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Review on Jal Pippali (Phyla Nodiflora)

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Abstract: ***Phyla nodiflora (Jal Pippali), a perennial herb belonging to the Verbenaceae family, is a vital but underexplored medicinal plant in Ayurvedic and traditional medicine systems. Found in moist and tropical regions, it has extensive therapeutic applications. Jal Pippali is recognized in ancient texts such as Nighantus and demonstrates various bioactivities, including antihypertensive, antidiabetic, antioxidant, anti - inflammatory, and antimicrobial effects. Chemical analysis reveals a wealth of bioactive compounds like flavonoids, phenols, and alkaloids, contributing to its pharmacological potential. Noteworthy activities include lowering blood pressure, improving glucose tolerance, regenerating pancreatic islets, and promoting kidney health. Additionally, it exhibits potent antioxidant effects, mitigates inflammatory responses, and provides antimicrobial action against various pathogens. Traditional applications range from treating respiratory infections, gastrointestinal disorders, and skin ailments to wound healing and fever reduction. Despite its broad spectrum of uses, clinical validation and exploration of modern pharmacological applications remain limited. Jal Pippali's robust medicinal properties and adaptability to diverse environments make it a promising candidate for further research and therapeutic development. Its integration into contemporary medicine could unlock new avenues for treating complex diseases.***

Keywords: *Jal pippali, Bukan booti,* Phyla nodiflora, Traditional medicine

1. Introduction

Jala Pippali, scientifically identified as *Phyla nodiflora L. Greene* (syn. *Lyppa nodiflora*), belongs to the Verbenaceae family and is commonly found growing in wetlands, riverbanks, and along the edges of lakes and freshwater bodies across India. This plant has been documented in various Ayurvedic texts, particularly in the *Nighantus*, ancient lexicons detailing the medicinal properties of plants, where it is recognized for its therapeutic value. However, references in the core classical Ayurvedic texts, such as the *Brihatrayee*, are limited. This review aims to explore the references to *Jala Pippali* in Ayurvedic literature, emphasizing its therapeutic potential.

2. Material and Method

A comprehensive review of the literary and therapeutic uses of *Jala pippali* was conducted through classical texts such as the Charaka Samhita, Sushruta Samhita, Ashtanga Sangraha, Ashtanga Hridaya, and various Nighantus including Raja Nighantu, Dhanvantari Nighantu, and Bhaishajya Ratnavali. Additionally, articles published on Indian medicinal plants and relevant literature were also examined to understand the plant's medicinal properties and applications.

Description: Jal Pippali (Phyla nodiflora)
Phyla nodiflora, commonly known as Jal Pippali, frog fruit, or Turkey tangle, is a perennial, creeping much branched herb belonging to the Verbenaceae family found throughout the India. It thrives in moist environments and is found in tropical and subtropical regions. It can be found up to 900 meters across India, generally in moist areas near water supplies, canal borders, and irrigation channel bunds.

Classification (Bentham and Hooker System)
Kingdom: Plantae– Plants
Division: Tracheophyta
Class: Magnoliopsida– Dicotyledons
Order: Lamiales
Family: Verbenaceae (Verbena family)
Genus: Phyla Lour.
Species: Phyla nodiflora (L.) Greene

Classical Names
Ayurvedic: Jalapippali, Shaaradi, Shakulaadani, Jalakarnaa
Unani: Bukkun or Bukkum/ BukanBooti
Siddha: Paduthalai

Vernacular Names [1]
Sanskrit: *Jalapippali, Toyavallari, Sharadi, Matyagandha*
Hindi*: Bakkan, Bhuiokra, Jalpipali, Panisigaa*
Kannada: *Nela - hippali*
Gujarati: *Ratavilo, Ratolia, Ratveliyo*
Malayalam: *Katu - tippali, Nirtippali, Podutalai (Siddha)*
Bengali: *Bakkan, Bhuiokra*
Marati: *Ratoliya, jalapippali*
Punjabi: *Bhuiokra, Mokna, Bukan*
English: Purple lippia, frog fruit
Telugu: *Bokkena*
Tamil: *Potuttali*

Macroscopic Characteristics [2]
- **Root**: Fibrous, branched, brown, 2 to 10 cm long, with a diameter of 1.0 to 1.5 mm. Nodal roots are smaller, 0.5 to 1.0 cm long and unbranched.
- **Stem**: Branched, sub - quadrangular, 1 to 2 mm in diameter, rooting at nodes. Covered with appressed, two - armed white hairs under 10x magnification. Brownish - green with internode lengths ranging from 5.0 to 9.0 cm.
- **Leaf**: Opposite, sub - sessile, 1.5 to 3.7 cm long and 1 to 2 cm wide, spathulate, cuneate at the base. The upper part is sharply serrate, covered with minute, two - armed white hairs on both sides.

- **Flower**: Sessile, densely packed in long, pedunculate axillary spikes, 1.0 to 2.0 cm long and 0.4 to 0.5 cm wide when mature. Peduncles range from 2.5 to 7.5 cm long. Bracts are 2.5 mm long, broadly elliptic or obovate, mucronate, and glabrous. The calyx is 2.0 mm long, bilobed, mitre - shaped, and pubescent underneath. The corolla is 2.5 to 3.0 mm long, white or light pink, bilipped, with the upper lip erect and bifid, and the lower lip 3 - lobed. Stamens are didynamous, with 2 - celled anthers that dehisce longitudinally. The ovary is superior, bicarpellary, with solitary ovules in each cell. The style is short, and the stigma is oblique, subcapitate.
- **Fruit**: Small, 1.5 to 2.0 mm long, globose to oblong, splitting into two 1 - seeded planoconvex pyrenes. Seeds are exalbuminous and about 1 mm in size.

Appearance: This plant has prostrate stems that can root at nodes, forming dense mats. Its leaves are small, opposite, and oblong with serrated edges.

Habitat: It grows well in wet places such as the edges of ponds, streams, and moist grasslands.

Chemical Constituents

Phyla nodiflora contains diverse bioactive compounds, including flavonoids, triterpenoids, phenols, steroids, and alkaloids, contributing to its medicinal properties. Its leaves are rich in flavonoids like nodifloretin, β - sitosterol glycoside, and stigmasterol glycoside, along with sugars such as lactose, maltose, glucose, fructose, and xylose. Secondary metabolites such as alkaloids, terpenes, tannins, saponins, and phytosterols are responsible for its antioxidant, anti - inflammatory, antimicrobial, and antiviral effects.

The plant's extractive values vary by solvent, with water extract showing the highest value (13.6%), followed by methanol (8.6%), ethanol (4.17%), chloroform (2.63%), and petroleum ether (1.76%). Each solvent extracts distinct constituents, such as terpenes and alkaloids from petroleum ether, tannins and alkaloids from methanol, and phytosterols and diterpenes from ethanol. GC - MS analysis of methanolic extracts has identified major constituents, including acids, phytol, stigmasterol, nodifloretin, batatifolin, and flavonoids like luteolin derivatives and 5 - hydroxy - 3', 4', 7 - trimethoxyflavone. These compounds underline its significant pharmacological potential, particularly in antioxidant and antimicrobial applications.

Figure 1: Phyla nordiflora

Figure 2: Phyla nordiflora

Traditional and Folklore Medicinal Uses of Phyla nodiflora

Phyla nodiflora, locally known as *Jala Pippali* or *Bukkanbooti*, is a medicinal plant with diverse therapeutic properties. It has been traditionally used in various cultures for treating a wide range of health conditions. Below are some of the key medicinal uses:

- **Anti - inflammatory**: Extracts from the plant are used to reduce inflammation, particularly in conditions such as arthritis, rheumatic pain, and swelling. Its anti - inflammatory properties are also beneficial in managing conditions like joint pain and muscle strains.
- **Antimicrobial**: Phyla nodiflora exhibits significant antibacterial and antifungal properties, making it useful

in the treatment of infections. It is traditionally used for treating skin infections, boils, and ulcers. The plant is also effective against oral thrush, fungal skin conditions, and other microbial infections due to its broad - spectrum antimicrobial activity. Its leaves and decoctions are used in folk medicine to treat respiratory infections such as bronchitis and colds.

- **Diuretic and Fever Reduction**: In the Himalayan region and Nepal, Phyla nodiflora is called "*Bukkanbooti*" and is used in the form of root and whole plant powder or decoction for its diuretic properties. It promotes the excretion of urine and helps in managing kidney - related disorders and urinary tract infections. Additionally, it is used to reduce fever, especially in conditions like malaria and other febrile illnesses, helping to lower body temperature and reduce discomfort.
- **Digestive Aid**: The infusion of leaves and tender stalks is used in traditional medicine to aid digestion. It is commonly given to children suffering from indigestion and also to women post - delivery to aid in digestion and recovery. The plant is believed to help treat gastrointestinal issues such as constipation, diarrhoea, and dysentery. In addition, it has been used in treating gonorrhoea and infertility in the folk medicine practices of the Himalayan region and Nepal.
- **Respiratory Health**: Traditional remedies employ Phyla nodiflora for treating coughs, colds, and other respiratory issues. The dried leaves are often infused and consumed to soothe bronchial coughs, chronic coughs, and respiratory infections. The plant's antimicrobial and anti - inflammatory properties help reduce symptoms of respiratory conditions and promote easier breathing.
- **Wound Healing**: The leaves of Phyla nodiflora are applied topically to promote the healing of cuts, wounds, and ulcers. Its antimicrobial and anti - inflammatory properties help prevent infection and accelerate the healing process. The plant is also used in treating boils and swollen glands, further demonstrating its broad - spectrum healing abilities.

Additional Uses:

- **Postpartum Care**: In some cultures, an infusion of Phyla nodiflora is given to women after delivery to aid in recovery. The plant helps in reducing postpartum pain and supporting the mother's overall recovery by promoting uterine health and strengthening the body.
- **Pain and Inflammation Relief**: The whole plant is used to relieve pain from various sources, including rheumatic pain, back pain, and muscle soreness. Its anti - inflammatory effects make it an effective remedy for conditions involving chronic pain and inflammation.
- **Skin Disorders**: Phyla nodiflora is also beneficial for treating skin conditions such as eczema, acne, and psoriasis. Its paste or juice is applied to the skin to treat rashes, boils, and chronic skin ulcers. The plant's antimicrobial properties make it useful in managing infections like fungal rashes or wounds that are slow to heal.
- **Gastrointestinal Health**: The plant is utilized in the treatment of jaundice, dysuria (painful urination), and other liver - related conditions. It supports liver function, promotes detoxification, and helps in regulating urinary function, further emphasizing its role in maintaining digestive and urinary health.

Table 1: Ethno botanical uses: Here's the information in a table format for clarity:

System	Uses [3]
Central Nervous System	Antipyretic (fever - reducing), Paralysis treatment
Gastrointestinal	Antidiarrhoeal, Antiflatulence, Antispasmodic, Antiulcer, Bowel disorders, Digestive aid, Dyspepsia (indigestion), Fistula, Haemorrhoids/Piles, Hyperacidity, Inflammatory bowel disease, Liver tonic
Integumentary System	Boils, Burns, Cooling agent, Dermatological ailments, Erysipelas, Wound healing, Antidandruff, Hair tonic and treatment
Musculoskeletal	Bone fractures
Reproductive	Aphrodisiac, Sperm deficiency, Gynaecological disorders, Menorrhagia (heavy menstrual bleeding), Orchitis (inflammation of testes), Postpartum health support
Respiratory	Antiasthmatic, Cold relief, Antitussive (cough relief), Pneumonia
Urinary	Diuretic, Ischuria (retention of urine), Renal diseases, Urinary disorders, Urinary tract infection, Ureteral stones, Urinary blocks, Resume urination
ENT (Ear, Nose, Throat)	Nasal congestion
Haematological	Blood purifier, Haemostatic (stopping bleeding)
Infectious	Antibacterial, Gonorrhoea
Inflammation and Pain	Analgesic (pain relief), Anti - inflammatory, Knee joint pain, Rheumatism, Swollen glands
Other Uses	Rejuvenator, Tonic

3. Discussion

Vedas: There are no references to the drug *Jalapippali* in the Vedas.

Charaka Samhita: In the 27th chapter of the *Sutrasthana*, *Annapanavidhi Adyaya*, which discusses the categorization and regimen of food and drink, *Jalapippali* is mentioned by *Harita Varga*. *Jalapippali* possesses qualities such as *Teeksna*, *Ushna*, *Rukshya*, and *Laghu*. Furthermore, it is described as *Kapha - vatahara*. In his commentary on *Jalapippali*, *Chakrapani* stated that the plant, which bears fruits resembling *pippali*, is primarily found in close proximity to water sources. *Dhanwantari Nighantu* explains it as *Krimigna*. It is *Tikta* and *Kashaya* in *Rasa* and is considered to be *Kaphapitta - nashaka*. It is indicated for conditions such as *Swasa*, *Raktadosha*, *Vran*, *Visha*, *Brama*, *Hridroga*, and *Krimi*.

Sushruta Samhita: According to *Dalhana*, a commentator of the *Sushruta Samhita*, *Prachibala* is associated with the synonyms *Matyakshi*, *Kakajangha*, and *Nadipippali* in his *Nibhanda Vyakya* commentary on *Surasadigana* medicines. *Prachibala* is referred to as *Jalapippali*, *Gandadurva*, or

Kakajangha. Ayurvedic texts such as the *Nighantus* explain *Jalapippali*. While the primary texts of Ayurveda (*Brihatrayee*) contain either very few or no references, the majority of the *Nighantus* emphasize its therapeutic value. Even the oldest *Nighantu*, *Dhanwantari Nighantu*, alludes to it. In the fourth chapter of *Chikistastana*, *Vatavyadhi Chikistadyaya*, one of its ingredients in the *Kalyanaka* contest is *Gandira Lavana*, which is recommended for *Vatavyadi*, *Gulma*, *Krimi*, and so on. *Dalhana* remarked that there are two kinds of *Gandira* in this context: *Jalaja* and *Stalaja*. One *Jalaja Gandira* is *Jalapippali*, and the other *Sthalaja Gandira* is described in the *Shakavarga* (vegetables group).

Astanga Sangraha: There is a mention of the plant *Sharadhi* in the *Varti* preparation contest for *Apasmara Chikista* in the *Uttaratantra Adyhaya - Apasmara Chikistadyaya*. In this context, *Sharadi* is named as *Jalapippali* in *Indukara's* commentary *Shashilekha Vyakya* on *Astanga Sangraha*. *Jalapippali* is not mentioned in the *Astanga Hridaya*, *Madava Nidhana*, or *Sharangadhara Samhita*.

Nighantus: The plant *Jalapippali* is referenced in almost all of the *Nighantus*. In fact, the oldest *Nighantu*, *Dhanwantari Nighantu*, discusses the plant in its *Dravyavali* chapter, which is the oldest section of the *Nighantu*. Most traditional medical systems use *Nighantus*, which have been shown to have therapeutic benefits in treating blood disorders, wounds, burning sensations, diarrhea, indigestion, asthma, bronchitis, and other conditions. The *Dhanwantari Nighantu* explains it as *Krimigna*. It is *Kaphapitta - nashaka* because of its *Tikta* and *Kashaya Rasa*. It is indicated for *Swasa*, *Raktadosha*, *Vrun*, *Visha*, *Brama*, *Hridroga*, and *Krimi*.

In ***Bhaishajya Ratnavali*** [4] the formulations of *Jala - pippali* are detailed. Two such preparations are mentioned:

- **Kanchatadi Kwath**: Beneficial in the treatment of *Atisar* (diarrhea).
- **Kanchatadi Avaleha**: Useful in managing *Ghrani Roga* (digestive disorders).

Phyla nodiflora's Adaptability: *Phyla nodiflora*'s adaptability to different environmental conditions and its low maintenance requirements make it an attractive plant for both medicinal and ornamental purposes. It is often grown as a ground cover and is used to support pollinators in gardens. Its versatility and ease of cultivation add to its value in both medicinal applications and aesthetic gardening.

Table 2: Reference of Jalapippali in *Brihattrayee*

S. No.	Samhita	Reference	Context	Commentary
1	*Charaka Samhita* [5]	C. S. Su.27/171	*Annapana Vidhi Adyaya*, Haritavarga	Chakrapanidatta, *Ayurveda Deepika*
2	*Sushruta Samhita* [6]	S. S. Su.38/18	*Dravya Sangrahaneeya Adyaya*, Surasadigana	Nibhanda Vyakya by Dalhana
3	*Astanga Sangraha* [7]	A. S. Ut.10/22	*Apasmara Pratisheda Adyaya*, Vrischikali Varti	Shashilekha Vyakya by Indukara

Table 3: Classification of Jalapippali and its pharmacological actions in Nighantus

S. No.	Nighantu	Varga	Pharmacological Action
1	Dhanwantari Nighantu [8, 9]	Karaveeradi Varga	*Swasa, Rakta - vikar, Visa, Daha, Bhram, Murcha, Trishna nashaka, Kriminashaka*
2	Shodal Nighantu [10]	Karaveeradi Varga	*Hridya, Rochana, Deepana, Grahi (baddavit), Hikka, Kasa, Visha, Swasa, Parshwa ruk, Kriminashana*
3	Madhava Dravyaguna [11]	Vividhoushadi Varga	*Kaphavatahara*
4	Siddamantra Nighantu [12]	Tridoshagna Varga	*Hridya, Chaksushya, Sukra - janak, Daha, Rakta - vikar nashaka*
5	Madanapal Nighantu [13]	Abhayadi Varga	*Hridya, Chaksushya, Sukral, Sangrahi, Daha, Vrana nashaka*
6	Raj Nighantu [14]	Shatahwadi Varga	*Mukha sodhaka, Vrana, Vish hara*
7	Kaiyadeva Nighantu [15]	Aushadhi Varga	*Hridya, Chaksushya, Vatavardhak, Ruchikar, Agnivardhak, Daha, Vrana, Rakta - vikarnashaka*
8	Bhava Prakasha Nighantu [16]	Guduchyadi Varga	*Hridya, Chaksushya, Malasangrahi, Ruchikar, Agnivardhak, Daha, Vrana nashaka*
9	Shaliigram Nighantu [17]	Guduchyadi Varga	*Hridya, Chaksushya, Malarodhak, Ruchikar, Agnivardhak, Sukra janak, Daha, Vrana nashaka*
10	Adarsha Nighantu [18]	Nirgundyadi Varga	*Premeha nashaka, Mutra - vikar nahaka*

Pharmacological and biological studies

Antihypertensive

Methanolic (Gadhvi et al., 2012, 2015), chloroform, ethyl acetate, and aqueous extracts of the plant were tested at 500 mg/kg orally for 14 days in uninephrectomized DOCA - salt - induced hypertensive Wistar rats. The methanolic extract significantly lowered blood pressure compared to the other extracts. However, none of the treatments showed significant changes in biochemical markers like serum urea, triglycerides, cholesterol, glucose, or protein. The methanolic extract also protected the kidneys by reducing high serum creatinine levels. Kidney tissue examination showed fewer inflammatory cells and normal structure. Ramipril was used as a standard drug (Gadhvi et al., 2012, 2015). [19, 20]

Antidiabetic

The plant's extracts have demonstrated significant antidiabetic potential through improvements in glucose tolerance, reductions in blood glucose, and increased insulin levels in both normal and diabetic models. Methanolic extract showed dose- dependent effects in STZ - induced diabetic rats, lowering plasma glucose, glycosylated hemoglobin, and lipid profile markers while enhancing liver and muscle glycogen levels and HDL. It also promoted pancreatic islet regeneration, with prominent effects at higher doses, comparable to the standard drug glibenclamide (Balamurugan and Ignacimuthu, 2011). [21]

Similarly, the 95% ethanolic leaf extract provided protective effects in alloxan - induced diabetic rats over 30 days,

improving antioxidant defense by reducing oxidative stress markers (TBARS) and increasing levels of vitamin C, vitamin E, GSH, SOD, CAT, and GPx in the pancreas. It also enhanced lipid profiles by reducing cholesterol, triglycerides, and LDL while increasing HDL levels, showing efficacy comparable to gliclazide (Subramanian et al., 2011). [22] These findings highlight the plant's potential as an effective natural therapeutic agent for diabetes management through its antidiabetic and antioxidant properties.

Antioxidant

The plant's extracts demonstrated significant antioxidant potential across various assays, indicating strong free radical scavenging and lipid peroxidation inhibition capabilities. The methanolic extract exhibited dose - dependent antioxidant activity, effectively inhibiting peroxidation and scavenging DPPH, superoxide anion, nitric oxide, hydroxyl radicals, and hydrogen peroxide. It also showed notable reducing power, comparable to standards like BHT, vitamin C, and α - tocopherol (Ashokkumar et al., 2008). [23]

Similarly, methanolic extract fractions and isolated compounds displayed concentration - dependent antioxidant effects, with IC50 values showcasing their efficacy against superoxide, hydroxyl, and nitric oxide radicals. These treatments also exhibited strong FRAP values and inhibited lipid peroxidation effectively (Sudha and Srinivasan, 2014). [24]

In addition, the aqueous, ethanol, and petroleum ether extracts of the leaves demonstrated antioxidant activity, with the aqueous extract showing the highest DPPH inhibition (Narayanaswamy et al., 2011). [25] Collectively, these findings confirm the plant's robust antioxidant properties, validating its potential for therapeutic applications.

Anticancer/Antiproliferative

The methanolic leaf extract showed strong antiproliferative effects against human lung cancer cells (NCI - H460) in a dose - dependent manner, with an IC50 value of 10 µg/ml in the MTT assay. It induced apoptosis by increasing mitochondrial membrane depolarization, raising intracellular reactive oxygen species, and causing noticeable cell changes, such as irregular shapes, atrophy, and cell suspension. Its effects were comparable to the standard drug paclitaxel (Vanajothi et al., 2012). [26]

Anti - inflammatory

The methanolic extract of the plant and the isolated compound cyclo - pentano phenanthrenol (CPP) exhibited significant anti - inflammatory activity through multiple mechanisms in various in vitro models. Both treatments effectively inhibited mitogen - stimulated lymphocyte proliferation, with IC50 values of 10 µg/ml and 20 µg/ml, respectively. They suppressed the expression of key inflammatory cytokines, including TNF - α, IL - 18, and IL - 6, as well as inhibited the activation of MAPK and NF - κB pathways at different time points (6, 12, and 24 hours) in peripheral blood mononuclear cells (PBMCs).

Additionally, the extract and CPP reduced nitric oxide production in LPS - stimulated RAW 264.7 cells and inhibited PLA2 (phospholipase A2) activity in calcium ionophore - stimulated RBL - 2H3 cells. They also demonstrated inhibitory effects on COX - 2, MMP - 2, and MMP - 9 expression, as well as ERK and JNK phosphorylation, further supporting their anti - inflammatory action. These results suggest that both the methanolic extract and CPP have the potential to be developed as effective therapeutic agents for managing inflammatory conditions (Balakrishnan et al., 2010). [27]

Effect on Renal System

Antiurolithiatic

The ethanolic extract of the plant showed strong antiurolithiatic and antioxidant properties in male Wistar albino rats with urolithiasis. When administered at doses of 0.5 and 1 g/kg for 15 days, the extract reduced calcium and oxalate deposition in the kidneys and lowered the urinary excretion of these ions, both in preventive and curative treatments. It also increased urinary pH and reduced kidney weight. Histological studies showed that the extract protected kidney tissue by preventing damage, hemorrhages, and atrophy. Additionally, it decreased malondialdehyde levels and increased the activity of antioxidant enzymes like GSH and catalase in the kidney.

The extract also exhibited antioxidant activity in vitro, with significant radical scavenging effects against nitric oxide and DPPH, indicating its potential for reducing oxidative stress. These results suggest that the plant extract could be an effective natural remedy for both preventing and treating kidney stones, while also offering antioxidant protection to the kidneys (Dodoala et al., 2010). [28]

Diuretic

Both the methanol and aqueous extracts of the plant's aerial parts, when administered at doses of 250 and 500 mg/kg intraperitoneally (i. p.), showed significant diuretic effects in rats. At the 500 mg/kg dose, both extracts increased urine volume significantly. Additionally, the excretion of sodium and potassium ions also rose in a dose - dependent manner, indicating the potential of these extracts to enhance kidney function and fluid balance (Shukla et al., 2009). [29]

ACE Inhibition

The aqueous, ethanol, and acetone extracts of the plant demonstrated inhibitory effects on angiotensin - converting enzyme (ACE), which plays a key role in regulating blood pressure. Specifically, the aqueous extract showed 21% ACE inhibition, the ethanol extract showed 24% inhibition, and the acetone extract showed 22% inhibition. These findings suggest that the plant extracts possess the potential to influence blood pressure regulation, as ACE inhibitors are commonly used to treat conditions like hypertension. The variation in inhibition levels across different extracts indicates that the chemical composition of the extracts, depending on the solvent used, may contribute to their overall effectiveness in ACE inhibition (Nyman et al., 1998). [30]

Antiplasmodial

he ethanolic extract of the plant demonstrated promising in vitro antiplasmodial activity against the chloroquine -

susceptible strain of *Plasmodium falciparum*, the parasite responsible for malaria. When tested at concentrations ranging from 12.5 to 100 µg/ml, the extract showed significant inhibition of the parasite's growth, with an IC50 value of 35 µg/ml. The IC50 value represents the concentration required to inhibit 50% of the parasite's activity, indicating that the extract has moderate potency in preventing *Plasmodium falciparum* replication. This finding suggests that the plant's ethanolic extract contains bioactive compounds that could potentially be developed into a natural treatment option for malaria, especially in cases where the parasite is susceptible to chloroquine. Further research into the active components and mechanisms of action would be necessary to evaluate its therapeutic potential more fully (Simonsen et al., 2001). [31]

Enzyme Activity

The petroleum ether, ethanol, and aqueous extracts of the plant's leaves were evaluated for their in vitro tyrosinase inhibitory activity. Tyrosinase is an enzyme involved in the biosynthesis of melanin, the pigment responsible for skin color, and its overactivity is associated with hyperpigmentation disorders such as melasma and age spots. The extracts showed varying levels of tyrosinase inhibition, suggesting that they contain compounds capable of modulating melanin production. By inhibiting this enzyme, these extracts may have potential applications in treating pigmentation - related skin conditions or in the development of skin lightening agents. The different solvent extracts (petroleum ether, ethanol, and aqueous) likely contain distinct active compounds, which could explain the variation in their inhibitory effects on tyrosinase. This study supports the potential of these plant extracts as natural agents for managing skin pigmentation issues (Narayanaswamy et al., 2011). [32]

Toxicity

In acute toxicity studies, the ethanolic extract of the plant was found to be non - toxic up to a dose of 8 g/kg when administered orally to rats, indicating a relatively high safety margin at this dosage level (Dodoala et al., 2010). [33] Similarly, another study involving the methanolic extract of the plant reported that it was non - toxic up to a dose of 5 g/kg orally in rats, further supporting the safety profile of the plant's extracts at these doses (Balamurugan and Ignacimuthu, 2011). [34] These findings suggest that both the ethanolic and methanolic extracts of the plant may be considered safe for use at the tested doses, with no observed adverse effects, making them potential candidates for further pharmacological studies and therapeutic applications.

Antimicrobial

Antibacterial

In various studies, the antibacterial activity of different extracts from the plant has been evaluated with mixed results. n - Hexane, chloroform, acetone, ethanol, and aqueous extracts did not show any antibacterial activity against several bacterial strains, including *E. coli*, *K. pneumoniae*, *P. aeruginosa*, *S. aureus*, and *S. typhi* (Khond et al., 2009). [35] However, the ethanolic extract demonstrated effectiveness against *E. coli*, *S. aureus*, *P. vulgaris*, and *P. aeruginosa* (Rani et al., 2012). [36] Additionally, methanolic extracts from both the plant and its seeds also showed antibacterial properties, particularly against *P. aeruginosa*, *S. aureus*, and *E. coli* (Patel et al., 2011; Salve and Bhuktar, 2012). [37] Furthermore, a methanolic extract, along with an uncharacterized isolated compound, exhibited activity against a wide range of bacteria, including *K. pneumoniae*, *B. cereus*, and *B. subtilis* (Regupathi et al., 2014). [38] The hexane, chloroform, and alcoholic extracts of the leaf also demonstrated significant antibacterial effects, particularly against *B. cereus*, *S. aureus*, and *S. flexneri* (Malathi et al., 2011) [39], and the ethanol, petroleum ether, and aqueous extracts of the leaf and stem were effective against *S. aureus* and *M. luteus* (Ravikumar and Sudha, 2011). [40] These findings suggest that while some extracts show no activity, others, particularly the ethanolic and methanolic extracts, have considerable antibacterial potential, which could be explored further for therapeutic use.

Antifungal

In several studies, different extracts of the plant were tested for antifungal activity with varying results. n - Hexane, chloroform, acetone, ethanol, and aqueous extracts did not show any antifungal activity against *Aspergillus flavus*, *A. fumigatus*, *A. niger*, *Candida albicans*, or *Saccharomyces cerevisiae* (Khond et al., 2009) [41].

However, the ethanolic extract demonstrated antifungal effects against *Candida albicans* and *Trichophyton rubrum* (Rani et al., 2012). [42] Methanolic extracts (250 and 500 µg/disc) and an isolated compound from the plant (25 and 50 µg/disc) also showed antifungal activity against *Aspergillus niger* and *Candida albicans* (Regupathi and Chitra, 2015). [43]

Additionally, petroleum ether, ethanol, and aqueous extracts from the leaf and stem at 1000 µg/ml exhibited antifungal activity against these same fungi (Ravikumar and Sudha, 2011). [44] Furthermore, the ethanolic extract and isolated compound were found to be effective against *Malassezia furfur*, the fungus associated with dandruff (Regupathi and Chitra, 2015). [45]

Larvicidal:

The methanolic extract of the plant, when tested at concentrations ranging from 10 to 100 mg/l, was found to be ineffective against the fourth instar larvae of *Culex quinquefasciatus*, a species of mosquito known for transmitting various diseases such as filariasis and West Nile virus. The study conducted by Nazar et al. (2009) [46] indicates that the methanolic extract did not exhibit any significant larvicidal activity within the tested concentration range. This suggests that, under the conditions of the study, the plant's methanolic extract may not be a viable candidate for controlling the larval stages of *Culex quinquefasciatus* mosquitoes. Further research could explore different concentrations, formulations, or other extracts of the plant to assess their potential as mosquito larvicides.

4. Research Aspects

1) Neuroprotective Potential:
- Investigate its antioxidant and anti - inflammatory properties in managing neurodegenerative diseases like Alzheimer's and Parkinson's.
- Focus on its ability to reduce oxidative stress and neuroinflammation to protect neuronal cells.

2) Anti - cancer Mechanisms:
- Conduct comprehensive studies to analyse its anti - proliferative effects across diverse cancer models.
- Elucidate mechanisms such as apoptosis induction and tumour suppression pathways.

3) Gut Microbiome Modulation:
- Explore its role in promoting gut health by influencing the composition and balance of gut microbiota.
- Assess its impact on beneficial bacterial growth and gut symbiosis.

4) Autoimmune Diseases:
- Evaluate its immunomodulatory activities in regulating pro - inflammatory cytokines and immune responses.
- Assess its potential in managing conditions like rheumatoid arthritis and lupus.

5) Environmental Adaptation Studies:
- Study its role as a bio indicator for water quality and ecosystem health.
- Examine its adaptability to environmental stress and climate changes.

6) Skin Regeneration:
- Assess its antioxidant properties for promoting anti - aging effects and stimulating collagen synthesis.
- Evaluate its efficacy in skin repair and tissue regeneration (Wound healing).

7) Larvicidal and Vector Control:
- Expand research on its larvicidal properties for integrated pest management.
- Investigate its potential in controlling vectors like mosquitoes as an eco - friendly alternative to chemical insecticides.

5. Conclusion

The plant *L. nodiflora* is found globally and has been widely utilized for various health conditions. Although *Jalapippali* is rarely mentioned in the major classical texts like the Brihatrayees, it is prominently recognized in numerous Nighantus for its medicinal properties. The Dhanwantari Nighantu, one of the oldest texts, includes *Jalapippali* in its "Ganadravyavali, " an early section of the Nighantu. Despite significant research highlighting its pharmacological potential, there is a lack of extensive clinical studies to fully validate these benefits. As integrated studies and alternative options to Ayurvedic and Unani practices gain momentum, *Jalapippali* has been somewhat overlooked, despite its ease of cultivation and wide therapeutic potential. This plant can play a significant role in treating a variety of diseases and offers a promising, accessible option for future clinical applications. Further investigation into its medicinal uses, especially in modern contexts, is crucial to unlock its full therapeutic value. Additionally, the references to *Jalapippali* in the Brihatrayees should be thoroughly explored to confirm its botanical identity and redefine its clinical relevance.

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