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Review Article

# *Butea monosperma* (Lam.) Taub.: A Comprehensive Review of its Phytochemistry, Traditional Uses, and Pharmacological Profile

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## Abstract

**Objective(s):** Butea monosperma (Lam.) Taub., also referred to as the "Flame of the Forest" or "Plash," is a highly prized medicinal plant that is frequently used in Ayurvedic and Unani traditional Indian medical systems. The goal of this thorough review is to methodically summarize the phytochemistry, pharmacognostic traits, botanical profile, and numerous pharmacological activities of its different sections, such as the flowers, leaves, seeds, stem, and bark.

**Data sources for Study selection:** Literature from various scientific databases was reviewed.

**Summary of contents of the article:** Important secondary metabolites such alkaloids, flavonoids, tannins, sterols, and isoflavones are identified by phytochemical analyses. Significant antidiabetic, anti-inflammatory, antibacterial, anthelmintic, wound healing, and osteoprotective benefits are among the many therapeutic qualities that these bioactive components are principally responsible for. Additionally, this analysis provides a fair scientific viewpoint by highlighting the safety profile and possible toxicity linked to the long-term ingestion of several plant parts.

**Conclusion:** This study offers a strong basis for future researchers to investigate Butea monosperma for the creation of safe, standardized, and efficient commercial treatments by bridging the gap between traditional ethnomedical claims and contemporary pharmacological data.

**Keywords:** *Butea monosperma*, *Fabaceae*, Phytochemistry, Pharmacological activity, Palash, Traditional medicine.

## 1. Introduction:

Natural Products have been highly important in the treatment and prevention of human ailment all over the world.[1] As per WHO reports, around 80% of people globally depend on traditional healers for their primary health needs. India is uniquely positioned in this area, being home to the majority of the world's medicinal plants.[2] Three of India's major traditional medical systems include Ayurveda, Siddha, and Unani.[3] Currently, many people prefer herbal treatments over synthetic drugs because they are highly effective, affordable, easy to get, and have minimal side effects.[4]

*Butea monosperma* is one of the hundreds of plants that are said to have the ability to cure various illnesses in Indian ethnobotanical literature.[1] Commonly referred to as the "flame of forest," it is a member of the *Fabaceae* ( previously *Leguminosae*) family.[5] With 630 genera and 18,000 species, this family makes up one of the biggest groups all throughout the south Asian peninsula and India.[6] In Indian culture, the tree symbolizes the fire god Agnidev. Additionally, its vibrant flowers are often offered to goddess kali instead of blood during certain rituals.[7, 8]

In addition to its broad medicinal uses in Ayurveda and Unani treatments, the plant is utilized economically. Its leaves are used to make bowls, cups, platters, and beedi wrappers. Cordage is made is used for water scoops, well curbs, and wood pulp for newsprint.[6] Furthermore, the tree is helpful in creating natural lac since it serves as a host lac insects.[9]

Despite these extensive traditional and economic uses, the only problem is that these medicines must be objectively assessed using modern scientific parameters. Therefore, the current review focuses on the morphology, each plant part's traditional usage, phytochemical components, ethnobotany, products produced by the plant, and its diverse pharmacological roles.

## 2. Botanical Profiling and Geographical Distribution

### 2.1. Taxonomic Classification[10]

Butea monosperma (Lam.) Taubert is a major plant within the Fabaceae family. Botanical classify this tree systematically from its kingdom down to its species level. The detailed botanical classification is provided in Table 1.

**Table 1:** Taxonomic classification of *Butea monosperma.*

| Taxonomic Rank | Name |
|---|---|
| Kingdom | Plantae (Plants) |
| Sub-kingdom | Tracheobionta (Vascular plants) |
| Super-division<br>Division<br>Class<br>subclass | Spermatophyte (Seed plants)<br>Magnoliophyta (Dicotyledons)<br>Magnoliopsida ( Dicotyledons)<br>Rosidae |
| Order<br>Family | Fabales<br>Fabaceae ( pea family) |
| Subfamily | Faboideae |
| Genus | Butea Roxb.ex Wild. ( Butea) |
| Species | Monosperma ( Lam.) Taubert ( Bengal Kino) |

### 2.2. Synonyms and Vernacular Names[17]

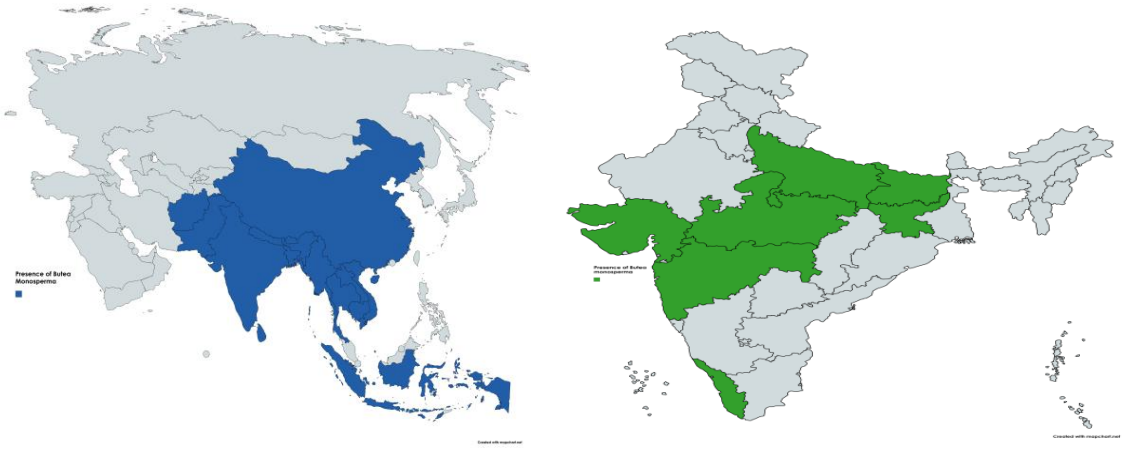
The plant has several local names depending on the region. In English, it is commonly known as the Flame of the Forest, Bastard Teak, or Parrot Tree. In India, people locally call it Dhak or Palas in Hindi, Palas in Marathi, Modugu Puvvu in Telugu, and kimsuka or Bramha Vrksa in Sanskrit.

**Table 2:** Varnacular names and synonyms of *Butea monosperma.*

| Sr No. | Language/ Region | Synonyms/Vernacular Names |
|---|---|---|
| ***Indian Language*** | | |
| 1 | English | Flame of the forest, Bastard teaks, Parrot Tree |
| 2 | Hindi | Dhak, Palas, Chichra tesu, Desukajhad, Chalcha |
| 3 | Marathi | Palas, Kakracha |
| 4 | Punjabi | Tesh |
| 5 | Kannada | Muttagamara, Muttulu |
| 6 | Malayalam | Plasu Camata, Muriku, Shamata |
| 7 | Sanskrit | Palasah, Kimsuka, Bramha Vrksa |
| 8 | Oriya | Porasu, Kijuko |
| 9 | Tamil | Porasum, Parasu, Camata |
| 10 | Telugu | Modugu Puvvu |
| 11 | Gujarat | Ki, Kesuda |
| 12 | Bengali | Palas, Polashi |
| 13 | Urdu | Palashpapra, Dhak (Tesu) |
| ***Foreign Language*** | | |
| 1 | Burmese | Pouk-PEN |
| 2 | Cantonese | Muthuga |
| 3 | Indonesian | Palasa, Plasa |
| 4 | Javanese | Plasa |
| 5 | Khmer | Chaa |
| 6 | Lao(Sino-Tibetan) | Chaan |
| 7 | Nepali | Dhak, Palans, Paras |
| 8 | Thai | Tong, Kwaao, Tong thammachaat |
| 9 | Sinhala | kela |

### 2.3. Geographical Distribution

The tropical and subtropical regions of South and Southeast Asia are where *Butea monosperma* first appeared. Geographically, it can be found in a number of Asian countries, including China, Bangladesh, Nepal, Sri Lanka, Myanmar, Thailand, and Indonesia. The tree is mainly associated with Bihar and Jharkhand in India, according to early sources. Nowadays, practically every Indian state, including Maharashtra, Madhya Pradesh, Uttar Pradesh, Gujarat, and Kerala, has an abundance of it.[11]



**A** **B**

**Figure 1:** Geographical distribution of *Butea monosperma.* (A) Presence across Asian countries; (B) Prominent distribution across Indian states.

### 2.4. Habitat and Ecology

Butea monosperma is typically found in India's drier areas. Although the tree is very resistant to drought, severe dry spells may cause its leaves to drop and turn white. It thrives in regions that receive between 450 and 4500 mm of rainfall annually. The plants may grow in a variety of soil types, such as clay loams, black cotton soil, shallow gravelly places, and even wet or salty areas. Interestingly, findings indicate that seedling thrive in pure black soil.[12]

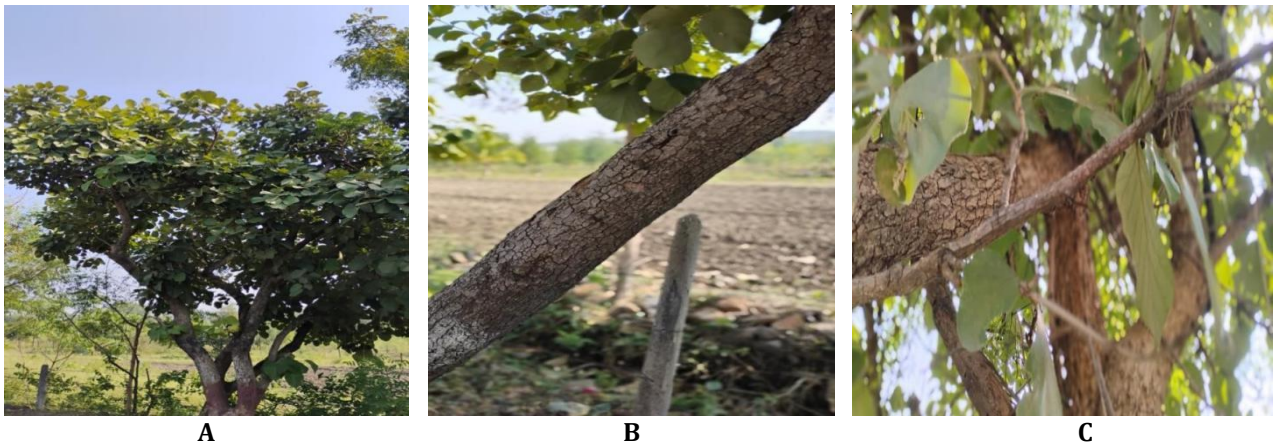
### 2.5. Cultivation and Propagation Practices

The seedlings require high temperatures, good relative humidity, and rich loamy soil (pH 6-7) for healthy growth. Growers place the pods 25-30 cm apart and lightly cover them with soil to cultivate the plant. Alternatively, before the rainy season starts, they disperse mature seeds at a distance of 10cm in nursery beds. Every day, the nursery needs to be weeded and watered. During the rainy season, the seedlings are moved after the stem has been chopped to a length of 5 cm. Additionally, the air layering approach for clonal propagation can quickly establish plantations.[12]

## 3. Macroscopic Evaluation

### 3.1. General Appearance (Tree, Stem, Bark, Wood, and Root)

*Butea monosperma* is an upright, deciduous tree with a crooked, twisted trunk that is 20 to 40 centimeters in diameter and a height range of 5 to 15 meters (up to 20 meters). 43 cm is the maximum diameter at breast height (DBH). The shoots have a smooth, brown or grey pubescence covering them, while the branches are uneven and heavily pubescence covering them, while the branches are uneven and heavily pubescent. The bark has a fibrous, ash-colored, greyish-brown appearance with red exudates. With a delicate, porous texture and hardly perceptible annual rings, the wood is greenish-white in color. The soft wood weighs about 14 to15kg per cubic foot. It is useful for piles and well curbs since it lasts much longer underwater but soon perishes under weather swings[13]. The plant has several lateral roots for stable anchorage in addition to a thick, long, well- developed tap root.[14]



**A** **B** **C**

**Figure 2:** General appearance of *Butea monosperma.* (A) Whole Plant; (B) Stem; (C) Bark

### 3.2. Leaves

The leaves have linear-lanceolate stipules and are foliate, big, trifoliate, and stipulate. The petiole is 10 to 15 cm long and sturdy. The underside of leaflets is delicately smooth, hairy, velvety, and clearly reticulate-veined, while the top is obtuse, coriaceous, and glabrous. They originate from deltoid or connate bases. The leaves, which are 15 to 20 cm long, are rich in oleic and lignoceric acids and contain glucosides and kino-oil. The leaves reappear in the spring after the plant goes bald from January to March.[15]



**Figure 3:** Leaves of *Butea monosperma*

### 3.3. Flower (Calyx and Corolla)

The main characteristic of the plant is its flowers, which grow on bare branches in huge, stiff racemes up to 15 cm in length. The calyx is around 12 to 13 mm long, dark olive green to brown in color, and richly velvety on the outside. Its internal hair is silky, and it has three bottom equal teeth and two upper connate teeth. The corolla measures 3 to5 cm in length and 2 to 4 cm in diameter. It is saffron, bright orange-red, or salmon in color. Its unique shape is semi-circular and beaked, and its exterior is coated with silky, silvery hair. These flowers last from February to nearly the end of April and are frequently closely clustered.[14, 16]



**Figure 4:** Flowers of *Butea monosperma*

### 3.4. Fruit, Pod, and Seed

The fruit is an indehiscent, stalked pod with short brown hairs all over it. It takes on a light gray or yellowish- brown hue when mature. The pods have a single seed near the summit, are 12.5-20 cm long and 2.5-5 cm wide, flat in the reticulate veins. The seeds are ellipsoid, kidney-shaped, and flattened. Their dimensions range from 24 to 25 mm in length, 15 to 25 mm in breadth, and 1 to 3 mm in thickness.[17, 18] The seed coat is glossy, wrinkled, and dark reddish- brown. It has two big, yellowish cotyledons and of thin, glossy hilum in the center of the bulged border. The seed has a subtle smell and a somewhat harsh, caustic taste.[14]

**Table 3:** Morphological characteristics of *Butea monosperma* (Lam.) Taub.

| Plant Parts | Morphological Description |
|---|---|
| Leaf | Trifoliate leaves with linear stipules; each leaflet is obtuse, glabrous, silky, and distinctly reticulate-veined beneath.<br>Leaflets measure 15-20cm in length and arise from deltoid, connate bases.<br>Leaves contain glucosides and Kino-oil rich in oleic and lignoceric acids. |
| Flower | Flowers are large, bright orange-red, and velvety on the outer surface, appearing in dense clusters on leafless branches from February to April.<br>The calyx is dark olive green to brown, velvety, about 13mm long. The corolla is 3-5cm in length, saffron-orange in color, with silky, silvery hairs externally.<br>Flowers are typically arranged in stiff racemes up to 15cm long.<br>Calyx is thickly velvety externally, dark olive green to brown, measuring around 13mm.<br>Corolla is bright orange-red, smooth, with silvery hairs, 3-5cm long, forming a beak-shaped standard petal-the most distinctive feature of the species. |
| Fruit | Pods are stalked, indehiscent, and covered with short brown hairs.<br>When mature, they become pale yellowish-brown or gray.<br>The pods are 12-20cm long and 2.5-5cm wide, flat in the lower portion with a single seed near the apex. |

| | |
|---|---|
| Seed | Seeds are flattened, kidney-shaped, and dark reddish-brown with a glossy, wrinkled surface.<br>Size varies from 24–45 mm in length, 15–25 mm in width, and 1–3 mm in thickness. Each seed possesses a slender, shiny hilum located centrally along the bulged edge. Cotyledons are large, yellowish, and the seed has a slightly bitter and acrid taste with a faint odour. |
| Stem/Bark | Medium-sized, slowly growing deciduous tree reaching 12–15 m in height with a crooked and irregular trunk 20–40 cm in diameter.<br>The wood is greenish-white, soft, and porous with indistinct annual rings.<br>Each cubic foot weighs approximately 14–15 kg.<br>Though perishable under fluctuating weather conditions, it is durable under water, making it suitable for piles and well curbing. |
| Root | Root Possesses a well-developed tap root that is long and thick, accompanied by numerous lateral roots, providing firm anchorage and efficient nutrient absorption. |

### 3.5. Microscopic Evaluation

#### A. Leaf

The leaves' upper epidermis has distinct epidermal cells when viewed under a microscope. The unicellular, long, pointed trichomes gradually taper toward the tips. The xylem vessels have discernible secondary wall thickenings. The vascular tissue has a unique structure in which a ring of phloem encircles the central xylem. The presence of fibers, vascular components, sticky masses, and unicellular trichomes-all of which are diagnostic microscopic features of the plant material-is shown by powder microscopy.[12, 19]

#### B. Flower

The upper epidermis is composed of single-layered, wavy, thin-walled cells, according to microscopic analysis of the floral sections. The dense, unicellular, non-glandular trichomes that cover the standard petal's exterior give the flower its characteristic texture. The majority of the ground tissue is composed of angular, thin-walled parenchymatous cells that give the floral structure mechanical support. The small, papillate appearance of the epidermal cells on the inner surface of the inner surface of the epidermal cells on the inner surface of the typical petal is a defining hallmark of this papilionaceous corolla morphology.[20]

#### C. Stem and Bark

The stem powder exhibits distinct parenchymatous cells, phloem fibers, and exterior cork cells when viewed under a microscope. Well-developed secondary phloem tissue and successive layers of periderm with noticeably lignified cell walls are what set the bark apart. These lignified phloem components considerably increase the stem's mechanical strength and structural integrity.[12, 21]

#### D. Root

The root's transverse section shows distinct main tissues. Vessels with visibly thicker, lignified walls and parenchymatous cells containing crystals of calcium oxalate make up the xylem. In the phloem area, lignified components can also be seen. Visible medullary rays are made of parenchymatous cells, which are comparatively thin in the xylem zone and broader in the phloem region. There are discernible spaces between the loosely packed parenchymatous cells that make up the pith. Moreover, the tightly packed cork cells that make up the outermost protective periderm are readily visible.[21]

## 4. Phytochemistry

### 4.1. Extraction Methods

#### A. Soxhlet Extraction

The dried and powdered plant material of Butea monosperma (leaves, flowers, or bark) is extracted using a soxhlet apparatus and solvents such as methanol, petroleum ether, or ethyl acetate. The solvent is heated to evaporate, condense, and repeatedly wash the power in order to achieve full extraction. To achieve a dry residue, the extract is filtered and the solvent is evaporated.[22]

#### B. Maceration:

The process of macerating dried, powdered Butea monosperma leaves involves submerging them in a solvent, such as methanol, chloroform, ethyl acetate, or water, and stirring them periodically. Once the combination has been sufficiently steeped, it is filtered to yield the liquid extract.[23, 24]

#### C. Cold Percolation:

Butea monosperma flower petals are soaked in ethanol at a low temperature while being continuously shaken as part of the cold percolation procedure. After changing the solvent multiple times until the extraction is finished, the combined extracts are concentrated under a vacuum to remove excess solvent.[23, 24]

### 4.2. Phytochemical Screening

A fundamental and crucial step in identifying the many kinds of secondary metabolites found in plant extracts is preliminary phytochemical screening. Researches use a varity of qualitative chemical assays to verify the existence of active substances such as alkaloids, glycosides, tannins, and flavonoids. Table 5 provides a summary of the common diagnostic tests and their general protocols.

**Table 4:** Preliminary phytochemical screening tests for *Butea monosperma* (Lam.) Taub.[25]

| Phytochemical | Name of the Test | Procedure |
|---|---|---|
| Alkaloids | Hager's Test | 2ml extract + Picric acid |
| Carbohydrates | Benedict's Test | 2ml extract + 2ml benedict's reagent heated for 5mins |
| Flavonoids | Alkaline Reagent Test | 2ml extract + a few drops sodium hydroxide solution |
| Glycosides | Keller-Kiliani Test | 2 ml extract + acetic acid + FeCl3 + H2SO4 |
| Oil & fats | Soap Test | 2ml extract + ether, benzene, and chloroform; formed precipitate and insoluble in ethanol |
| Proteins and amino acids | Biuret Test | 2ml extract + Sodium hydroxide + Copper Sulphate Solution |
| Saponins | Foam Test | 2ml extract + a small quantity of distilled water |
| Steroids | Salkowski Test | 2ml extract + Chloroform + H2SO4. |
| Tannins/Phenols | Lead Acetate Test | A few drops of 10% lead acetate solution were added to aqueous solution of plant extract |

### 4.3. Phytochemical Constituents

**A. Leaves:** Glucosides, kino-oil, and a number of acids, including palmitic, lignoceric, oleic, and linoleic acids, are found in the leaves. Researchers separated 3,9-dimethoxypterocarpan from the methanol extract's ethyl acetate fraction. Additionally, the hexane fraction yielded 3-alpha-hydroxyeuph-25-enylheptacosanoate.[26, 27]

**B. Flower:** Triterpenes, butein, butin, isobutrin, coreopsin, isocoreopsin, sukphuretin, monospermoside, isomonospermoside, dihydromonospermoside, chalcones, aurones, and isobutyine are among the flavonoids found in the flower.[28] Butrin is the primary glycoside among these. Chalcones and aurones are principally responsible for the flower's vivis color. Additionally, it includes 5,7-dihydroxy-3,6,4'-trimethoxyflavine-7-O-alpha-L-xylopyranosyl-(1-->3)-O-alpha-L-arabinopyranoside, a recently discovered bioactive flavone glycoside. Palasitrin, histidin, myricyl alcohol, fructose, glucose, and a number of acids (alanine, phenyl-alanine, stearic, palmitic, arachidic, and lignoceric acids) are additional constituents.[12]

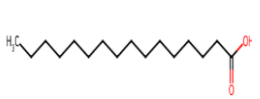
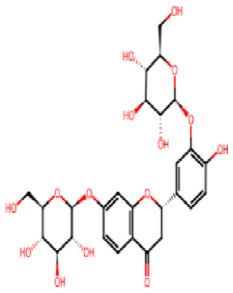
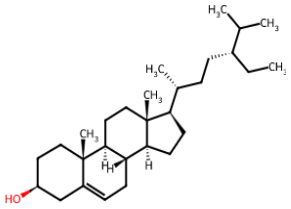
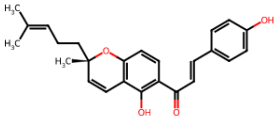
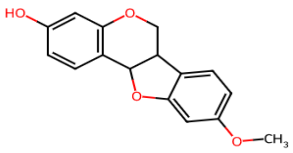
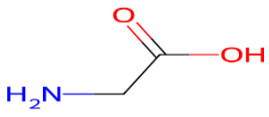
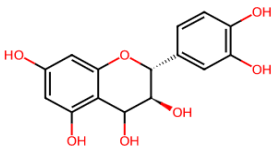
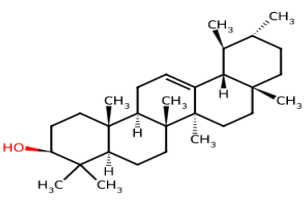
**C. Seed:** Moodooga oil, also known as Kini-tree oil, is a fatty oil that may be extracted from the seeds in up to 20%. The two lipolytic and proteolytic enzymes found in fresh seeds are polypeptidase and plant proteinase.[29] They also include a nitrogenous acidic material, monospermoside (butein-3-e-D-glucoside), and palasonin. Monospermin, phosphatidylcholine, phosphatidylethanolamine, α-amyrin, β-sitosterol, β-sitosterol-β-D-glucopyranoside, sucrose, phosphatidyl-inositol, and a variety of fatty acids (oleic, linoleic, stearic, arachidic, myristic, palmitic, and linolenic acids) have also been identified components.[30]

**D. Stem:** Lupenone, lupeol, stigmasterol, stigmasterol-β-D-glucopyranoside, and nonacosanoic acid are all present in the stem. Additionally, it contains two isoflavones: 5-methoxygenestein and prunetin. There are flavonoids such 3-hydroxy-9-methoxypterocarpan [(-)-medicarpin], 8-C-prenylquercetin, and 7'-di-O-methyl-3-O-α-L-rhamnopyranosyl(1-4)-α-L-rhamno-pyranoside.[30] Stigmasterol-3-α-L-arabinopyranoside, 3-methoxy-8,9-methylenedioxypterocarp-6-ene, 21-methylene-22-hydroxy-24-oxooctacosanoic acid, penta-cosanyl-β-D-glucopyranoside ester, and 4-penta-cosanylphenol are the four more compounds that were found.[31]

**E. Bark:** Gallic acid, kino-tannic acid, and pyrocatechin make up the bark. Cyanidin, histidine, palasimide, butrin, alanine, butolic acid, shellolic acid, and miroestrol are also present.[32] The methanolic extract of the stem bark has yielded two structurally identical methoxyisoflavones: isoformononetin and cajanin. Other compounds such as buteaspermin A, buteaspermin B, buteasperminol, medicarpin, formononetin, and cladrin are revealed by phytochemical research. Interestingly, the active component that is extracted from the stem bark's petroleum and ethyl acetate preparations is medicarpin.[33, 34, 35]

**F. Resins, Roots, and Gum:** The resin contains lactone-n-heneicosanoic acid-delta-lactone, α-amyrin, β-sitosterone, its glucoside, sucrose, and laccijalaric esters I and II (terpenic lac acid). Along with laccijalaric esters III and IV, it also contains jalaric esters I and II. Glucose, glycine, and an aromatic hydroxy molecule are found in plant roots. [36] Lastly, the gum includes mucilaginous materials, pyrocatechin, and tannins.[3]

**Table 4:** Phytochemical constituents of different parts of *Butea monosperma* along with their chemical structures.

| Plant parts | Type of Active Principle | Example | Structure | Properties/Biological Activity |
|---|---|---|---|---|
| Leaves | Fatty Acid | Palmitic Acid<br>Kino-oil containing oleic, linoleic acid,lignoceric acid, 3,9-dimethoxypterocarpan. |  | Contains methoxypterocarpans with potential anti-oxidant activity. |
| Flower | Triterpene<br>Glycoside | Butrin, isobutrin, coreopsin, sulphuretin, monospermoside, isocoreopsin, chalcones, aurones.<br>5,7-dihydroxy3,6,4'-trimethoxy flavone-7-O-alpha-L-xylopyranosyl-(1-->3)-O-alpha-L-arabinopyranosyl-(1-->4)-O-beta-D-galactopyranoside. |  | Chalcones and aurones impart the bright orange color of the flowers. Butrin is the major bioactive glycoside. |
| Seed | Sterols | β-sitosterol-β-D-glucopyranoside. |  | Seed oil and palasonin exhibit anthelmintic and antiinflammatory activities. |
| Stem | Sterols | Lupeol, stigmasterol, stigmasterol-β-D-glucopyranoside. |  | Stem is rich in flavonoids and sterols with strong antioxidant and antimicrobial potential. |
| Bark | Isoflavones | Medicarpin, cajanin, isoformononetin, formononetin. |  | Medicarpin is the major active isoflavone in bark extracts. |
| Root | Amino acid | Glycine, medicarpin. |  | Contains isoflavone derivative contributing to antiinflammatory activity. |
| Gum | Tannins | Pyrocatechin, mucilaginous substances, Leucocyanidin. |  | Used<br>traditionally for its astringent and demulcent properties. |
| Resin | Esters | Jalaric esters I, II, and laccijalaric<br>esters III, IV, α- amyrin |  | Rich in terpenoids and resin acids with antimicrobial and healing properties. |

## 5. Traditional Uses

### 5.1. Leaves:

Leaves are very helpful for eye disorders. They reduce inflammation and lumbago and have tonic, astringent, carminative, anthelmintic, and aphrodisiac properties. They also treat boils and piles. Chewing the petiole and consuming its juice is a useful remedy for colds, coughs, and intestinal isues. A cup of water and two spoonfuls of leaf power should be taken every day for a month in order to treat diabetes.[37, 38]

### 5.2. Flower:

Flower juice is beneficial for eye disorders. Additionally, "Kapha," leprosy, gout, strangury, skin disorder, thirst, and related emotions are all treated with flower. They help with biliousness, inflammation, and gonorrhea and are astringent to the colon. The flower's color aids in spleen expansion, and it also has bitter, aphrodisiac, expectorant, tonic, emmenagogue, and diuretic properties. Flower are used as a poultice to promote menstruation and lessen edema due to their depurative qualities. They also aid in preventing pus buildup in the male urinogenital tracts. For a month, taking three to four spoonfuls of crushed flowers in milk with additional sugar every day can help reduce fever and body temperature. Leucorrhea is treated by soaking flower in water for the entire night and drinking a cup of the infusion every morning for 28 to 30 days.[39, 40, 41]

### 5.3. Seeds:

Children with intestinal worms are treated with powdered seeds. Urinary symptoms are relieved and urinary stones are relived and urinary stones are avoided by taking around two spoonfuls of ground seeds combined with milk orally. The fruit and seeds are digestible, aperients, and used to heal scorpion stings, according to Ayurveda. Additionally, they treat piles, inflammation, tumors, stomach problems, skin disorders, and eye disorders. They have been used as powerful rubefacient to cure Dhobi's itch, a kind of herpes, when crushed with lemon juice and applied to the skin.[42, 43]

### 5.4. Steam and Bark:

Human goiter is treated with stem juice, whereas ax-related injuries are treated with powdered stem bark. Applying stem bark paste aids in the reduction of edema. There are many uses for the bark, such as treating biliousness, hydrocele, dysentery, piles, ulcers, tumors, and anus problems. In addition, it is a laxative, anthelmintic, aphrodisiac, bitter, and acrid. This drug is included under four different categories of herbal medicines (Rudaradigana, Musakadigana, Amabasatadigana, and Nyagrodhabigana) in the sushruta samhita. These categories cure a variety of conditions, including Medoroga, Striroga, and Prameha. Additionally, it is said to have caused kapha.[43]

### 5.5. Roots:

The root reduces visual defects, treats elephantiasis, and cures night blindness. Heated root pieces and two to three spoonful of extract are given at night for a month as a therapy for impotence. Furthermore, an antidote for snake bites is a teaspoon of root power mixed with water. [44, 45, 13]

### 5.6. Gum:

Gum is used to full up foot sole cracks. It is recommended to take two spoons of diluted gum on a regular basis till the dysentery is resolved. Additionally, stomatitis, resolved. Additionally, stomatitis, cough, pterygium, perspiration can all be efficiently treated by the gum, which is also astringent to the intestine.[44, 45]

## 6. Pharmacological Activities

Significant biological activity are displayed by a variety of extracts and active ingredients derived from different portions of the *Butea monosperma* plant, which are explained below:

### 6.1. Antidiabetic Activity

**Flower:** The flower's ethanolic extract significantly reduces serum cholesterol, HDL chloesterol blood sugar, and antioxidant enzyme activity. In rats given a high-fat diet and streptozotocin-induced diabetes, a methanolic extract demonstrated anti-diabetic and lipid-lowering qualities. Additionally, dexamethasone-induced hyperglycemia and hyperlipidemia in mice were considerably reduced by the n-butanolic fraction. Flavonoids, saponins, and sterols-strong anti-hyperglycemic and anti-oxidative agents-were found in the ethanolic extract according to phytochemical analysis.[46]

**Leaves:** The ethanolic leaf extract showed antidiabetic benefits in male rats with alloxan-induced diabetes when taken orally. The extract dramatically raised antioxidant enzyme activity and reduced blood glucose levels after 45 days of treatment (300 mg/kg). Additionally, aqueous leaf extracts are utilized to reduce blood sugar.[47]

### 6.2. Anti-inflammatory Activity

**Leaves:** A strong mono-inflammatory response was observed when a methanolic extract of the leaves was investigated for its anti-inflammatory properties using cotton pellet granuloma and carrageenan-induced paw oedema models in rabbits.[45, 48]

**Seed:** In rats with carrageenan-induced paw oedema and cotton pellet-induced granuloma, fixed oil, mixed fatty acids, and unsaponifiable materials from the seeds had potent anti-inflammatory qualities.[49, 50]

### 6.3. Antimicrobial, Anthelmintic, and Antifilarial Activities

**Flower:** Dihydromonospermoside, dihydrochalcone, monospermoside, isoliquiritigenin, and butein are examples of bioactive flavonoids found in flowers that

have antimycobacterial and antifungal qualities against a range of fungas species. Antibacterial activity was demonstrated by the flavone 5,7-dihydroxy-3,6,4-trimethoxy xylopyranosyl (1→3)-7-O-α-L (1→4) O-α-L-arabinopyranosyl O-β-D-galactopyranoside.[51]

**Seed:** Seed oil has potent bactericidal and fungicidal effects on dangerous bacteria and fungi in vitro. Caenorhabditis elegans was considerably suppressed by methanolic seed extracts. Its anthelmintic efficacy against Trichostrongylid nematodes in sheep is both time- and dose- dependent.[52, 53]

**Leaves:** In a dose-dependent manner, an aqueous leaf extract significantly reduced the motility of microfilariae (Brugia malayi) (IC50 value of 83 ng/ml).[45]

### 6.4. Antiestrogenic, Antifertility, and Hormone Balancing Effects

**Flower:** In order to assess the estrogenic and antiestrogenic capabilities, methanolic extracts affected the uterotropic and uterine peroxidase activities of ovariectomized rats. Additionally, alcoholic floral extracts are said to have antifertility and antiestrogenic properties.[54]

**Seed:** Methanolic and alcoholic seed extracts have anti-implantation, anti-estrogenic, and anti-fertility properties. Butin, which also has male contraceptive qualities, is one of the active ingredients responsible for the total estrogenic activity. Butin taken orally showed decreased implantation sites and dose-dependent anti-implantation efficacy during pregnancy termination. Butin showed estrogenic activity at similar anticonceptive dosages in young female rats undergoing ovariectomies, although having no antiestrogenic effect.[55, 56]

### 6.5. Anticancer Activity

**Flower:** The concentration of G1 phase cells, the suppression of cell proliferation, and the marked promotion of apoptotic cell death indicted that the aqueous extract has anticancer effects.

### 6.6. Osteogenic and Osteoprotective Activity

**Stem:** The stem bark contains two structurally similar methoxyisoflavones that stimulate osteoblast differentiation: Cajanin and isoformononetin. Isoformononetin has powerful anti-apoptotic properties, but cajanin has substantial mitogenic effects. Moreover, osteogenic activity is caused by substances such medicarpin, formononetin, isoformononetin, and cladrin. The stem bark's standardized fractions and total extracts have strong oateoprotective potential.[8, 45]

### 6.7. Wound Healing Activity

**Stem Bark:** Rats' complete excision wounds healed more quickly when ethanolic extracts were administered topically. DNA, total protein, and totak collagen in granulation tissues rose as a result of topical treatment, which also boosted collagen synthesis and celluar proliferation. Additionally, it improved wound contraction, shortened the time it took for epithelialization, raised the tensile strength of the incision wound, and increased the weight and hydroxyproline content of granulation tissue.[48]

### 6.8. Anticonvulsant and Antidopaminergic Activities

**Flower:** An isoflavone-isolated methanolic extract inhibited foot shock-induced aggression and dose-dependently increased haloperidol-induced catalepsy in rats, suggesting antidopaminergic action. The acetone-soluble portion of the petroleum ether extract has anticonvulsant properties, protecting mice against electrical kindling, maximum electroshock, and pentylenetetrazole-induced convulsions.[57]

## 7. Toxicity and Safety Profile

The Butea monosperma seed extract showed minimal mouse mortality in acute toxicity testing, indicating a comparatively low acute toxicity Profile. However, a 90-day chronic toxicity investigation of the seed powder at a dose of 800 mg/kg/day in albino rats produced notable negative results. Although bone marrow cytology was unaffected, hematological examinations revealed significant drops in hemoglobin content, red blood cell (RBC) count, and hematocrit, indicating an anemic condition. Biochemical study showed significant increases in very low-density lipoprotein (VLDL) and triglyceride levels, indicating impacts on lipid metabolism, coupled with decreases in total protein, albumin, and bilirubin. Additionally, lipid changes, glomerular congestion, tubular bleeding in the kidneys, epithelial disruption in the jejunum, and a modest reduction in spermatogenesis in the testis were among the histological alterations seen in a number of organs. The overall toxicity profile shows that Butea monosperma seeds are likely to have toxic consequences when given chronically in powder from, even if organ weights were not considerably impacted.[58]

## 8. Conclusion

The medicinal herb Butea monosperma is highly prized for its therapeutic properties in Ayurveda and other ancient systems. The current analysis emphasizes the presence of significant phytochemicals including flavonoids, isoflavones, terpenoids, tannins, and sterols in all plant parts, including flowers, leaves, seeds, bark, gum, and roots. Numerous pharmacological activities, including as anti-inflammatory, antidiabetic, antioxidant, antibacterial, wound- healing, and anticancer properties, are greatly aided by these active ingredients. More advanced studies, such as clinical evaluations, comprehensive toxicity assessments, and mechanism-based investigations, are still needed to prove its full medicinal potential, even if preliminary research has supported many traditional uses. In addition, growing demand and habitat loss necessitate the use of sustainable farming and conservation techniques. All things considered, *Butea monosperma* continues to be a remarkable natural resource with significant promise for upcoming scientific research and medicine development.

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