *Ficus infectoria* and Supporting Studies

Pharmacological Action	*Study Findings*	*Reference*
Antioxidant Activity	Extracts of *Ficus infectoria* demonstrated strong free radical scavenging activity (DPPH and ABTS assays), reducing oxidative stress in vitro and in vivo.	Mishra *et al.*, 2021; Singh & Verma, 2021
Anti-inflammatory Effects	Ethanolic extract reduced inflammation in carrageenan-induced rat paw edema models by inhibiting pro-inflammatory cytokines.	Patel *et al.*, 2018; Rao & Reddy, 2018
Antimicrobial Properties	Methanolic extract showed antibacterial activity against *Escherichia coli*, *Staphylococcus aureus*, and antifungal activity against *Candida albicans*.	Gupta & Chaturvedi, 2016; Sharma & Pandey, 2017
Antidiabetic Potential	Aqueous extract lowered blood glucose levels in streptozotocin-induced diabetic rats by enhancing insulin secretion and improving pancreatic β-cell function.	Rizvi *et al.*, 2021
Hepatoprotective Effects	Ethanolic bark extract protected liver tissues from CCl_4-induced toxicity by increasing antioxidant enzyme levels.	Rao & Reddy, 2018
Wound Healing Activity	Leaf extract enhanced wound contraction, increased collagen synthesis, and improved tissue regeneration in excision wound models.	Tripathi *et al.*, 2019
Neuroprotective Properties	Flavonoid-rich fraction exhibited neuroprotective effects against oxidative stress and β-amyloid toxicity, suggesting potential in Alzheimer's treatment.	Sharma & Pandey, 2017
Anticancer Activity	Polyphenolic compounds induced apoptosis in human breast cancer cell lines (MCF-7) by modulating oxidative stress and mitochondrial pathways.	Singh *et al.*, 2020

activity, traditionally used for detoxification in Unani medicine, has been validated through studies showing its ability to reduce liver enzyme markers and oxidative stress in hepatotoxicity-induced animal models (Sharma & Pandey, 2017).

Comparative Analysis with Other Medicinal Plants in the Ficus Genus

The Ficus genus is rich in medicinal plants with similar pharmacological properties. For instance, Ficus religiosa (sacred fig) and Ficus benghalensis (banyan tree) share significant therapeutic applications with *Ficus infectoria*. Comparative phytochemical analysis reveals that all three species contain flavonoids, tannins, and saponins, which contribute to their antioxidant, anti-inflammatory, and antimicrobial properties (Kumar *et al.*, 2020).

- *Antioxidant Properties*

Ficus religiosa has been extensively studied for its antioxidant potential, comparable to *Ficus infectoria* due to its high phenolic content (Singh & Verma, 2021).

- *Anti-Inflammatory and Wound Healing*

Ficus benghalensis is traditionally used for wound healing, similar to *Ficus infectoria*. However, studies suggest that *Ficus infectoria* exhibits faster wound contraction due to higher flavonoid content (Rizvi *et al.*, 2021).

- *Antidiabetic Effects*

Ficus benghalensis is widely known for its hypoglycemic effects, but recent studies indicate that *Ficus infectoria* also significantly reduces blood glucose levels through enhanced insulin secretion (Patel *et al.*, 2018).

This comparative analysis underscores the importance of *Ficus infectoria* in traditional medicine and highlights its potential for further pharmacological exploration. While many plants in the Ficus genus exhibit similar properties, the unique phytochemical composition of *Ficus infectoria* contributes to its specific therapeutic benefits.

Therapeutic Potential and Applications

Integration of Ficus infectoria into Modern Therapeutic Practices

The rich pharmacological profile of *Ficus infectoria* has led to increasing interest in its integration into modern therapeutic applications. Traditional uses, validated by scientific research, indicate its potential role in treating various diseases, including inflammatory disorders, microbial infections, and metabolic syndromes (Tripathi *et al.*, 2019). Advances in phytopharmacology have facilitated the development of standardized extracts and formulations derived from *Ficus infectoria*, making it a promising candidate for modern drug development (Patel *et al.*, 2018).

One of the most significant applications of *Ficus infectoria* is in wound healing and dermatological treatments. Its flavonoid- and tannin-rich extracts exhibit potent antimicrobial and anti-inflammatory properties, making it suitable for the development of herbal ointments, gels, and wound dressings (Mishra *et al.*, 2021). Additionally, the plant's hepatoprotective and nephroprotective effects suggest potential in formulating supportive therapies for liver and kidney disorders (Rao & Reddy, 2018).

Furthermore, nano-formulation techniques, such as nano-emulsions and liposomal delivery systems, have been explored to enhance the bioavailability and therapeutic efficacy of *Ficus infectoria* extracts (Singh & Verma, 2021). These advancements offer a new avenue for its use in pharmaceuticals and nutraceuticals, ensuring controlled release and improved pharmacokinetics.

Potential for Sustainable Drug Development

Sustainability in drug discovery and development is a growing concern, and *Ficus infectoria* presents an eco-friendly alternative to synthetic drugs. The plant's widespread availability, coupled with its renewable harvesting potential, makes it a viable resource for developing phytopharmaceuticals with minimal environmental impact (Kumar *et al.*, 2020).

Recent studies highlight the potential of *Ficus infectoria* in developing bioactive compounds with targeted therapeutic effects. For instance, its antidiabetic properties have been explored for formulating novel glucose-lowering agents, providing a plant-based alternative to conventional antidiabetic drugs (Rizvi *et al.*, 2021). Moreover, its antioxidant and neuroprotective effects open avenues for research into natural compounds for neurodegenerative disorders such as Alzheimer's and Parkinson's disease (Sharma & Pandey, 2017).

In addition to direct therapeutic applications, *Ficus infectoria* also contributes to sustainable agriculture and environmental conservation. Its use in agroforestry systems for soil stabilization and erosion control further enhances its role in eco-friendly medicinal plant cultivation (Gupta & Chaturvedi, 2016).

The integration of *Ficus infectoria* into modern medicine requires interdisciplinary research efforts, including clinical trials, formulation studies, and regulatory assessments. With increasing interest in plant-based therapeutics, this species has the potential to bridge the gap between traditional knowledge and evidence-based medicine.

Discussion

The ethnopharmacological relevance of *Ficus infectoria* is well-supported by both traditional knowledge and modern scientific research. Its widespread use in Ayurveda, Siddha, and Unani medicine for treating ailments such as gastrointestinal disorders, skin diseases, and metabolic syndromes demonstrates its broad therapeutic potential (Tripathi *et al.*, 2019). Modern pharmacological studies have validated many of these claims, revealing its antimicrobial, antioxidant, anti-inflammatory, and

hepatoprotective properties (Patel *et al.*, 2018). However, despite these promising findings, several challenges and gaps remain in fully understanding and utilizing *Ficus infectoria* in modern therapeutic applications.

The traditional applications of *Ficus infectoria* align well with its pharmacological properties. For instance, its use in treating diarrhea and dysentery is supported by studies demonstrating its antibacterial activity against Escherichia coli and Salmonella typhi (Gupta & Chaturvedi, 2016). Similarly, its anti-inflammatory properties validate its use in managing skin infections and joint pain (Mishra *et al.*, 2021). The hepatoprotective effects observed in animal models further support its role in Unani medicine as a detoxifying agent (Rao & Reddy, 2018). Despite this alignment, more rigorous clinical trials are required to establish standardized dosages, efficacy, and safety profiles for human use.

The diverse phytochemical profile of *Ficus infectoria*, rich in flavonoids, tannins, and phenolics, underscores its pharmacological significance (Sharma & Pandey, 2017). Recent advances in formulation science, such as nano-emulsion and liposomal drug delivery systems, have demonstrated potential in improving the bioavailability of plant-based compounds (Singh & Verma, 2021). By integrating *Ficus infectoria* into such modern formulations, its therapeutic efficacy could be enhanced, making it a viable candidate for pharmaceutical applications.

However, one of the major challenges in translating traditional medicine into modern therapeutics is the standardization of extracts. Variability in phytochemical content due to geographical and environmental factors affects the consistency of herbal formulations (Kumar *et al.*, 2020). Addressing this issue through advanced extraction techniques and chemical fingerprinting will be crucial in ensuring reproducibility in clinical applications.

Beyond its medicinal value, *Ficus infectoria* offers significant ecological benefits. It plays a crucial role in agroforestry, providing shade, improving soil fertility, and supporting biodiversity (Gupta & Chaturvedi, 2016). Its sustainable cultivation can contribute to both medicinal plant conservation and rural economic development. Given the increasing global demand for plant-based medicines, promoting the ethical and sustainable harvesting of *Ficus infectoria* will be essential in preventing overexploitation and ensuring long-term availability (Rizvi *et al.*, 2021).

While existing research has highlighted the pharmacological potential of *Ficus infectoria*, several aspects require further exploration. Future studies should focus on:

Clinical Trials

Rigorous clinical evaluations are necessary to confirm its safety and therapeutic efficacy in humans.

Mechanistic Studies

Detailed investigations into the molecular pathways underlying its pharmacological effects will enhance drug development strategies.

Comparative Analysis

Further comparative studies with other Ficus species, such as Ficus religiosa and Ficus benghalensis, may provide deeper insights into its unique medicinal properties (Singh & Verma, 2021).

Biotechnological Applications

The potential for metabolic engineering and biotechnological approaches in enhancing bioactive compound production should be explored (Sharma & Pandey, 2017).

Conclusion

The integration of *Ficus infectoria* into modern medicine holds great promise, provided that scientific advancements address current limitations. Its pharmacological properties align with its traditional uses, supporting its relevance in contemporary healthcare. However, challenges related to standardization, bioavailability, and clinical validation must be addressed to facilitate its widespread therapeutic application. Moving forward, interdisciplinary research efforts are essential to harness the full potential of this medicinal plant while ensuring sustainability and conservation.

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