



## Research Article

# Phytochemical Profiling and Therapeutic Potential of *Butea monosperma* (Lam.) leaf: A Comprehensive Analytical Study

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*Butea monosperma*, a medicinally significant plant species within the Fabaceae family, has been extensively utilized in traditional healthcare systems across the Indian subcontinent. This investigation systematically evaluates the phytochemical constituents present in leaf extracts of *B. monosperma* through qualitative analytical methods. Fresh leaf specimens were collected from Ranchi, Jharkhand, India, and subjected to sequential extraction using five solvents of varying polarities: petroleum ether, benzene, chloroform, ethanol and distilled water. Phytochemical screening detected the presence of tannins, saponins, reducing sugars, phenolic compounds, alkaloids, terpenoids, and flavonoids across different solvent systems. The ethanol extract demonstrated the broadest spectrum of phytochemical diversity, yielding positive results for all seven tested compound classes. Conversely, the benzene extract showed positive reactions in six categories, with saponins being absent. These findings substantiate the ethnopharmacological applications of *B. monosperma* and provide empirical evidence supporting its traditional therapeutic uses. The diverse array of bioactive secondary metabolites identified warrants further pharmacological investigation to elucidate specific mechanisms of action and potential clinical applications in contemporary medicine.

**Keywords:** *Butea monosperma*, phytochemical screening, secondary metabolites, solvent extraction, traditional medicine, Fabaceae.

## INTRODUCTION

Natural product chemistry continues to serve as a fundamental resource for drug discovery and development, with traditional medicinal plants offering a vast repository of bioactive compounds [1, 2]. *Butea monosperma* (Lam.) Taub, commonly designated as 'Flame of the Forest' or 'dhak', represents a botanically and medicinally significant species within the Fabaceae family [3]. This deciduous tree exhibits widespread distribution throughout the Indian subcontinent, including regions of Burma and Ceylon, with its natural range extending to the northwestern Himalayan zones near Jhelum, excluding hyper-arid environments [4]. The species has maintained prominence in traditional healing

systems, particularly within Ayurvedic, Unani, and homeopathic medical frameworks, where various plant organs are employed therapeutically [5, 6]. Ethnobotanical documentation indicates that root preparations address helminthic infections, night blindness, hemorrhoids, ulcerative conditions, and neoplastic growths [7]. Floral components demonstrate astringent, diuretic, and depurative properties, while bark preparations are traditionally applied to gastrointestinal disorders, ulcerations, and envenomation cases [8]. Beyond medicinal applications, *B. monosperma* possesses considerable economic value. Leaves are processed into biodegradable food service items and tobacco wrappers, bark fibers contribute to cordage

manufacturing, and wood serves multiple purposes including construction materials and pulp production for paper manufacturing [9]. Additionally, the tree functions as a host for *Laccifer lacca*, the insect species responsible for natural lac production [10]. Preliminary phytochemical investigations have identified numerous bioactive constituents within different plant tissues, including triterpenic compounds, glycosidic structures, tannins, enzymatic proteins, ester linkages, fatty acid chains, amino acid sequences, and steroidal frameworks [11, 12]. Pharmacological evaluations have demonstrated anti-

inflammatory, antioxidant, hepatoprotective, anticonvulsant, antihyperglycemic, antimicrobial, and antineoplastic activities [13, 14, 15]. Despite extensive ethnopharmacological utilization, comprehensive phytochemical profiling studies employing standardized analytical protocols remain limited. The present investigation addresses this knowledge gap by conducting systematic qualitative phytochemical screening of *B. monosperma* leaf extracts prepared using solvents of varying polarities, thereby establishing a foundational chemical profile for subsequent pharmacological research.



**Fig. 1. *Butea Monosperma* leaf**

## **MATERIALS AND METHODS:**

### **2.1 Collection and Authentication of Plant Material**

Fresh leaf specimens of *Butea monosperma* were harvested from the campus premises of Sai Nath University, Ranchi, Jharkhand, India (geographic coordinates: 23°29'18.47"N, 85°24'28.73"E) during the vegetative growth phase. Botanical identification and taxonomic authentication were conducted at the Acharya Jagadish Chandra Bose Indian Botanic Garden (formerly Shibpur Botanical Garden), West Bengal, India, by qualified taxonomists. Following collection, leaf specimens underwent gentle washing with potable water to remove surface contaminants, followed by air-drying under shade conditions at ambient temperature to preserve thermolabile constituents.

### **2.2 Chemicals and Reagents**

All chemical reagents employed in this investigation were of analytical grade purity and procured from authenticated suppliers through Sai Nath University. The extraction solvents included petroleum ether, benzene, chloroform, absolute ethanol, and double-distilled water. Phytochemical detection reagents comprised ferric chloride, Benedict's reagent, silver chloride, mercuric chloride, concentrated sulfuric acid, sodium hydroxide, magnesium sulfate, hydrochloric acid, Mayer's reagent, Kedde's reagent, and alkaline reagent solution. Stock solutions were prepared at a concentration of 1 mg/mL by dissolution in appropriate solvents, with subsequent dilutions performed according to experimental requirements.

### **2.3 Preparation of Plant Extracts**

Dried leaf material was mechanically pulverized using an electric blender to obtain a fine powder with enhanced surface area for optimal solvent penetration. Fifty grams of powdered leaf material was subjected to sequential maceration extraction using solvents arranged in order of increasing polarity: petroleum ether, benzene, chloroform, ethanol, and distilled water. The maceration procedure was conducted over a 25-day period at room temperature with periodic agitation to facilitate mass transfer. Following extraction, each solvent fraction was concentrated under reduced pressure using rotary evaporation techniques to remove volatile solvents while preserving heat-sensitive compounds. Concentrated extracts were transferred to sterile, airtight amber-colored containers and stored under refrigeration at 4°C until phytochemical analysis.

## 2.4 Qualitative Phytochemical Screening

Standardized qualitative analytical protocols were implemented to detect the presence of major phytochemical classes within each solvent extract [16, 17]. The following tests were conducted:

### 2.4.1 Detection of Tannins (Ferric Chloride Test):

Extract solutions were treated with 5% aqueous ferric chloride solution. Formation of dark greenish-black coloration indicated tannin presence.

**2.4.2 Detection of Saponins (Foam Test):** Extract samples were vigorously agitated with distilled water in test tubes. Persistent foam formation exceeding 1 cm height for 15 minutes indicated saponin content.

**2.4.3 Detection of Reducing Sugars (Benedict's Test):** Extract aliquots were mixed with Benedict's reagent and heated in a water bath. Development of green, yellow, orange, or brick-red precipitate indicated reducing sugar presence.

**2.4.4 Detection of Phenolic Compounds (Legal's Reagent Test):** Extracts were treated with Legal's reagent. Appearance of dark greenish coloration confirmed phenolic compound presence.

**2.4.5 Detection of Alkaloids (Mayer's Test):** Acidified extract solutions were treated with Mayer's

reagent (potassium mercuric iodide solution). Formation of cream-colored precipitate indicated alkaloid presence.

### 2.4.6 Detection of Terpenoids (Salkowski Test):

Extract samples were mixed with chloroform and concentrated sulfuric acid. Development of reddish-brown coloration at the interface indicated terpenoid presence.

### 2.4.7 Detection of Flavonoids (Alkaline Reagent Test):

Extract solutions were treated with dilute sodium hydroxide solution. Formation of intense yellow coloration that disappeared upon acidification indicated flavonoid presence.

### 2.4.8 Detection of Glycosides (Kedde's Reagent Test):

Extracts were treated with Kedde's reagent. Color development would indicate cardiac glycoside presence.

## RESULTS

Qualitative phytochemical screening of *B. monosperma* leaf extracts revealed diverse secondary metabolite profiles across the five solvent systems examined (Table 1). Each solvent extract demonstrated positive reactions for at least six of the seven phytochemical classes investigated, indicating substantial chemical diversity within the leaf tissue. The ethanol extract exhibited the most comprehensive phytochemical profile, showing positive results for all seven tested compound categories: tannins, saponins, reducing sugars, phenolic compounds, alkaloids, terpenoids, and flavonoids. The petroleum ether and chloroform extracts similarly demonstrated positive reactions across all seven screening tests, suggesting effective extraction of both polar and non-polar constituents. The aqueous extract yielded positive results for six phytochemical classes, with all tests except glycoside detection showing positive reactions. The benzene extract also demonstrated six positive outcomes, with saponins being the only compound class not detected in this fraction. Notably, cardiac glycosides were not detected in any of the five solvent extracts examined, as evidenced by negative results in the Kedde's reagent test across all extraction systems.

**Table 1: Qualitative Phytochemical Profile of Butea monosperma Leaf Extracts**

| Phytochemical Class | Aqueous | Ethanol | Petroleum Ether | Chloroform | Benzene | Detection Method | Positive Indicator        |
|---------------------|---------|---------|-----------------|------------|---------|------------------|---------------------------|
| Tannins             | +       | +       | +               | +          | +       | Ferric chloride  | Dark greenish-black color |
| Saponins            | +       | +       | +               | +          | —       | Foam test        | Persistent foam           |
| Reducing sugars     | +       | +       | +               | +          | +       | Benedict's test  | Green color formation     |
| Phenolic compounds  | +       | +       | +               | +          | +       | Legal's reagent  | Dark greenish color       |
| Alkaloids           | +       | +       | +               | +          | +       | Mayer's test     | Cream precipitate         |
| Terpenoids          | +       | +       | +               | +          | +       | Salkowski test   | Reddish-brown color       |
| Flavonoids          | +       | +       | +               | +          | +       | Alkaline reagent | Yellow color              |
| Cardiac glycosides  | —       | —       | —               | —          | —       | Kedde's reagent  | No reaction observed      |

**Note:** (+) indicates presence; (—) indicates absence



**Fig. 2**  
**Standard extract of B. monosperma**



**Fig. 3**  
**Test for Tannins**



**Fig. 4**  
**Test for Saponins**



**Fig. 5**  
**Test for Reducing sugar**



**Fig. 6**  
**Test for Alkaloids**



**Fig. 10**  
**Test for glycosides (No result)**



**Fig. 7**  
**Test for Terpenoids**



**Fig. 8**  
**Test for Flavonoids**



**Fig. 9**  
**Test for Phenolic compounds**

## DISCUSSION:

The present investigation provides systematic evidence for the diverse phytochemical composition of *B. monosperma* leaf tissue, corroborating its extensive ethnopharmacological applications. The detection of multiple bioactive secondary metabolite classes across different solvent systems supports the traditional medicinal uses documented in classical Ayurvedic and Unani texts.

- **Alkaloids:** The presence of alkaloids in all tested extracts is pharmacologically significant, as these nitrogen-containing compounds exhibit diverse biological activities including antimicrobial, antioxidant, analgesic, antimalarial, and central nervous system modulatory effects [18]. Alkaloids represent promising candidates for anti-inflammatory, anticancer, and neuroprotective therapeutic development.
- **Flavonoids:** Universal detection of flavonoids across all solvent extracts aligns with the known anti-inflammatory and antioxidant properties of *B. monosperma*. Flavonoids demonstrate antiproliferative effects against cancer cell lines through multiple mechanisms including cell cycle arrest, apoptosis induction, and antiangiogenic activity [19].
- **Phenolic Compounds and Tannins:** The consistent presence of phenolic compounds and tannins across all extracts substantiates the antioxidant capacity of *B. monosperma*. These compounds function as free radical scavengers and metal chelators, potentially contributing to

hepatoprotective effects and cellular protection against oxidative stress-induced damage [20].

- **Saponins:** Detection of saponins in four of five solvent systems (absent only in benzene extract) is notable given the documented antitumor, immunomodulatory, and hypocholesterolemic properties of these glycosidic compounds. Saponins warrant further investigation regarding their potential role in cancer chemoprevention and treatment.
- **Terpenoids:** The universal presence of terpenoids across all extraction systems is consistent with the broad therapeutic applications of these compounds, which include antifungal, anti-inflammatory, analgesic, antibacterial, and anticancer activities. Terpenoids represent a structurally diverse class with significant pharmaceutical potential.
- **Reducing Sugars:** The detection of reducing sugars in all extracts may correlate with potential hypoglycemic effects, as these compounds could modulate pancreatic insulin secretion or glucose metabolism pathways.
- **Absence of Cardiac Glycosides:** The negative results for cardiac glycoside detection across all solvent systems suggest that *B. monosperma* leaves do not contain significant quantities of these cardioactive compounds, which is consistent with the absence of traditional use for cardiac conditions.

The superior performance of ethanol as an extraction solvent, yielding positive results for all seven phytochemical classes, can be attributed to its intermediate polarity, enabling extraction of both hydrophilic and lipophilic constituents. This finding supports the traditional preparation methods employing hydroalcoholic solvents in Ayurvedic formulations.

## CONCLUSION:

This systematic phytochemical investigation demonstrates that *B. monosperma* leaf tissue contains a diverse array of bioactive secondary metabolites with established pharmacological significance. The

ethanol extract exhibited the most comprehensive phytochemical profile, supporting its preferential use in traditional medicine systems. The presence of alkaloids, flavonoids, phenolic compounds, tannins, saponins, terpenoids, and reducing sugars provides empirical justification for the ethnopharmacological applications of this species. These findings establish a foundational chemical profile that should guide subsequent research directions, including isolation and structural characterization of individual compounds, quantitative phytochemical analysis, in vitro bioactivity screening, in vivo pharmacological evaluation, and toxicological assessment. Further investigations employing advanced analytical techniques such as high-performance liquid chromatography, gas chromatography-mass spectrometry, and nuclear magnetic resonance spectroscopy are warranted to elucidate the complete chemical fingerprint of *B. monosperma* and facilitate its integration into evidence-based phytotherapy protocols.

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