

Review Article

**Phytochemicals and Pharmacological Prospective of *plumeria alba*:
A Comprehensive Review**

Ms. Snehal Pralhad Zankar¹, Dr. Yogesh V. Ushir

¹SMBT College of Pharmacy, Dhamangaon, Nashik

²Principal, SMBT College of Pharmacy, Dhamangaon, Nashik

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Plumeria alba (commonly known as white frangipani) is a widely distributed ornamental plant valued for its therapeutic properties in traditional medicine. This comprehensive review compiles and analyzes the phytochemical constituents and pharmacological activities of *P. alba*. The plant is rich in diverse bioactive compounds, including alkaloids, flavonoids, triterpenoids, glycosides, and essential oils. These constituents contribute to a broad spectrum of biological activities such as anti-inflammatory, antimicrobial, antioxidant, anticancer, wound healing, and hepatoprotective effects. The review also highlights recent advancements in isolation techniques, mechanisms of action, and potential therapeutic applications. A critical discussion on current research gaps and future perspectives is included to guide further pharmacological exploration and drug development efforts based on *Plumeria alba*.

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* Corresponding Author- Snehal P. Zankar, ¹SMBT College of Pharmacy, Dhamangaon, Nashik
snehalzankar7@gmail.com, Mobile No. 7517650948

Introduction:

Ayurveda, the ancient system of medicine originating from India, stands as one of the most prominent and respected forms of alternative and complementary healthcare. Much like other traditional herbal systems, a significant portion of Ayurvedic treatments depend on heavily on the use of indigenous remedial plants. For practitioners and researchers in this field, a comprehensive and detailed understanding of these plants is essential not only for accurate identification but also for selecting the right species to treat specific health conditions. In current years, there has been a remarkable recovery of interest in medicinal plants, both within India and globally. This growing awareness has fueled a wave of scientific inquiry, particularly in Western countries, where researchers have begun to rigorously investigate the therapeutic potential of plant-based

medicines. This cross-cultural interest highlights the increasing recognition of Ayurveda as a valuable resource for developing safe and effective natural remedies[1][2]

The Apocynaceae family is a large group of blossoming plants predominantly distributed transversely tropical and subtropical areas. However, their growth tends to be limited in areas with extremely high temperatures. This family comprises various genera such as *Adenium*, *Alstonia*, *Alyxia*, *Nerium*, *Plumeria*, and *Vinca*, many of which have a rich past of traditional medicinal use supported by observed evidence. For instance, *Adenium* species, despite their toxic milky latex, have been traditionally employed in topical applications, notably in the treatment of lice and other skin-related conditions. *Alstonia* has been used for the

management of respiratory ailments, while *Alyxia* is known for its use in postnatal care. *Nerium*, although highly toxic, has been applied in folk medicine for cancer treatment, and *Vinca* species have been utilized in managing diabetes. From a pharmacological perspective, these genera possess a wide spectrum of bioactivities. *Adenium* is reported to exhibit potent antioxidant properties. *Alstonia* demonstrates antiviral and antifungal activities, while *Nerium* and *Vinca*, despite their toxicity, are known for their central nervous system (CNS) depressant and antitumor effects, respectively. Among these, *Plumeria* emerges as a particularly promising genus within the Apocynaceae family, meriting deeper exploration for its diverse species and wide-ranging medicinal applications. Its unique phytochemical profile and traditional uses position it as an attractive candidate for further ethnobotanical and pharmacological studies [3].

Plumeria, commonly admired for its beautiful and fragrant flowers, is not only valued for ornamental purposes but also holds significance in traditional medicine and wellness practices. The essential oils extracted from its blossoms are widely utilized in the perfumery industry and in aromatherapy, owing to their soothing fragrance and potential therapeutic effects. According to a World Health Organization (WHO) report (2003), approximately 85% of the population in developed countries depend on traditional medicine predominantly plant-based medications for their prime healthcare needs. This reliance stems from limited access to conventional pharmaceuticals due to economic or geographical constraints. In recent decades, herbal medicines have gained global traction, not just in developing nations but also in the developed world. Their popularity is largely attributed to their broad spectrum of biological activities, relatively high safety profiles, fewer side effects, and cost-effectiveness. As such, plants like *Plumeria* are increasingly being recognized as promising candidates for further exploration in both ethnopharmacological and modern medicinal research[4]

Medicinal Importance of *Plumeria alba*

Plumeria alba has long been recognized for its ornamental beauty and fragrant flowers; however, it also holds substantial value in traditional medicine systems across various cultures. Different parts of the shrub including the bark, leave, latex, flowers, and roots have been utilized for their therapeutic properties in the handling of a wide array of ailments. Traditionally, the bark decoction is used to manage fevers, chronic cough, dysentery, and intestinal parasitic infections, while the latex is applied topically to treat skin disorders such as warts, boils, ringworm, and other persistent dermal infections. The leaves, when prepared as a poultice or

extract, are used for relieving inflammatory conditions, including arthritis, muscle pain, and joint swelling. The flowers are known for their calming properties and are used in infusions or decoctions to alleviate headaches, anxiety, and sleep disturbances. In certain traditional practices, the roots have been used to regulate menstrual flow and support reproductive health, though such applications warrant further toxicological validation. Modern pharmacological investigations have confirmed several of these traditional uses. Extracts of *P. alba* have demonstrated significant antioxidant activity, which plays a vital role in modifying oxidative stress, a contributory factor to the development of long-lasting illnesses such as cardiovascular diseases, neurodegenerative disorders, and cancer. The plant's antioxidant activity also supports wound healing, enhancing tissue repair while minimizing infection risk. *Plumeria alba* has also exhibited broad-spectrum antimicrobial activity, showing efficacy against various bacterial and fungal pathogens, thereby supporting its traditional use in treating infectious diseases. In addition to its antimicrobial and antioxidant properties, the plant has shown promise for its anti-inflammatory, anti-ulcer, hepatoprotective, analgesic, and immunomodulatory activities, as evidenced by both in vitro and in vivo studies. Phytochemical analyses have identified several bioactive compounds, including alkaloids, flavonoids, triterpenoids, steroids, glycosides, phenolic acids, and essential oils. These constituents are believed to contribute synergistically to the plant's pharmacological effects. For instance, flavonoids and phenolics are known to exert strong antioxidant and anti-inflammatory activities, while triterpenoids have demonstrated antimicrobial and anticancer potential. Given its diverse pharmacological profile, natural abundance, and cultural relevance, *Plumeria alba* represents a valuable resource for the development of herbal formulations, cosmeceuticals, and plant-based pharmaceuticals. However, further research is necessary to isolate specific active compounds, establish standardized extracts, and validate clinical efficacy through well-designed human trials[5][3]



Fig. 1: *Plumeria alba*

Plumeria alba, often known as White Champa, is a small, native tropical American laticiferous tree or shrub. Its leaves and stems have been studied for their phytoconstituents, which are cast-off to pleasure a variability of ailments in traditional medicines. The plant is mostly grown for its fragrant, beautiful blossoms, which have therapeutic use as well[6]

In acknowledgment of its therapeutic potential as an anticancer and antibacterial agent, current study aims to describe the physiochemical and pharmacological properties of *P. alba* leaf extract[3]

Taxonomical classification[3]

Table no 1: Taxonomical Classification of *Plumeria alba*

Rank	Scientific name and common name
Kingdom	<i>Plantae</i>
Subkingdom	<i>Tracheobionta</i>
Superdivision	<i>Spermatophyte</i>
Division	<i>Magnoliophyta</i>
Class	<i>Magnoliopsida</i>
Subclass	<i>Asteridae</i>
Order	<i>Gentianales</i>
Family	<i>Apocynaceae juss</i>

Phytochemical Constituents of *Plumeria alba*[7][8]

Plumeria alba, usually known as white frangipani, is a tropical plant rich in diverse bioactive phytochemicals, contributing to its traditional medicinal uses and pharmacological potential. Various portions of the plant including the leave, bark, stem, and roots contain an array of secondary metabolites with biological activities.

1. Triterpenoids and Sterols

The plant is known to contain a significant amount of triterpenoids and sterols, particularly in the leaves and bark. Compounds such as α -amyrin and β -amyrin, which are pentacyclic triterpenoids, have been reported and are known for their anti-inflammatory and analgesic properties. β -sitosterol, a phytosterol with structural similarity to cholesterol, is also present and is recognized for its cholesterol-lowering and anti-inflammatory effects.

2. Flavonoids and Alkaloids

Flavonoids, which are abundant in the aerial parts such as leaves and stems, exhibit strong antioxidant, anti-inflammatory, and antimicrobial activities. Alkaloids present in the root bark and aerial parts contribute to the plant's potential analgesic and cytotoxic effects.

3. Polysaccharides and Tannins

The presence of polysaccharides suggests immunomodulatory and wound-healing properties.

Tannins, known for their astringent and antimicrobial activities, are found in various parts of the plant, especially the root bark.

4. Iridoid Glycosides

Iridoid compounds such as plumericin, fulvoplumerin, plumeride, plumeride coumarate, and plumeride coumarate glucoside have been isolated. These iridoids exhibit a wide range of pharmacologic effects counting cytotoxic, anti-inflammatory, and antimicrobial Activity. Fulvoplumerin, in particular, is reported to have cytotoxic and antibacterial actions.

5. Other Notable Phytochemicals

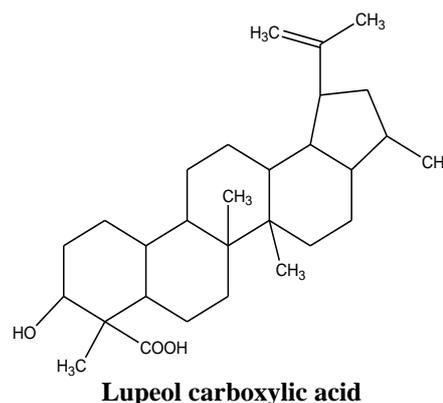
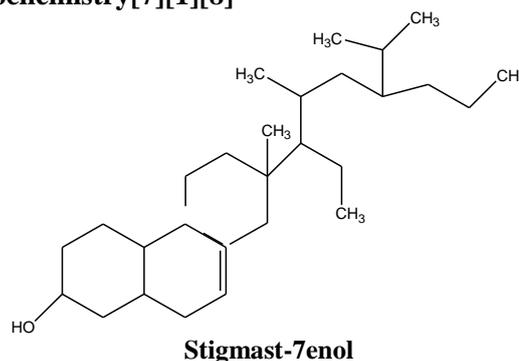
Rainieride and resinic acid are found in the fresh leaves and bark, contributing to the plant's anti-inflammatory and wound-healing capacities. Coprotein and isoplumericin have been reported and are of interest for their possible bioactivities.

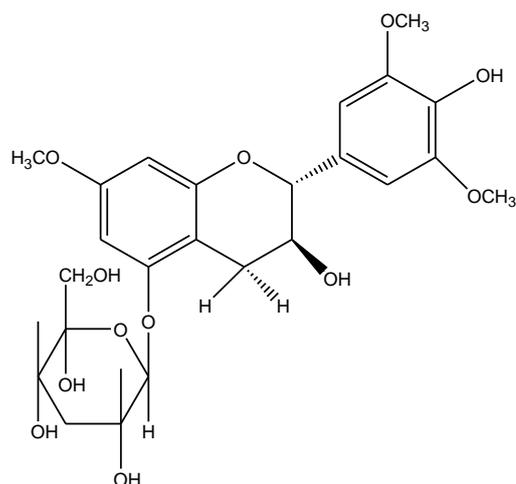
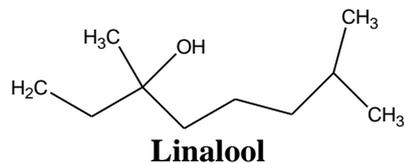
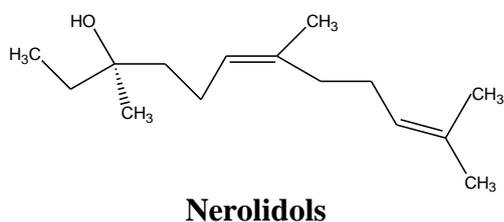
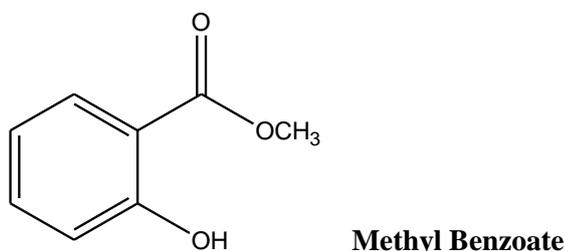
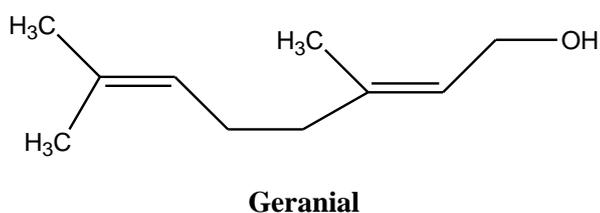
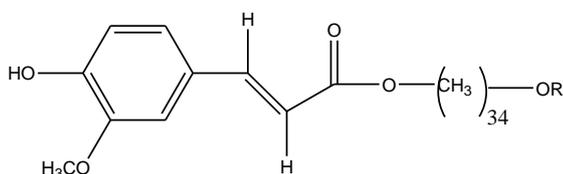
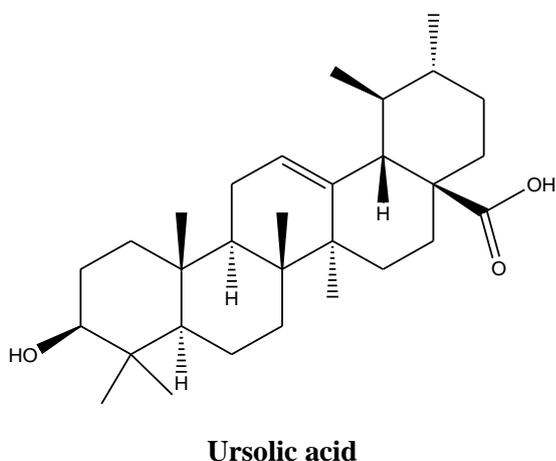
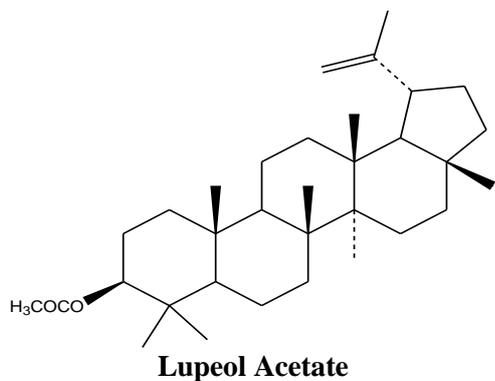
The bark contains additional cytotoxic iridoids such as allamcin, allamandin, and 2,5-dimethoxy-p-benzoquinone, as well as liri dendrin, a lignan compound known for potential antioxidant effects.

6. Root Bark Constituents

The root bark of *Plumeria alba* is particularly rich in alkaloids, tannins, and iridoids, suggesting its traditional use in various folk medicine systems for treating infections and inflammatory conditions.

Phytochemistry[7][1][8]





General information[1][3]

Name in science: *Plumeria alba*

Common names: White Frangipani, Nosegay Tree, Pigeon Wood, Caterpillar Tree, Pagoda Tree, and White Frangipani.

Family: Apocynaceae

Availability: Within its hardiness range, it is typically found in a wide range of locations.

Native Range: Lesser Antilles and Puerto Rico

Zone: ten to twelve

Height: between 15 and 25 feet

Dispersion: 15 to 25 feet

Pharmacological Activity [7][9][7]

Pharmacological Activities of *Plumeria alba*

Plumeria alba (family: Apocynaceae), usually known as white frangipani, has been widely recognized for its therapeutic potential in traditional and modern medicine. The pharmacological activities attributed to the plant are largely due to its rich phytochemical profile, including triterpenoids, iridoids, flavonoids, sterols, and alkaloids. Various preclinical studies have validated several biological properties of different plant parts leaves, stem bark, flowers, and roots demonstrating its potential as a source of bioactive compounds.

1. Anti-inflammatory Activity

Several studies have shown that ethanolic and methanolic extracts of *P. alba* possess significant anti-inflammatory effects in both severe and long-lasting models. The activity has been detected in carrageenan-

increasing paw edema and fiber pellet-induced granuloma model. Iridoids such as plumericin and fulvoplumierin, along with amyryns and other terpenoids, contribute to the suppression of pro-inflammatory mediators like prostaglandins and cytokines.

2. Antimicrobial and Antifungal Activity

P. alba extracts have exhibited broad-spectrum antimicrobial properties against both gram-positive and gram-negative bacteria, additionally various fungal strains. The antimicrobial activity is probable due to the occurrence of iridoids, flavonoids, and terpenoids, which disrupt microbial membranes and inhibit enzymatic activities.

3. Antioxidant Activity

The antioxidant potential of *P. alba* has been demonstrated using multiple assays, including DPPH, ABTS, and nitric oxide scavenging methods. This activity is attributed to flavonoids and phenolic compounds, which scavenge reactive oxygen species (ROS), thus preventing oxidative damage and inflammation.

4. Cytotoxic and Anticancer Activity

Plumericin and fulvoplumierin, among other iridoids, have shown cytotoxicity against various cancer cell lines such as MCF-7 (breast), HeLa (cervical), and HepG2 (liver). These compounds induce apoptosis, inhibit cell proliferation, and modulate the expression of apoptotic genes, highlighting their potential as anticancer agents.

Major cytotoxic compounds identified in *P. alba* include **Plumericin** – a spiro lactone iridoid with established anti-proliferative effects.

Fulvoplumierin – known for cytotoxicity and apoptosis induction.

Allamandin – a cytotoxic iridoid lactone
2,5-Dimethoxy-p-benzoquinone – a quinonoid compound with known redox activity leading to ROS generation and apoptosis.

Liriodendrin – a lignan with anticancer potential.

5. Analgesic Activity

Extracts of *P. alba* have demonstrated both central and peripheral analgesic activity in animal models. The mechanisms involve the inhibition of prostaglandin synthesis and interaction with opioid receptors. Alkaloids and flavonoids are believed to contribute significantly to this activity.

6. Antipyretic Activity

The plant exhibits antipyretic effects comparable to standard drugs in yeast-induced pyrexia models. These effects are likely due to inhibition of prostaglandin

synthesis in the hypothalamus, attributed to triterpenoids and phenolic constituents.

7. Antidiabetic drug Activity

Experimental studies on diabetic rat models have shown that *P. alba* leaf extracts significantly reduce fasting blood glucose levels. Activity may include stimulus of insulin secretion, enhancement of glucose uptake, and inhibition of carbohydrate-digesting enzymes, possibly due to flavonoids and saponins.

8. Wound-Healing Activity

Topical application of *P. alba* leaf and bark extracts accelerates wound contraction, promotes collagen synthesis, and enhances re-epithelialization. This effect is potentiated by its antimicrobial and antioxidant properties, facilitating rapid tissue regeneration.

9. Antiviral Activity

Preliminary studies have suggested antiviral activity of iridoids and terpenoids from *P. alba* against viruses like HSV and dengue virus. However, further studies are necessary to elucidate exact mechanisms and validate clinical relevance.

10. Hepatoprotective Activity

P. alba has shown hepatoprotective effects in models of drug- and chemical-induced liver damage. Extracts reduce serum markers of liver injury (ALT, AST, ALP) and oxidative stress, indicating membrane stabilization and antioxidative properties.

11. Antifertility and Uterotonic Effects

Some extracts of *P. alba* have demonstrated antifertility effects in rodent models, possibly by altering the hormonal balance or uterine environment. The uterotonic effect suggests potential use in menstrual regulation, though this requires deeper investigation.

Measurement of Drug Entrapment Efficiency (%EE)

After centrifugation, supernatant was collected and diluted with 10 ml with 7.4 pH buffer solution. This solution was analysed by UV-Visible Spectrophotometer at 288 nm using pH 7.4. It expresses the amount of untrapped drug in the supernatant (Tayade et al., 2004). The Drug Entrapment Efficiency was calculated by following equation 2

$$\% \text{ Entrapment efficiency} = \frac{D_a + D_s}{D_a} * 100 \dots \dots 2$$

Characterization of Nanoparticles

1. Fourier Transform Infrared Spectroscopy

For qualitative analysis, FTIR analyses of Prepared Nano particles, Compritol 888 ATO, Tween 80, physical mixtures, and formulations were performed. The pellet was stored in an Agilent CARY 630 FTIR spectrophotometer sample holder, and it

was scanned between 400 and 4000 cm⁻¹ at a resolution of 4 cm⁻¹ (Racault et al., 1994).

Table.2: Summary of Pharmacological Activity [9]

Pharmacological Activity	Key Constituent involved
Anti-inflammatory	Amyrins, Plumericin
Antimicrobial / Antifungal	Fulvoplumierin, Iridoids
Antioxidant	Flavonoids, Polyphenol
Cytotoxic/ Anticancer	Plumericin, Fulvoplumierin
Analgesic	Alkaloids
Antipyretic	Triterpenoids, Iridoids
Antidiabetic	Flavonoids, Saponin
Wound healing	Tannins, Terpenoids
Antiviral	Iridoids
Hepatoprotective	Phenolics, Iridoids

Conclusion

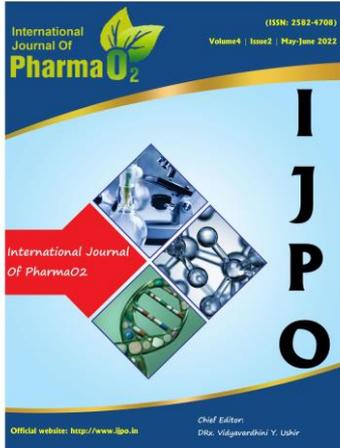
Plumeria alba stands out as a promising medicinal plant, richly endowed with diverse phytochemicals such as flavonoids, alkaloids, terpenoids, and essential oils, which contribute to its wide range of pharmacological activities including anti-inflammatory, antimicrobial, antioxidant, anticancer, and wound healing effects. Despite the substantial traditional and experimental evidence supporting its therapeutic potential, further well-designed preclinical and clinical studies are essential to validate its efficacy and safety. Future research should also focus on the isolation of novel bioactive compounds and understanding their precise mechanisms of action. Overall, *Plumeria alba* holds significant promise for the development of new, plant-based therapeutic agents.

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