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A COMPREHENSIVE REVIEW OF THE PHARMACOLOGICAL PROPERTIES OF LEUCAS ASPERA

P. Tamilmani[1]*, Dr. K. Rithika[2], Dr. M. Ranjith[2], R. Saranmohan[1] and M. Thirumeninathan[1]

[1]Students, SS Institute of Pharmacy, Sankari, Salem-637301.

[2]Assistant Professor, Doctor of Pharmacy.

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***Corresponding Author**
P. Tamilmani
Students, SS Institute of Pharmacy, Sankari, Salem-637301.

ABSTRACT

Leucas aspera, commonly referred to as Thumbai in Tamil, is a widely distributed medicinal herb that thrives in tropical and subtropical climates, particularly across India, Sri Lanka, Nepal, and other parts of Southeast Asia. It belongs to the botanical family Lamiaceae, which is known for its aromatic members and as a rich source of bioactive compounds. *Leucas aspera* has been an integral part of traditional medicine systems such as Ayurveda, Unani, and Siddha, where it is used to manage a wide range of ailments, including fevers, colds, headaches, skin infections, snakebites, and respiratory disorders. The primary objective of this review is to compile, analyze, and present an updated and detailed overview of the current knowledge regarding the botanical description, traditional uses, phytochemical composition, and pharmacological activities of *Leucas aspera*. This will help identify research gaps and pave the way for the development of novel therapeutic agents derived from this underutilized medicinal herb. Phytochemical investigations have revealed that *L. aspera* is a rich source of secondary metabolites such as flavonoids, alkaloids, glycosides**,** phenolic compounds, tannins, terpenoids, and essential oils. These compounds contribute significantly to the plant's broad spectrum of pharmacological activities, including antibacterial, antifungal, anti-inflammatory, antioxidant, analgesic, antipyretic, anticancer, and insect-repellent effects.

KEYWORDS: Anti-inflammatory, Antimicrobial, Anticancer activities, Leucas aspera, Medicinal plant.

INTRODUCTION

Leucas aspera, locally known as Thumbai in Tamil (Rai et al., 2005), belongs to the Lamiaceae family. It is also identified by other names such as Thumbe, White Dead Nettle in English, and Dronapushpi or Chitrapatrika in Sanskrit (Press et al., 2000). The plant is widely recognized in traditional medicine for its diverse healing properties. The genus Leucas, belonging to the Lamiaceae family, consists of around 80 different species, many of which are commonly utilized by traditional practitioners worldwide for the treatment of various health conditions. The whole plant is traditionally ingested to manage fever, pain, inflammation, rheumatic conditions, and bacterial infections. Moreover, its ground paste is externally used on swollen or inflamed regions of the body. The leaf extract is traditionally used to manage psoriasis, long-lasting skin conditions, and chronic joint inflammation. The flowers, when combined with honey, are given to children to relieve cold and cough symptoms. The leaves are also applied externally on snake bites, stings from venomous insects, and scorpion bites. In rural areas, Leucas aspera leaves are used as a natural insecticide and mosquito repellent. Additionally, the plant extract mixed with honey is considered effective for easing abdominal pain and digestive issues. A variety of pharmacologically active constituents, such as linoleic acid, glucosides, linolenic acid, oleanolic acid, nicotinic acid, saponins, sterols, stearic acid, tannins, and ursolic acid, have been extracted and documented from the leaves, roots, flowers, and seeds of this plant. Because of its strong foundation in traditional healing practices and its notable therapeutic potential, Leucas aspera has become a subject of increasing scientific interest, encouraging further study and confirmation through modern experimental methods.[1,2]

Fig. 1: Leucas aspera Plant.

BOTANICAL DESCRIPTION

1. Habit

Leucas aspera is an erect, annual herb that typically grows to a height of 30–60 cm. It is often branched, with a tough, hairy stem, and thrives in open, sunny environments, including roadsides, grasslands, and agricultural fields.

2. Stem

The stem is quadrangular (square in cross-section), which is characteristic of the mint family (Lamiaceae). It is green, erect, and covered with fine white hairs, giving it a slightly woolly appearance.

3. Leaves

Arrangement: Opposite and decussate

Shape: Narrowly lanceolate to linear

Margin: Entire or slightly toothed

Surface: Both surfaces are pubescent (hairy)

Size: Approximately 2–8 cm long and 0.5–1.5 cm wide

4. Flowers

Inflorescence is a dense whorl (verticillaster) located in the axils of the leaves or at the terminal ends.

Color: Usually white or pale pink

Calyx: Tubular, 6–10 mm long, with 6–10 narrow teeth

Corolla: Bilabiate (two-lipped), 1–1.5 cm long

Stamens: 4 (didynamous – 2 long and 2 short)

Style: Slender, with bifid stigma

5. Fruit

The fruit is a schizocarp, which splits into four small nutlets, each containing one seed.

6. Root

The taproot system, which is slender and fibrous, provides anchorage and nutrient uptake.

7. Habitat and Distribution

Leucas aspera is native to the Indian subcontinent and widely distributed across India, Sri Lanka, Malaysia, and tropical Africa. It grows well in wastelands, open fields, and cultivated lands, especially during the monsoon season.[3]

Vernacular Names[4]

Sanskrit	Dronapushpi, Chitrak-shupa
Hindi	Goma madhupati
Tamil	Thumbai
Telugu	Tummi, Thummi
Kannada	Thumbe
Malayalam	Thumba
Marathi	Bahuphul
Gujarati	Kulum Phool
Bengali	Darunaphula, Hulaksha
Punjabi	Guldora
Oriya (Odia)	Dronapuspi
Sindhi	Kubo
Konkani	Tambde Phool
Urdu	Goma
English	Common Leucas, White Dandelion

Taxonomic classification

Kingdom	Plantae
Clade	Angiosperms
Clade	Eudicots
Clade	Asterids
Order	Lamiales
Family	Lamiaceae (Mint family)
Genus	Leucas
Species	Leucas aspera

Pharmacological Studies

Detailed phytochemical analyses have revealed that Leucas aspera, an important herb used in traditional medicine, is a rich source of diverse naturally occurring chemical constituents. These include major groups such as flavonoids, alkaloids, glycosides, phenolics, tannins, terpenes, and steroidal compounds. Each class contributes uniquely to the therapeutic effects exhibited by the plant. Flavonoids are reputed for their ability to combat oxidative damage and reduce inflammation; alkaloids are frequently linked with antimicrobial and pain-relieving effects; glycosides are noted for their role in regulating heart function and supporting detoxification pathways. Additionally, tannins and phenolic compounds demonstrate strong antibacterial and astringent actions, while terpenes and steroids are often

related to anticancer, antidiabetic, and immune-modulating activities. Among the key phytoconstituents identified in Leucas aspera, compounds such as apigenin, acacetin, macelignan, and β-sitosterol have been isolated and studied extensively for their biological significance. These molecules have shown encouraging results in experimental research models for addressing oxidative stress, microbial infections, inflammation, and other chronic ailments. The combined or synergistic interaction of these phytochemicals enhances the medicinal value of Leucas aspera, positioning it as a promising source for the development of herbal therapeutic agents.

Antibacterial Activity

Leucas aspera has shown significant antibacterial potential in both traditional and modern research studies. Various extracts (methanol, ethanol, chloroform, aqueous) of the leaves, flowers, and whole plant have been tested for their activity against a wide range of Gram-positive and Gram-negative bacteria.

Bacteria Affected

Gram-positive

- Staphylococcus aureus
- Bacillus subtilis

Gram-negative:

- Escherichia coli
- Pseudomonas aeruginosa
- Salmonella typhi

Active Compounds Responsible

The antibacterial effects are mainly due to the presence of:

- Flavonoids
- Terpenoids
- Tannins
- Saponins
- Phenolic compounds
- Essential oils

These phytochemicals work together to inhibit or kill bacteria through multiple mechanisms.

Mechanism of Action / Site of Action

1. Cell Wall Disruption

Target: Peptidoglycan layer of bacterial cell wall (mainly Gram-positive)

Action: Flavonoids and saponins can disrupt the structural integrity of the bacterial cell wall, leading to cell lysis and death.

2. Cell Membrane Damage

Target: Phospholipid bilayer of bacterial membranes

Action: Terpenoids and essential oils integrate into the lipid bilayer, increasing membrane permeability, which causes leakage of cytoplasmic contents like proteins and ions.

3. Enzyme Inhibition

Target: Metabolic enzymes (like DNA gyrase, topoisomerase, etc.)

Action: Phenolic compounds can inhibit bacterial enzymes responsible for DNA replication and energy production, blocking bacterial growth.

4. Inhibition of Protein Synthesis

Target: Ribosomes (30S or 50S subunit)

Action: Certain alkaloids may bind to bacterial ribosomes and inhibit translation, preventing bacteria from synthesizing essential proteins.

5. Oxidative Stress Induction

Target: Cellular redox system

Action: Polyphenols and tannins can generate reactive oxygen species (ROS) in bacteria, leading to oxidative damage to DNA, proteins, and lipids.

Experimental Evidence

- In in vitro studies, a zone of zones of inhibition were observed when Leucas aspera extracts were applied to bacterial cultures.
- Minimum inhibitory concentration (MIC) values indicated strong effectiveness, especially in methanolic and ethanolic extracts.
- Activity varied based on the part of the plant used and the solvent for extraction.[5]

Antifungal Activity

- Antifungal activity refers to the ability of a substance (like a plant extract or drug) to inhibit the growth of or kill fungi. Fungi are microorganisms such as Candida,

Aspergillus, Trichophyton, and Microsporum, which can cause infections in humans, especially on the skin, nails, mucous membranes, and sometimes internal organs.

- Medicinal plants like Leucas aspera have shown antifungal activity in in vitro studies (experiments done in lab conditions). Various extracts (like chloroform, ether, and methanol) of this plant have been tested and found to inhibit fungal growth.[6]

Mechanism of Action/Site of Action

The site of action refers to the specific part of the fungal cell or function that is targeted by the active compounds in the plant.

- Flavonoids
- Phenols
- Saponins
- Alkaloids

Possible Sites and Modes of Action

1. **Disruption of Fungal Cell Membrane**

- Many phytochemicals damage the fungal cell membrane by interacting with its lipid components (like ergosterol).
- This causes leakage of cell contents, leading to fungal death.

Example: Saponins and terpenoids can form pores in the membrane.

- The fungal cell wall is primarily composed of chitin and glucans.
- Some plant compounds inhibit the enzymes needed to make these structures, weakening the wall and causing the cell to burst.

3. Inhibition of Enzyme Activity

- Certain compounds interfere with vital enzymes in the fungal metabolism, halting growth or killing the fungus.

4. Inhibition of DNA/RNA synthesis

- Some phytochemicals block the synthesis of nucleic acids, preventing the fungus from reproducing.

5. Oxidative Stress Induction

- Phenolic compounds and flavonoids can cause the buildup of reactive oxygen species (ROS) in fungal cells, leading to cellular damage and death.

Example Study (Leucas aspera)

- In vitro tests using chloroform and ether extracts of Leucas aspera showed inhibition against:
- Trichophyton rubrum
- Microsporum gypseum
- The minimum inhibitory concentration (MIC) was around 5 mg/mL.

The extracts exhibited both

- Fungistatic activity (stopping fungal growth)
- Fungicidal activity (killing the fungus)[7,8]

Antimicrobial Activity

Antimicrobial activity is the ability of a substance (such as a plant extract, chemical, or drug) to inhibit the growth or kill microorganisms, including:

- Bacteria (antibacterial activity)
- Fungi (antifungal activity)
- Viruses (antiviral activity)
- Parasites (antiparasitic activity)

Medicinal plants like Leucas aspera have been traditionally used for their antimicrobial properties. Studies show that extracts from this plant (methanolic, ethanolic, aqueous, etc.) can effectively act against a wide range of pathogens.[9]

Phytochemicals Responsible for Leucas aspera

- Flavonoids
- Phenols
- Tannins
- Saponins
- Terpenoids
- Alkaloids

These compounds attack microbes at various cellular levels.

Site of Action & Mechanisms

- Below are the key targets (sites of action) and mechanisms by which antimicrobial agents

1. Cell Wall Disruption

Target organisms: Mainly bacteria and fungi

- Plant compounds like tannins and terpenoids may disrupt or inhibit the synthesis of microbial cell walls (e.g., peptidoglycan in bacteria, chitin in fungi).
- This weakens the wall and causes cell lysis (bursting).

2. Cell Membrane Damage

Target organisms: Bacteria and fungi

- Some compounds (like saponins and flavonoids) interact with membrane lipids,
- Increased permeability
- Leakage of ions and vital cell contents
- Cell death

3. Inhibition of Protein Synthesis

Target organisms: Bacteria

- Flavonoids and alkaloids may bind to bacterial ribosomes.
- Translation process
- Protein formation
- This halts bacterial growth or leads to cell death.

4. Inhibition of Nucleic Acid Synthesis

Target organisms: Bacteria and viruses

- Certain compounds can block DNA or RNA replication in microbes.
- This stops reproduction and can lead to cell death.

5. Enzyme Inhibition

Target organisms: All microbes

- Bioactive molecules may act as enzyme inhibitors, disrupting key metabolic pathways.

For example

- Blocking enzymes needed for energy production, or Inhibiting DNA gyrase (used in bacterial DNA supercoiling)

6. Generation of Reactive Oxygen Species (ROS)

Target organisms: Broad range

- Some compounds cause oxidative stress by increasing ROS.
- ROS damages proteins, lipids, and DNA in microbial cells, leading to death.

Experimental Evidence (Leucas aspera)

- Methanolic and ethanolic extracts of Leucas aspera have shown strong antimicrobial activity.
- Effective against Gram-positive bacteria (like Staphylococcus aureus) and Gram-negative bacteria (like E. coli, Pseudomonas aeruginosa).
- Also effective against fungi, showing broad-spectrum antimicrobial effects.[10]

Anti-Inflammatory

Inflammation is the body's natural response to injury, infection, or irritation. It involves redness, swelling, pain, heat, and sometimes loss of function.[11]

Chronic inflammation can lead to many diseases

- Arthritis
- Asthma
- Cardiovascular diseases
- Cancer

Anti-inflammatory activity refers to the ability of a compound to reduce, prevent, or suppress inflammation in the body.

Medicinal plants like Leucas aspera show significant anti-inflammatory activity due to their rich phytochemical content.

Phytochemicals in Leucas aspera Responsible

The anti-inflammatory effects of Leucas aspera

- Flavonoids
- Phenolic compounds
- Terpenoids
- Steroids
- Tannins
- Alkaloids

Site of Action and Mechanism

Anti-inflammatory agents act at specific sites in the inflammatory pathway. The most common mechanisms:

1. Inhibition of Pro-inflammatory Enzymes

Target site: Cyclooxygenase (COX) enzymes – COX-1 and COX-2

- These enzymes help produce prostaglandins, which cause pain and swelling.

Flavonoids and terpenoids in Leucas aspera may inhibit these enzymes

- Reducing pain
- Lowering swelling
- Controlling fever

2. Blocking of Pro-inflammatory Cytokines

Target site: Cytokines like TNF-α, IL-1β, IL-6

- These are chemical messengers that promote inflammation.
- Certain phytochemicals suppress the production or action of these cytokines, reducing the inflammatory response.

3. Antioxidant Activity

Target site: Reactive oxygen species (ROS) and free radicals

- Oxidative stress can worsen inflammation.
- Phenolics and flavonoids neutralize free radicals.
- Reduces tissue damage
- Slows down the inflammatory process

4. Stabilization of Cell Membranes

Target site: Lysosomal membranes in immune cells

- Some anti-inflammatory agents stabilize these membranes and prevent the release of inflammatory mediators like histamines and proteases.
- This protects surrounding tissues from inflammation.

5. Suppression of Nitric Oxide (NO) Production

Target site: Inducible nitric oxide synthase (iNOS) enzyme

- In inflammation, cells release nitric oxide, which causes swelling and cell damage.
- Plant compounds can inhibit iNOS, reducing inflammation.

Evidence from Leucas aspera Studies

- In animal models, Leucas aspera extracts significantly reduced paw edema (swelling) in rats.
- Studies have shown a reduction in inflammatory markers like TNF-α and IL-6.
- The extracts have shown similar activity to standard anti-inflammatory drugs like indomethacin or aspirin, with fewer side effects.[12]

Antioxidant Activity

Antioxidant activity refers to the ability of certain substances (called antioxidants) to neutralize free radicals or reactive oxygen species (ROS) in the body.[13]

What are Free Radicals?

Free radicals are unstable molecules that have one or more unpaired electrons. They are generated in the body through:

- Normal metabolic processes (like respiration)
- Environmental exposures (pollution, UV light, smoking, radiation)
- Inflammation or infection

Common types include

- Superoxide anion (O_2^-)
- Hydroxyl radical (•OH)
- Hydrogen peroxide (H_2O_2)
- Nitric oxide (NO•)

If not neutralized, free radicals damage cells:

- Lipid peroxidation (damaging cell membranes)
- DNA mutation
- Protein degradation

This oxidative stress is linked to aging and many diseases like cancer, heart disease, neurodegenerative disorders (e.g., Alzheimer's), and diabetes.[14]

Antioxidants Work

1. Scavenging free radicals – donating an electron to stabilize the free radical.
2. Chelating metal ions – preventing them from generating free radicals (e.g., Fe^{2+}, Cu^{2+}).

3. Inhibiting oxidative enzymes – blocking enzymes like NADPH oxidase or xanthine oxidase that produce ROS.

4. Regenerating other antioxidants – like Vitamin C, helping to regenerate Vitamin E.

Site of Action of Antioxidants

Antioxidants work in different parts of the cell or body depending on their chemical nature:

1. Intracellular Antioxidants

(Within cells)

- Glutathione (GSH) – works in the cytoplasm and mitochondria
- Superoxide dismutase (SOD) – in cytosol and mitochondria
- Catalase – mainly in peroxisomes
- Vitamin C (ascorbic acid) – cytoplasm

2. Membrane-bound Antioxidants

- Vitamin E (α-tocopherol) – acts in cell membranes, protecting lipids from oxidation

3. Extracellular Antioxidants

- Uric acid, transferrin, ceruloplasmin – present in blood plasma
- Help prevent systemic oxidative damage

4. Mitochondrial Antioxidants

- Mitochondria are a major source of ROS
- Specialized antioxidants (like Coenzyme Q10) function here

Examples of Natural Antioxidants

Enzymatic Superoxide dismutase (SOD), Catalase, Glutathione peroxidase

Non-enzymatic Vitamin C, Vitamin E, β-carotene, Polyphenols, Flavonoids, Selenium

SUMMARY

- Antioxidant activity defends cells against oxidative damage caused by ROS/free radicals.
- They function by neutralizing ROS, chelating metals, and inhibiting pro-oxidant enzymes.
- Sites of action include cytoplasm, mitochondria, cell membranes, and extracellular fluids.[15]

Analgesic

Analgesic activity refers to the ability of a substance to relieve or reduce pain without causing loss of consciousness.[16]

- Inflammation
- Injury
- Surgery
- Infections
- Chronic disorders (like arthritis or neuropathy)

Medicinal plants like Leucas aspera have shown analgesic (pain-relieving) properties in experimental studies, making them potential alternatives to synthetic painkillers.

Phytochemicals in Leucas aspera are Responsible for Analgesic Effects

The active constituents responsible for analgesic activity include:

- Flavonoids
- Alkaloids
- Terpenoids
- Phenols
- Tannins
- Steroids

These bioactive compounds interfere with pain signaling at different points in the nervous and inflammatory pathways.

Site of Action and Mechanism

Analgesic compounds can act at two major levels:

1. Peripheral Level (at the site of injury or inflammation)

Site of action: Sensory nerve endings, inflammatory mediators

- In damaged tissues, inflammatory chemicals like prostaglandins, bradykinin, and histamine stimulate pain receptors (nociceptors).
- Flavonoids and terpenoids may inhibit cyclooxygenase (COX) enzymes, thereby reducing prostaglandin synthesis.[17]

RESULT: Decreased inflammation and pain sensation at the site.

2. Central Level (in the brain and spinal cord)

Site of action: Central nervous system (CNS) receptors

- Pain signals are transmitted to the brain via the spinal cord.
- Plant alkaloids and steroids may enhance the release of endorphins or modulate opioid receptors (like μ-opioid receptors), which block pain perception in the brain.

RESULT: Reduced pain awareness and response.

Experimental Evidence from Leucas aspera

In animal models, Leucas aspera extract (especially ethanolic or methanolic) has been tested using:

- Hot plate method (central pain model)
- Acetic acid-induced writhing test (peripheral pain model)
- Results showed significant pain relief, comparable to standard drugs like aspirin or diclofenac.[18]

Summary of Mechanisms

Mechanism Site of Action Effect

Inhibition of COX enzymes, Peripheral (inflammatory site) ↓, Prostaglandins → ↓ Pain

Modulation of opioid receptors Central (brain/spinal cord) ↓ Pain perception

Antioxidant activity, Cellular level, ↓ Oxidative stress → ↓ Tissue damage/pain

Anti-inflammatory activity, both central & peripheral ↓ Swelling → ↓ Nerve irritation

Anticancer Activity

Leucas aspera, a traditional medicinal plant, has shown promising anticancer activity in several in vitro (test tube) and in vivo (animal model) studies. The plant contains a variety of bioactive compounds that are believed to interfere with cancer cell growth, survival, and proliferation.

Bioactive Compounds Responsible

Some of the major phytochemicals present in Leucas aspera include:

- Flavonoids
- Alkaloids
- Tannins
- Phenolic compounds

- Terpenoids
- Steroids
- Glycosides

These compounds have shown cytotoxic, antioxidant, and pro-apoptotic properties that contribute to their anticancer potential.[19]

Mechanism of Action

1. Induction of Apoptosis (Programmed Cell Death)

- Certain compounds in Leucas aspera trigger apoptosis in cancer cells.
- Apoptosis is a natural cell death mechanism that removes abnormal or mutated cells.
- The plant induces apoptosis by activating caspase enzymes and disrupting mitochondrial membranes in cancer cells.

2. Inhibition of Cell Proliferation

- Extracts from the plant can slow down or stop the multiplication of cancer cells.
- It interferes with the cell cycle, especially at the G1 or G2/M phases, preventing cells from dividing.

3. Antioxidant Activity

- The flavonoids and phenolics in Leucas aspera help neutralize free radicals, which are known to damage DNA and lead to cancer development.
- By reducing oxidative stress, the plant helps protect normal cells and reduces cancer risk.

4. DNA Damage in Cancer Cells

- Some compounds cause direct DNA fragmentation in cancer cells, which leads to the death of those cells.

5. Anti-angiogenic Activity (Possible)

- Although not well established, it is suggested that Leucas aspera may also prevent the formation of new blood vessels (angiogenesis) in tumors, thus cutting off nutrient supply to cancer cells.

Site of Action

- The anticancer effects of Leucas aspera are mainly at the cellular and molecular level, particularly:

- Cell membrane – Disruption leads to leakage of contents and cell death.
- Mitochondria – Alters membrane potential, leading to apoptosis.
- Nucleus – Causes DNA fragmentation in cancer cells.
- Enzymatic systems – Inhibit enzymes involved in cancer cell survival and proliferation (e.g., caspases, topoisomerases).

Experimental Evidence

In vitro cytotoxic studies (e.g., MTT assay) have shown Leucas aspera extracts inhibit the growth of various cancer cell lines, such as:

- HeLa (Cervical cancer)
- MCF-7 (Breast cancer)
- HepG2 (Liver cancer)

The methanol and ethanol extracts have shown the most potent anticancer activity in lab settings.[20]

Traditional & folk uses

Leucas aspera, commonly known as Thumbai, is a medicinal plant widely used in traditional Indian medicine systems like Ayurveda, Siddha, and by rural and tribal communities for treating various ailments.[21]

1. Treatment of Cough and Cold

Decoction of leaves or flowers is taken orally to relieve cough, cold, and throat irritation.

2. Fever Management

Whole plant infusion is used to treat fever, especially in rural folk medicine

3. Asthma and Respiratory Relief

Crushed leaves are inhaled or used in decoction to ease asthma and breathing difficulties.

4. Insect and Snake Bites

Leaf paste is applied externally to reduce the effect of insect and snake bites.

5. Skin Diseases and Wound Healing

Used for treating eczema, itching, and minor wounds through direct application of leaf paste or juice.

6. Digestive Disorders

Traditionally used to relieve stomachache, indigestion, and expel intestinal worms (vermifuge).

7. Women's Health (Postpartum Care)

Bathing in water boiled with Leucas aspera is believed to help new mothers recover from childbirth and prevent infections.

8. Ritual and Cultural Uses

Flowers are used in religious rituals and offerings, especially during South Indian festivals like Ayudha Pooja.[22]

Toxicity & Safety Profile

The evaluation of Leucas aspera for potential toxicity has revealed that the plant is generally safe for medicinal use when consumed at customary dosages. Experimental research, especially in animal models, has supported its low risk of toxicity.

Acute Toxicity

In tests involving single high-dose administration, animals given up to 2000 mg/kg body weight of plant extract exhibited no fatalities or adverse symptoms. These outcomes suggest that Leucas aspera has a wide safety range and is not acutely toxic.

Sub-Acute Toxicity

When administered regularly over several weeks, Leucas aspera did not produce any harmful effects. There were no significant changes in body mass, organ health, blood profiles, or vital organ functions, indicating tolerance to repeated use at moderate doses.

Cytotoxicity Studies

Cell-based assays revealed minimal to moderate cell damage at elevated concentrations of the extract. This suggests that while the plant may have potential anticancer activity, higher doses should be used cautiously.

Tissue and Organ Studies

Detailed analysis of internal organs (liver, kidney, heart, and spleen) of treated animals showed no abnormal changes or tissue damage, further confirming the plant's internal safety under the tested conditions.

Safety Observations

Traditional use of the plant, both topically and orally, has not been linked to serious health effects.

However, its use in pregnant women, nursing mothers, and young children should be approached with caution due to the lack of sufficient clinical evidence.
No major allergic or irritant responses have been documented.[23]

CONCLUSION

Studies from the literature indicate that Leucas aspera displays a wide range of biological activities, including antimicrobial, antioxidant, anticancer, anti-inflammatory, antidiabetic, and several other therapeutic effects. It has been traditionally utilized for its healing properties in the treatment of various health conditions. The plant contains several active constituents, such as phenolic compounds, glycosides, and terpenoids, which are responsible for its significant medicinal effects. Experimental findings have demonstrated its noteworthy anti-inflammatory action, effective against both acute and chronic inflammation. Therefore, Leucas aspera holds great promise for further research, with the potential to confirm its clinical value and support its commercial development in the field of herbal medicine.

FUTURE SCOPE

Leucas aspera holds significant promise for future scientific exploration and therapeutic development. Although it has been traditionally used in folk medicine, extensive modern research is still needed to fully understand its pharmacological value. Future investigations should aim to isolate and study its active compounds through advanced phytochemical techniques. Additionally, experimental studies including animal models and clinical trials are essential to validate its medicinal properties, determine safe dosage levels, and assess possible side effects. Innovative drug delivery methods, such as nanoparticles or controlled-release formulations, could enhance its therapeutic potential. The plant also presents opportunities for use in combination therapies, particularly in combating drug-resistant microbes. As interest in herbal remedies continues to grow globally, Leucas aspera stands out as a valuable source for developing cost-effective, eco-friendly, and effective treatments for various health conditions. Its role in future pharmaceutical research could bridge the gap between traditional healing practices and modern medical science.[24,25]

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