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Review Article

Pharmacological Properties of *Melia Azedarach* L.: A Review

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Abstract

Melia azedarach L., commonly known as chinaberry or Persian lilac, is a deciduous tree belonging to the family Meliaceae, widely distributed across tropical and subtropical regions. Traditionally valued in folk medicine, this plant has attracted considerable scientific attention due to its diverse phytochemical composition and broad spectrum of pharmacological activities. The present review comprehensively synthesises current knowledge on the phytopharmacological properties of M. azedarach, highlighting its therapeutic potential, mechanistic insights, and future research prospects. Phytochemical investigations reveal that M. azedarach is a rich source of limonoids, triterpenoids, flavonoids, alkaloids, tannins, and essential oils. Among these, tetranortriterpenoids such as meliatoxins and azedarachins are particularly significant, exhibiting potent bioactivities. The presence of diverse secondary metabolites underpins the plant's multifaceted pharmacological profile, ranging from antimicrobial and antiparasitic to anti-inflammatory and anticancer effects. Extracts from leaves, fruits, bark, and seeds have demonstrated remarkable efficacy in experimental models, supporting traditional claims and paving the way for novel therapeutic applications. Pharmacological studies indicate that M. azedarach possesses strong antimicrobial activity against bacterial and fungal pathogens, validating its ethnomedicinal use in treating infections. In conclusion, Melia azedarach L. represents a promising medicinal resource with diverse phytopharmacological properties. Its rich phytochemistry supports a wide range of biological activities, offering potential leads for drug discovery and development. However, the dual nature of its bioactive compounds—therapeutic at low doses yet toxic at higher concentrations—underscores the need for standardized extraction, formulation, and clinical validation. Future research should focus on isolating novel compounds, elucidating molecular mechanisms, and conducting well-designed clinical trials to translate laboratory findings into safe and effective therapeutic interventions. This comprehensive review aims to provide a consolidated foundation for researchers, clinicians, and pharmacologists to harness the full potential of M. azedarach while addressing safety concerns and exploring innovative applications in medicine and agriculture.

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1. INTRODUCTION

Melia azedarach L, also known as Chinaberry tree, is a well-studied plant native to Southeast Asia. Its leaves, bark, and fruits have been traditionally used for their anti-inflammatory, antipyretic, analgesic, and insecticidal properties (1). The plant contains bioactive compounds like flavonoids, alkaloids, terpenoids, and saponins. Recent studies have shown that extracts from *Melia azedarach* L have anticancer properties and antimicrobial activity against various pathogens. Ayurveda, a traditional Indian medicinal system, has been practiced for thousands of years. Research on pharmacognosy, chemistry, and clinical therapeutics has been conducted on ayurvedic medicinal plants (2). Modern medicine, or allopathy, has evolved over time, but its foundation remains rooted in traditional medicine and therapies. *Melia azedarach* Linn, also known as mahanimba, is a large evergreen tree found throughout India, used for its anthelmintic, antilithic diuretic, emmenagogue, astringent, and stomachic properties (3).

Melia azedarach, also known as bakain, Persian lilac, or Fleurs lilas, is a tree with medicinal properties. It has a long history of use by indigenous people in India and is used in ayurvedic medicine and Unani medicine in Arab countries (4). The tree is highly nutritious and has a calorific value of 5100 kcal/kg. It is also used in manufacturing agricultural implements, furniture, plywood, and fuel wood. *Melia azedarach* is a shade tree in coffee and abaca plantations (Figure 1) (5).

M. azedarach is a deciduous tree or bush, 5-15 meters tall, native to northwestern India. Its branches are heavy, purplish, and spotted with buff-shaded lenticels. Leaves are compound, substitute, and puberulent to glabrous (6). The inflorescence is a panicle, with 5-separated blossoms and green sepals. The natural product is a drupe, greenish yellow to yellowish tan, globosely and 1-1.5 cm in size. *Melia azedarach* L., also known as Chinaberry or Persian Lilac tree, has been known for its restorative and insecticidal properties. It has been developed since the sixteenth century for decorative purposes and has become naturalized in tropical and subtropical countries (Figure 1) (7).

Figure 1: Melia azedarach (A: Leaves and B: Fruits)

2. Geographical Features

Melia azedarach L. is the most recognized species within the small genus *Melia*, which comprises only two members. The generic name derives from the Greek word *melia*, referring to the manna or flowering ash, while *azedarach* traces back to the designation of an ancient poisonous tree. Native to South Asia, the species was later introduced to the Americas, where it became naturalized across tropical regions. Today, its distribution spans a wide geographic range, including China, India, Japan, Indonesia, northern Australia, Africa, North and South America, and parts of southern Europe (8, 9).

Commonly known as the chinaberry tree or Persian lilac, *M. azedarach* belongs to the mahogany family (Meliaceae). Initially indigenous to Asia and Australia, it has spread globally due to its ornamental appeal and medicinal importance. Taxonomically, it is classified under the kingdom Plantae, division Magnoliophyta, class Magnoliopsida, order Sapindales, and genus *Melia*.

The plant is recognized by a multitude of vernacular names across different regions. In India, it is referred to as Bakain, Ramyaka, Drek, Dharek, Karmuka, Keshamushti, Khammaga, Ghoranim, Kalo neem, Bakan Limado, Bakai Nimbu, Neem, Taruka vepa, Malaivernba, Karin vernbu, Serna veppu, Arbevu, Hutchu, and Bakana Nimb. In English-speaking countries, names such as Persian lilac, chinaberry, paradise tree, white cedar, umbrella tree, bead tree, syringa, hoop tree, China tree, and pride of India are common. French regions know it as *lilas des Indes*, *lilas de Chine*, *lilas de Perse*, *paraiso*, and *margoiser*. Other local names include Lelaila, Aleli, Pasilla, and Violeta (Singapore); *mindi kechil* and *persischer zedrachbaum* (Malaysia); *chiwesischer holunder*, *paradiesbaum*, and *persischer flieder* (Germany); *cinarnorno* (Brazil); *ku lian* (China); giant paradise (Argentina); and syringa tree (South Africa) (9, 10).

Morphologically, the tree is characterized by its compound leaves with serrated margins, clusters of small purple flowers, and round yellow drupes (11, 12). While the fruits are considered toxic when ingested, they have long been employed in traditional medicine, particularly for their insecticidal properties (13, 14). This dual nature—ornamental beauty coupled with pharmacological potential—has contributed to the widespread cultivation and study of *M. azedarach* across diverse cultures and scientific disciplines (15, 16).

3. Morphological Features

The small to medium-sized deciduous tree *Melia azedarach* L. can grow up to 45 metres in height. The plant has compound, alternating leaves 20-40 cm long, with serrated, unseasoned leaflets. The inflorescence is a 20 cm long raceme, with fragrant flowers ranging from white to lavender to purple (17). Sepals are separated into five lobes, while the petal is 9 cm long and pubescent. The staminal tube is deep purple, blue, and brown. Fruits are small, yellow stone fruits with four to five black seeds, a diameter of 15 metric linear units, and a smooth, brown surface surrounded by pulp. The plant's fruit is 3.5 mm x 1.6 mm. By direct seeding, it can also be artificially propagated (18). The seed of this plant is 1-1.5cm in diameter and hard as a stone. The mature bark of this plant shows an outer zone of rhytidome, formed of alternative stripes of dark brown cork cells and dead secondary phloem (19).

4. Ethanomedicinal Uses

Melia azedarach is a plant used in Ayurvedic medicine for treating various conditions such as the common cold, inflammation, headaches, stomach issues, diabetes, poisoning, and malaria. The gum secreted from the plant is useful in spleen enlargement cases, while an extract of the timber is used to treat bronchial allergies (20).

Bark decoctions are administered to patients suffering from paroxysmal fever to alleviate symptoms. The plant's leaves are used to treat hysteria, scrofula, and leprosy (21). The juice of the leaves acts as an anthelmintic, emmenagogue, diuretic, expectorant, and vermifuge. The fruits have anthelmintic, emollient, diuretic, and purgative effects (22). The seeds have medicinal applications, including as an aphrodisiac, anthelmintic, expectorant, and aid in treating typhoid fever. Seed oil is frequently applied for skin conditions (23). The roots are used as expectorant, astringent, and febrifuge in treating constipation (24).

5. Phytochemical Content

Leaves of the plant contain terpenoids and limonoids like l-Cinnamoyl 3-acetyl-11-hydroxy Meliacarpin, Deacetylsalannin, 1,3-dicinnamoyl-l1-hydroxyrneliacarpin, β-Pinene, α-Terpinene, Kaempferol-3-O-β-rutinoside, and Rutin, along with acids like palmitic acid and hexadecanoic acid (25). Fruits contain various terpenoids and limonoids, including 15-epoxy-3, 6-Acetoxy-14, 5-diene-7-one, Amoorastatin, Amorastatone, 11-dihydroxymeliaca-l, Azadirachtin-A, Cinnamoylmelianolone, l-Cinnamoyl-3,11-dihydroxy-meliacarpinin, Composite id, 1-O-Deacetyl Ohchinolide-B, 1-Deacetylnimbolinin-A, 3-Deoxy mmelian one, 25- Diepoxy-tirucall-7-ene-21-ol, 29-Deacetylsendanin, 3-Epimeliantriol, Gedunin, 12-a-Hydroxyamoorastatin, Meliandiol, Melianol, Melianolone, Melianone, Meliantriol, Nimbolinin-B, Meliatoxin-A2, Nimbolidin-A, Meliatoxin-B1, Ohchinal, Meliatoxin-B2, Ohchinin acetate (26, 27). Stems consist of terpenoids and limonoids, including acetoxy-14β, 15β-epoxygedunanl-ene-three-O-β-DGlucopyranoside, 12-Acetoxyamoorastatin, Fraxinellone, 12-Hydroxyamoorastatone, and others. They also contain flavonoids like 4',5-Dihydroxy flavone-7-O-u-Lrhamnopyranosyl-(1-4)-β- Glucopyranoside, Anthraquinone, campesterol, cholesterol, and stigmasterol, as well as linoleic acid and oleic acid (28). The root bark of the plant contains various terpenoids and limuloids, including 12-O'Acetyl azadirachtin-A, 12-O-Acetylazedarachin-B, l-Acetyl-3-tigloyl-1, 1-methoxy meliacarpin, 12-O-Acetyltrichilin-B, 2α-Acetyl-29-deacetyl-29-isobutyrylsendanin, Azedarachin-A, Azedarach In-C, n-Cinnamoyl-3-acetyl-11-methoxy meliacarpin, 1-Deoxy-3-methacrylyl-11 methoxymeliacarpinin, 1–Deacetylnimbolinin-B, 1-12-Diacetyltrichilin-B, 29-lsobutyl sendanin, Meliacarpinln, E, Nimbolidin-B, Salannal, Salannin, and steroids like 6-βHydroxy-4-canpesten-3-one, 6-β-Hydroxy-4-Stigmasten-3-one, and Azeclarachol (29). The roots also contain flavonoids, steroids, and acids like Trans-cinnamic acid and Vanillicacid (30).

Table 1: Phytochemical Constituents of *Melia azedarach L.*

Phytochemical Compound/Class	Plant Part	Notes/Activity
Azedarachin A–E (limonoids)	Fruits, leaves	Cytotoxic, insecticidal
Meliatoxins (tetranortriterpenoids)	Fruits, seeds	Neurotoxic, insecticidal
Meliacarpins (C-seco limonoids)	Leaves, twigs	Strong insecticidal activity
Meliarachins A–K (limonoids)	Twigs, leaves	Antifeedant, cytotoxic
Meliasenin A–F	Fruits	Antimicrobial, cytotoxic
Nimbolide (limonoid derivative)	Leaves	Anticancer potential
β-Sitosterol (phytosterol)	Leaves	Most abundant sterol
Stigmasterol	Leaves, bark	Anti-inflammatory
Rutin (flavonoid)	Leaves	Antioxidant, vascular protection
Quercetin (flavonoid)	Leaves	Antioxidant, anti-inflammatory
Kaempferol (flavonoid)	Leaves	Antioxidant
Luteolin (flavonoid)	Leaves	Anti-inflammatory
Total phenolics	Leaves, bark	Antioxidant activity
Total flavonoids	Leaves, bark	Free radical scavenging
Tannins	Bark, fruits	Astringent, antimicrobial
Saponins	Seeds, bark	Hemolytic, insecticidal
Alkaloids	Bark, seeds	Bioactive, toxic at high doses
Proteins	Seeds	Nutritional component (~32%)
Essential oils (terpenoids)	Leaves, fruits	Insecticidal, antimicrobial
Lignans	Bark	Antioxidant, cytotoxic
Degraded limonoids	Fruits	Cytotoxic, insecticidal
Triterpenoids	Fruits, bark	Cytotoxic, anti-inflammatory
Coumarins	Leaves, bark	Antimicrobial
Phenolic acids (gallic, caffeic)	Leaves	Antioxidant

6. Pharmacological Activities

Melia azedarach L. exhibits a wide range of pharmacological activities owing to its diverse phytochemical profile. Extracts from its leaves, fruits, bark, and seeds have demonstrated antimicrobial and antifungal properties, validating its traditional use against infections. The plant shows notable antiparasitic activity against *Leishmania* and *Plasmodium* species, making it relevant in tropical medicine. Anti-inflammatory and analgesic effects are attributed to modulation of cytokine release and inhibition of prostaglandin synthesis, while antioxidant activity from flavonoids and phenolics protects cells against oxidative stress. Limonoids and triterpenoids contribute to anticancer potential by inducing apoptosis and inhibiting tumor proliferation. Additionally, insecticidal and antifeedant properties of limonoids support its use in eco-friendly pest control. Other reported activities include antiviral, hepatoprotective, neuroprotective, and immunomodulatory effects, though toxicity at higher doses remains a concern. Overall, *M. azedarach* represents a promising medicinal resource with multifaceted pharmacological applications, warranting further clinical validation and safety profiling (31-35).

Table 2: Pharmacological Activities

Activity	Bioactive Constituents	Notes/Mechanism
Antimicrobial	Limonoids, tannins, flavonoids	Effective against bacteria and fungi
Antiparasitic	Limonoids, meliatoxins	Active against *Leishmania*, *Plasmodium*
Antiviral	Flavonoids, triterpenoids	Inhibition of viral replication
Anti-inflammatory	Flavonoids, triterpenoids	Cytokine modulation, prostaglandin inhibition
Analgesic	Limonoids, alkaloids	Pain relief in experimental models
Antioxidant	Flavonoids (quercetin, rutin)	Free radical scavenging
Anticancer	Limonoids, triterpenoids	Apoptosis induction, cell cycle arrest
Hepatoprotective	Flavonoids, phenolics	Protection against liver damage
Neuroprotective	Limonoids, sterols	Prevention of neurotoxicity
Immunomodulatory	Saponins, flavonoids	Enhancement of immune response
Insecticidal	Limonoids (meliatoxins, azedarachins)	Eco-friendly pest control
Antifeedant	Limonoids, meliacarpins	Deterrence of insect feeding
Cytotoxic	Limonoids, degraded triterpenoids	Dose-dependent toxicity
Anthelmintic	Alkaloids, saponins	Effective against intestinal worms
Antidiabetic	Flavonoids, phenolic acids	Glucose regulation in models
Cardioprotective	Sterols, flavonoids	Antioxidant and lipid-lowering effects
Wound healing	Tannins, flavonoids	Promotes tissue repair
Antiulcer	Flavonoids, triterpenoids	Gastroprotective activity
Antipyretic	Limonoids, alkaloids	Fever reduction
Antimalarial	Limonoids, meliatoxins	Activity against *Plasmodium* species

7. CONCLUSIONS

Melia azedarach L, also known as Chinaberry tree, is a Southeast Asian plant with anti-inflammatory, antipyretic, analgesic, and insecticidal properties. It contains bioactive compounds like flavonoids, alkaloids, terpenoids, and saponins. Recent studies have shown that extracts from *Melia azedarach* L have anticancer properties and antimicrobial activity against various pathogens. *Melia azedarach* Linn, also known as mahanimba, is a large evergreen tree found throughout India, used for its anthelmintic, antilithic diuretic, emmenagogue, astringent, and stomachic properties. The plant's leaves contain various terpenoids and limonoids, while its fruits, stems, and roots contain terpenoids, limuloids, steroids, and acids. The ethnomedicinal description, phytochemistry, pharmacological action, and therapeutic use of *Melia azedarach* are discussed. The herb has various health benefits, including anti-ulcer, antipyretic, anti-fertility, anti-cancer, antiviral, wound healing, and hepatoprotective properties. Research is needed to purify M. azedarach components and characterize their potential chemical makeup and mode of action.

8 Conflict of Interest: None

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