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Review

Pterocarpus marsupium: A Review of Its Phytochemistry and Pharmacological Spectrum

Siddharth Prakash[1]*, Umesh Pratap Singh[2], Nidhi Srivastava[3]

[1]*Research Scholar, Department of Pharmacy, Rameshwaram Institute of Technology and Management, Sitapur Road, Lucknow, Uttar Pradesh, India*

[2]*Director, Department of Pharmacy, Rameshwaram Institute of Technology and Management, Sitapur Road, Lucknow, Uttar Pradesh, India*

[3]*Assistant Professor, Department of Pharmacy, Rameshwaram Institute of Technology and Management, Sitapur Road, Lucknow, Uttar Pradesh, India*

Corresponding Author:
Siddharth Prakash

Email: *sid887455@gmail.com*

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Abstract:

Pterocarpus marsupium, commonly known as Indian Kino Tree, is a versatile medicinal plant widely used in traditional systems of medicine across India, Sri Lanka, and Nepal. This comprehensive review highlights its botanical profile, phytochemical constituents, and diverse pharmacological properties. The plant is a rich source of bioactive compounds such as pterostilbene, marsupsin, and various flavonoid glycosides, which contribute to its therapeutic efficacy. Pharmacological studies demonstrate that extracts from different parts of the plant exhibit antihyperglycemic, antihyperlipidemic, hepatoprotective, anti-inflammatory, antimicrobial, anticancer, antifungal, anti-cataract, and antidiarrheal activities. Its efficacy in lowering blood glucose levels without noticeable toxicity has been affirmed in multicenter ICMR trials. The plant also shows promising cytotoxic activity through apoptosis induction mechanisms and exhibits strong antimicrobial potential against a broad spectrum of pathogens. Despite its beneficial effects, *P. marsupium* is not recommended in cases of constipation due to its astringent nature. Given the increasing reliance on plant-based therapeutics in primary healthcare, especially in rural settings, *P. marsupium* stands out as a significant candidate for further pharmacological research and clinical validation. This review aims to consolidate existing data and encourage future investigations into the therapeutic potential of this valuable medicinal species.

Keywords: *Pterocarpus marsupium*, phytochemicals, antidiabetic, antimicrobial, pterostilbene, hepatoprotective.

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Introduction:

Traditional medicine, which operates outside the scope of Western medicine, has existed since the earliest days of human civilization and primarily relies on medicinal plants.[1] Currently, herbal medicine is drawing significant interest, especially in low- and middle-income countries, where approximately 80% of the population depends on these treatments as their main healthcare approach. The therapeutic compounds present in medicinal plants are referred to as bioactive constituents. In traditional healing practices, these compounds are often unknown to practitioners, and their composition can vary from one plant to another. Some well-known bioactive constituents that contribute to the treatment of various diseases include anthraquinones, flavonoids, glycosides, morphine, saponins, tannins, atropine, codeine, steroids, lactones, and essential oils.[2,3]

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Plants have been processed and utilized in various forms—including infusions, syrups, decoctions, fortified and essential oils, ointments, and creams—for the treatment of numerous health conditions.[4]

Pterocarpus marsupium (PM), locally known in Sinhala as *Gammalu*, is one such medicinal plant traditionally employed for managing various ailments due to its diverse pharmacological properties. Also referred to as Malabar kino, Indian kino, or gum kino, this plant has a rich history of medicinal use.[5,6] It is a medium- to large-sized deciduous tree native to regions such as Sri Lanka, India, and Nepal, and can reach a height of up to 30 meters.[7]

Table-1 The scientific classification of *Pterocarpus marsupium*[8]

Taxonomic Rank	**Classification**
Domain	Eukaryota
Kingdom	Plantae
Subkingdom	Viridiplantae
Phylum	Magnoliophyta
Subphylum	Euphyllophytina
Class	Magnoliopsida
Subclass	Rosidae
Superorder	Fabanae
Order	Fabales
Family	Fabaceae
Genus	*Pterocarpus*
Species	*marsupium*

Botanical Profile

The plant is a medium to large-sized tree, typically growing between 15 and 30 meters in height. Its trunk is thick, irregular, and twisted, supporting a wide canopy with extensively spreading branches. The bark is coarse and varies in color from dark brown to grey. Leaves are compound and imparipinnate, typically comprising 5 to 7 leathery leaflets. These leaflets are oblong in shape, rounded or notched at the tip, occasionally bilobed, and smooth on both sides. The petioles are cylindrical, smooth, undulating between each leaflet, and measure about 5 to 6 inches in length, with no stipules present. The tree bears large, terminal panicles, whose branching pattern mimics that of the leaves. Peduncles and pedicels are slightly hairy and cylindrical. Small, short-lived bracts are found singly beneath each division of the panicle. The flowers are abundant, predominantly white with a subtle yellow hue. The vexillum (standard petal) is broad with a long, narrow base, its edges turned backward, undulating, curled, and veined. The keel is composed of two petals, slightly fused near the center, wavy and similar in structure to the vexillum. There are 10 stamens, united at the base and then separating into two sets of five; the anthers are spherical and two-lobed. The ovary is hairy, oblong, and borne on a short stalk, generally containing two chambers, each with a single seed. The style rises upward. The fruit is a legume, attached to a long stalk, nearly three-quarters circular in shape. The portion extending from the pedicel to the upper end of the style remains straight. The entire fruit is encased in a wavy, veined, hairy, membranous wing. Its center is thickened, rough, and woody, housing the seed(s), which do not naturally open upon maturity. Typically, the fruit contains a single kidney-shaped seed, though occasionally it may be two. [9,10]

Description of the Drug

The drug is derived from the heartwood of *Pterocarpus marsupium*. It appears as irregularly shaped fragments of varying sizes and thicknesses. The surface exhibits a golden yellowish-brown hue interspersed with darker streaks. The texture is extremely hard and brittle. When immersed in water, it produces a yellow-colored solution that displays blue fluorescence. Microscopic examination of a transverse section reveals alternating layers of larger and smaller polygonal cells, composed of tracheids, fibre tracheids, xylem parenchyma, and xylem rays. The xylem vessels are scattered throughout the section. Tyloses, often containing tannins, are prominently observed. The tracheids are elongated, have thick walls, tapering ends, and possess simple pits. Xylem parenchyma cells are rectangular in

shape, also bearing simple pits, while the xylem rays are uniseriate to biseriate. Calcium oxalate crystals are present within the tissue, but starch grains are absent.[11]

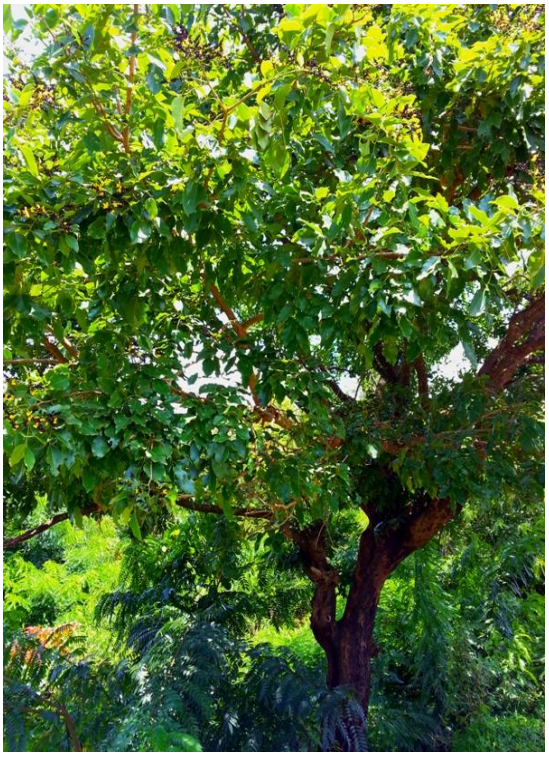

Figure 1- Picture of *Pterocarpus marsupium* [36]

Table 2- Vernacular name of *Pterocarpus marsupium* [11]

Language	Synonym(s)
Sanskrit	Bījaka, Pītāsara, Asanaka, Bījasāra
Assamese	Aajar
Bengali	Piyasala, Pitasala
English	Indian Kino Tree
Gujarati	Biyo
Hindi	Vijyasara, Bija
Kannada	Bijasara, Asana
Kashmiri	Lal Chandeur
Malayalam	Venga
Marathi	Bibala
Oriya	Piashala
Punjabi	Chandan Lal, Channanlal

Phytochemistry

The ethyl acetate extract derived from the dried and powdered heartwood of *Pterocarpus marsupium* was found to contain several phytoconstituents, including pterostilbene, (2S)-7-hydroxyflavanone, isoliquiritigenin, liquiritigenin, 7,4'-dihydroxyflavone, marsupsin, pterosupin, p-hydroxybenzaldehyde, (2R)-3-(p-hydroxyphenyl)-lactic acid, and a compound identified as pm-33. [12] According to Tripathi and Joshi, the ethyl acetate fraction of *Pterocarpus marsupium* yielded three key compounds: retusin-8-O-α-L-arabinopyranoside, naringenin, and lupeol.[13] Further chemical analysis of the ethyl acetate extract from an aqueous decoction of the dried heartwood led to the identification of pterocarpol. In another study, Handa and colleagues isolated a C-glucoside isoaurone, which they named pterocarposide. [14] Additionally, Suri et al. discovered a novel C-glucoside, 1-(2',6'-dihydroxyphenyl)-β-D-

glucopyranoside, from the aqueous extract of powdered heartwood.[15] Maurya and coworkers prepared an aqueous extract of the heartwood and isolated five previously unidentified flavonoid C-glucosides, namely pteroside, pteroisoauroside, marsuposide, flavon C-glucoside, and vijayosin, along with two known compounds: C-β-D-glucopyranosyl-2,6-dihydroxybenzene and a sesquiterpene.[16] In a separate investigation, the bark of *Pterocarpus marsupium* was processed using ethanol extraction via percolation, revealing the presence of the phenolic compound (-)-epicatechin. Additionally, the sterols sitosterol and stigmasterol were isolated. Tripathi and Joshi also reported the extraction of two novel flavonoid glycosides from the roots of this plant: 7-hydroxy-6,8-dimethylflavanone-7-O-α-L-arabinopyranoside and 7,8,4'-trihydroxy-3',5'-dimethoxyflavanone-4'-O-β-D-glucopyranoside.[17]

Documented Pharmacological Properties of *Pterocarpus marsupium*

1. **Antihyperlipidemic Activity:** The synergistic impact of a combined methanolic extract from *Ocimum sanctum* leaves and *Pterocarpus marsupium* heartwood was evaluated in both non-diabetic and oxidative stress-induced diabetic female Wistar rats (diabetes induced via alloxan administration). When administered at a dose of 500 mg/kg body weight, the combined extracts significantly improved lipid profile abnormalities (dyslipidemia) and enhanced the body's intrinsic antioxidant defense mechanisms in both test groups. [18,19] Furthermore, ethanolic extracts prepared from the wood and bark of *P. marsupium*, administered at a combined dose of 150 mg/kg body weight each, resulted in a notable reduction in blood glucose and lipid levels in albino Wistar rats with alloxan-induced diabetes (150 mg/kg, intraperitoneally) over a 14-day treatment period.[20]
2. **Antihyperglycemic Activity:** The hypoglycemic potential of key phenolic compounds isolated from *P. marsupium* heartwood—marsupsin, pterosupin, and pterostilbene—was evaluated in streptozotocin-induced diabetic rats. Intraperitoneal administration of marsupsin and pterostilbene resulted in a substantial decrease in blood glucose levels, underscoring their effectiveness as natural antihyperglycemic agents [21,22].
3. **Antidiarrheal Activity:** The ethanolic extract of *P. marsupium* heartwood demonstrated significant antidiarrheal activity in castor oil- and charcoal-induced gastrointestinal motility models in rats. At doses of 250 and 500 mg/kg body weight, the extract markedly reduced the frequency and severity of diarrheal episodes, supporting its traditional application for the treatment of diarrhea [23].
4. **Antifungal Activity:** In a ten-day clinical evaluation, the alcoholic extract of *P. marsupium* exhibited superior antifungal efficacy, with 78% and 93% of cases showing positive outcomes by the seventh and tenth day of treatment, respectively. In comparison, the aqueous extract showed a 73% effectiveness rate. The alcoholic formulation also produced noticeable therapeutic effects within just three days of application against *Tinea cruris* and *Tinea corporis*, validating its role as an effective topical antifungal agent [24].
5. **Anti-Cataract Activity:** The aqueous bark extract of *P. marsupium* demonstrated anti-cataract properties in alloxan-induced diabetic rat models. The treatment helped delay or prevent cataract formation, indicating its potential as a natural anti-cataract therapeutic [25].
6. **Anti-Inflammatory Activity:** Both methanolic and aqueous extracts of *P. marsupium* were tested using a carrageenan-induced rat paw edema model to assess their anti-inflammatory efficacy. The methanolic extract at 50 mg/kg and the aqueous extract at 100 mg/kg significantly reduced inflammation. Pterostilbene, a prominent compound in the plant, has also been recognized for its potent anti-inflammatory effects [26,27].
7. **Toxic Effects:** Due to its astringent properties, *Pterocarpus marsupium* is not recommended for individuals suffering from constipation [28]. A geotaxis assessment was performed on *P. marsupium* using both somatic and germ cells, particularly considering that herbal

treatments for diabetes are often used over extended periods. The results indicated that the extract did not exhibit any significant geotaxis effects [29]. In a study conducted by an ICMR research group across multiple centers, *P. marsupium* demonstrated a substantial reduction in blood glucose levels without any apparent adverse effects [30].

8. **Antimicrobial Activity:** The antimicrobial efficacy of aqueous and methanolic bark extracts of *P. marsupium* was evaluated using the disc diffusion method. The inhibition zones ranged from 11 to 22 mm. The extracts showed significant bactericidal activity against a range of pathogens, including *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *Salmonella typhi*, *Proteus mirabilis*, and *Micrococcus sp.* The methanolic extract of the stem bark, including apical, middle, and mature bark, exhibited potent antibacterial effects at various concentrations [31].
9. **Anticancer Activity:** The anticancer properties of *P. marsupium* were studied by Gosetti et al. using calcein acetoxymethyl ester (calcein-AM) assays to assess the cytotoxicity of its aqueous extract. The study found that pterostilbene, a key compound in *P. marsupium*, inhibited cell proliferation. It induced mitochondrial apoptotic signals, including upregulation of Bax, and activated a cascade of caspases, leading to cell death. Pterostilbene showed potential as a multi-target agent for inducing apoptosis, with applications in the treatment of breast and prostate cancer [32, 33].
10. **Antibacterial Activity:** The antibacterial activity of methanolic extracts from the stem of *P. marsupium* was investigated using the paper disc diffusion method. The extract showed significant growth inhibition of both gram-positive bacteria (*Bacillus coagulans*) and gram-negative bacteria (*Escherichia coli*). A concentration of 100 mg/mL was found to be highly effective in suppressing bacterial growth [34].
11. **Hepatoprotective Activity:** *Pterocarpus marsupium* methanolic extract has demonstrated hepatoprotective effects. In a study, the extract was administered at doses of 100 and 300 mg/kg body weight per day for 21 days, resulting in a dose-dependent reduction in serum glucose levels. The extract also regulated biomarkers such as total bilirubin, serum proteins, and enzymes like alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALP). Histopathological analysis revealed normal hepatic cords with no fatty infiltration or necrosis in the treated groups, indicating the hepatoprotective potential of the plant [35].

Conclusion

Pterocarpus marsupium is a valuable medicinal plant with a rich ethnobotanical history and a wide spectrum of pharmacological activities. Its diverse bioactive constituents—especially flavonoids, stilbenes, and tannins—contribute to its therapeutic potential in managing chronic and acute health conditions such as diabetes, inflammation, microbial infections, cancer, and liver disorders. Numerous in vivo and in vitro studies have validated the efficacy of its extracts, particularly in reducing blood glucose levels and improving lipid profiles, making it a strong natural candidate for anti-diabetic formulations. The plant also demonstrates significant antimicrobial and anticancer activities, attributed mainly to compounds like pterostilbene. Despite its promising health benefits, caution is warranted due to its astringent properties, which may aggravate certain conditions like constipation. The absence of major toxicity in long-term use further strengthens its potential for clinical applications. However, standardized dosing, clinical trials, and toxicity profiling are essential to ensure its safe and effective integration into modern therapeutics. Overall, *P. marsupium* represents a potent natural resource that deserves further exploration for novel drug development and integrative healthcare solutions.

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