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A COMPREHENSIVE REVIEW ON THE ETHNOPHARMACOLOGY, PHYTOCHEMISTRY, AND THERAPEUTIC APPLICATIONS OF *BAUHINIA RACEMOSA*

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Abstract

Bauhinia racemosa Lam., commonly called the "Bidi Leaf Tree," is a small to medium-sized deciduous plant native to tropical Asia, notably India and Sri Lanka. Traditionally recognized in Ayurvedic medicine, this species has been used to treat ailments such as diarrhea, wounds, inflammation, respiratory issues, and metabolic disorders. This review emphasizes the ethnobotanical significance, phytochemical profile, and pharmacological activities of the plant. Key bioactive constituents—flavonoids, alkaloids, tannins, steroids, saponins, and triterpenoids—are identified in different plant parts, with variations based on extraction solvents. Studies confirm antioxidant, anti-inflammatory, antidiabetic, antimicrobial, and wound healing activities through in vitro and in vivo models. Modern extraction techniques such as ultrasound-assisted methods have improved the yield and efficacy of therapeutic compounds. Although safety evaluations indicate low toxicity, challenges remain in terms of clinical validation and formulation standardization. With further research, *B. racemosa* holds great potential for development into multifunctional phytopharmaceuticals.

Keywords: *Bauhinia racemosa*, Phytochemicals, Ethnomedicine, Pharmacological activities, Herbal drug development

1. Introduction

Bauhinia racemosa, commonly known as the "Bidi Leaf Tree," is a small to medium-sized deciduous tree belonging to the family *Fabaceae*. Botanically classified under the genus *Bauhinia*, the species is scientifically denoted as *Bauhinia racemosa* Lam. The tree is widely distributed across tropical and subtropical regions of Asia, particularly in India, Sri Lanka, and parts of Southeast Asia [1]. It is well-recognized by its distinct bilobed leaves, which resemble a camel's hoof, and its racemose inflorescence of yellowish-white flowers. This

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versatile plant is known by various vernacular names across different regions and languages. In Hindi, it is referred to as "Apta", "Kanchanara", or "Sonapatta"; in Sanskrit, it is known as "Sona-patri" or "Arimeda"; in Tamil, it is called "Avala"; in Marathi, it is known as "Apta"; and in Telugu, it goes by "Tella-mandaram". These regional names reflect the wide recognition and usage of the plant throughout the Indian subcontinent [2,3].

Bauhinia racemosa has occupied a vital role for centuries. In Ayurveda, it is revered for its diverse therapeutic properties and is included in formulations used to treat a range of ailments, including diarrhea, dysentery, piles, wounds, inflammation, ulcers, and respiratory conditions. The bark is especially valued for its astringent and anti-inflammatory properties, while the leaves, flowers, and roots are employed for their antimicrobial, analgesic, and wound-healing effects. The leaves are also used as wrappers for making traditional Indian bidi cigarettes, which gives the plant significant economic as well as medicinal value [4,5].

Botanical Description: *Bauhinia racemosa* belongs to the Kingdom Plantae, Family Fabaceae, Genus Bauhinia, and Species racemosa. It is a small to medium-sized deciduous tree that typically grows to a height of 6–9 meters. The bark is smooth and greyish-brown, often fissured with age. The leaves are simple, bilobed, and resemble a camel's hoof, a characteristic feature of the genus. Flowers are pale yellowish-white, fragrant, and arranged in racemose inflorescences. The tree produces flat, elongated pods that contain several hard, brown seeds. *Bauhinia racemosa* is commonly found in dry deciduous forests and scrublands and is widely distributed across India, Sri Lanka, and parts of Southeast Asia, thriving in warm tropical climates and well-drained soils [1].

2. **Objectives**: The objective of this review is to explore the traditional uses, phytochemical constituents, and pharmacological activities of *Bauhinia racemosa*. It aims to highlight its therapeutic potential and promote further scientific research.

3. Traditional Uses

- Used in Ayurveda as a key ingredient in Kanchanar Guggulu for treating thyroid issues and glandular swellings.
- Leaves are applied as a poultice for wounds, swellings, and skin infections.
- Bark decoction is taken for diarrhea, dysentery, and as a febrifuge.
- Flowers are used in respiratory ailments like asthma and cough [6].
- Root extracts are given for intestinal worms and stomach disorders.
- Folk medicine uses leaf juice for ear pain, ulcers, and snake bites.

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- The plant is valued ethnobotanically for its antimicrobial, anti-inflammatory, and analgesic actions [7].

4. Phytochemical Constituents

Bauhinia racemosa is known for its rich phytochemical profile distributed across various parts of the plant, including the leaves, bark, roots, and flowers. Phytochemical screening has revealed the presence of several major classes of bioactive compounds such as flavonoids (e.g., quercetin, kaempferol), tannins, steroids, triterpenoids, alkaloids, saponins, and glycosides. These constituents are responsible for the plant's various pharmacological actions including antioxidant, antimicrobial, anti-inflammatory, and wound healing properties [8]. The phytochemical content varies depending on the part of the plant and the solvent used for extraction. Methanolic and ethanolic extracts of the leaves and bark are particularly rich in flavonoids, tannins, and alkaloids, while aqueous extracts show a predominance of tannins and carbohydrates. Root extracts have shown the presence of alkaloids and steroids, and floral extracts primarily contain flavonoids and phenolic glycosides [8,9]. The table below summarizes the phytoconstituents identified in various parts of the plant using different solvents:

Table1: Phytochemical Constituents of *Bauhinia racemosa* [8,9]

Sr. No.	Plant Part	Solvent Used	Phytoconstituents Identified
1	Leaves	Methanol	Flavonoids, tannins, alkaloids, saponins, glycosides
2	Leaves	Aqueous	Tannins, flavonoids, carbohydrates, proteins
3	Bark	Ethanol	Flavonoids, tannins, steroids, alkaloids
4	Bark	Methanol	Glycosides, flavonoids, saponins, triterpenoids
5	Root	Methanol	Alkaloids, steroids, flavonoids
6	Flowers	Ethanol	Flavonoids, glycosides, phenolic compounds

5. Pharmacological Activities: Some activities are being shown by the *Bauhinia racemosa* which are explained below:

• **Antioxidant Activity**: *Bauhinia racemosa* exhibits significant antioxidant properties, primarily attributed to its high content of flavonoids and phenolic compounds. Studies using DPPH (2,2-diphenyl-1-picrylhydrazyl) and FRAP (Ferric Reducing Antioxidant Power) assays have confirmed its radical scavenging potential. Methanolic extracts of the leaves and

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bark have shown dose-dependent antioxidant activity, which supports its traditional use in managing oxidative stress-related conditions [10].

• **Anti-inflammatory and Analgesic Effects:** Experimental models in rats and mice have demonstrated that the plant possesses anti-inflammatory and analgesic properties. Carrageenan-induced paw edema and acetic acid-induced writhing tests have revealed that ethanolic and methanolic extracts of the bark and leaves significantly reduce inflammation and pain. These effects are likely due to the presence of flavonoids, triterpenoids, and steroids that inhibit prostaglandin synthesis and other inflammatory mediators [11].

• **Antidiabetic Properties**: In in vivo studies, particularly in streptozotocin-induced diabetic rat models, the oral administration of *Bauhinia racemosa* leaf extracts has shown significant hypoglycemic effects. The plant extract helps in lowering blood glucose levels, possibly by enhancing insulin secretion or increasing glucose uptake by tissues. These effects are supported by the presence of glycosides and flavonoids, which are known to exhibit insulin-mimetic actions [10,11].

• **Antimicrobial and Antifungal Activity**: The plant exhibits broad-spectrum antimicrobial activity against various Gram-positive and Gram-negative bacteria, as well as certain fungal strains. Extracts of bark and leaves (especially methanol and ethanol-based) have shown inhibitory zones in agar diffusion assays against *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, and *Candida albicans*. The antimicrobial effect is attributed to the alkaloids, tannins, and flavonoids present in the plant [12].

• **Wound Healing Activity:** Topical application of *Bauhinia racemosa* leaf paste or extract-based ointments has demonstrated effective wound healing in excision and incision wound models in rats. It accelerates the wound closure rate, enhances collagen synthesis, and reduces the inflammation period. This activity is due to the presence of tannins, flavonoids, and saponins, which contribute to tissue regeneration and antimicrobial protection of wounds [12].

• **Anti-cancer and Hepatoprotective Potentials:** Although limited, some studies suggest the anti-cancer potential of *Bauhinia racemosa* due to its antioxidant and cytotoxic activity against certain cancer cell lines. Methanolic extracts have shown moderate inhibition of cell proliferation in in vitro models. Additionally, hepatoprotective effects have been observed in paracetamol-induced liver toxicity models in rats, where the extracts helped in restoring liver enzymes (ALT, AST) and histological architecture. These properties are linked to the antioxidant defense mechanisms enhanced by flavonoids and triterpenoids [10-12].

6. Extraction Methods:

Various extraction methods have been employed to isolate the bioactive constituents of *Bauhinia racemosa*, depending on the nature of compounds targeted and the plant part used.

- **Soxhlet Extraction:** This is a widely used hot extraction method, especially for extracting non-polar to moderately polar phytochemicals from leaves, bark, and roots using solvents like methanol, ethanol, chloroform, or petroleum ether. It ensures exhaustive extraction and is suitable for phytochemical and pharmacological studies [13].
- **Cold Maceration:** In this cold extraction method, powdered plant material is soaked in solvents such as water, alcohol, or hydroalcoholic mixtures at room temperature for 48–72 hours. This method is particularly used for heat-sensitive compounds, mainly flavonoids and glycosides. It is commonly applied in traditional medicine and ethnobotanical studies [13].
- **Aqueous Extraction (Decoction/Infusion):** Traditional methods involve boiling or steeping the plant parts (especially bark and leaves) in water to prepare decoctions or infusions. This method is used in Ayurvedic practices and provides extracts rich in tannins, saponins, and phenolic compounds [14].
- **Ultrasound-Assisted Extraction (UAE) *(modern method)*:** Recent approaches have also utilized ultrasound waves to enhance extraction efficiency and reduce solvent usage and time. It is suitable for thermolabile and high-value phytochemicals and yields better recovery of antioxidants and flavonoids [14].

7. Conclusion

Bauhinia racemosa stands out as a versatile medicinal plant with a broad spectrum of traditional and scientifically validated pharmacological activities, including antioxidant, anti-inflammatory, antidiabetic, antimicrobial, and wound healing effects. Toxicity studies indicate that it is relatively safe, with a high LD_{50} and minimal cytotoxicity at therapeutic doses, though long-term safety profiles and GRAS regulatory approvals remain areas for further exploration. A few patents and commercial herbal products already utilize its extracts, particularly in Ayurvedic formulations like Kanchanar Guggulu, yet there is considerable untapped potential. Current research gaps include limited clinical trials, lack of standardized extract formulations, and inadequate quality control measures. Prospects lie in the development of novel delivery systems, such as nano-formulations, and exploring its use in synergistic herbal combinations. Overall, *Bauhinia racemosa* holds significant promise as a

multi-target phytomedicine, warranting deeper clinical and pharmacological investigation to fully harness its therapeutic value.

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