



**BUTEA MONOSPERMA (LAM.) TAUB: REVIEW ON ITS CHEMISTRY, MORPHOLOGY, ETHNOMEDICAL USES, PHYTOCHEMISTRY AND PHARMACOLOGICAL ACTIVITIES**

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**Abstract**

Since ancient times plants are used for their medicinal and cosmetic properties. India has well-recorded and well practiced knowledge of traditional herbal medicine. As only little studies are done on this plant, the purpose of current review is to make accessible up-to-date information on, botany, morphology, ecological biodiversity, therapeutic uses, phytochemistry and pharmacological activities on diverse parts of *Butea monosperma* (Lam.) Taub (*B. monosperma*). *B. monosperma* belong to family Fabaceae, popularly known as Flame of the Forest, Dhak, Palash or Bastard teak and widely distributed in Indian Subcontinent and Southeast Asia, ranging across India, Bangladesh, Nepal, Sri Lanka, Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaysia, and western Indonesia. It is a plant that has been electively used in traditional Asian medicines for centuries. It has been used for the treatment of different ailments such as cancer, diabetes, diarrhoea, dysentery, fever and jaundice. Recent *in vivo* and *in vitro* studies have indicates its anti-diabetic, anti-cancer, anti-inflammatory, anti-asthmatic, anti-oxidant, anti-convulsant, anti-microbial, anti-viral and hepatoprotective properties. The aerial part of the plant contains a large number of phytochemicals mainly flavonoids, lactones, diterpenoids, diterpene glycosides and phytosterols. Bark yield red juice known as 'Butea gum' or 'Bengal kino'. This alternative system of medicine is gaining increasing fame universal. There is a required to isolate active constituents, their biological test, molecular mechanisms, experimental defense and legalization of therapeutic uses of *B. monosperma*. The collected information will be obliging to locate up study protocol for current drugs and Ayurvedic formulation extension in remedial and luxury a variety of ailments. Clinical trials for the reported preclinical studies should be executed immediately to further validate the claims on humans.

**Keywords:** *Butea monosperma*, Fabaceae, Phytochemistry, Pharmacological activity, Ethno medical uses.

**INTRODUCTION**

Earlier the foreword of contemporary medicines, disease treatment was completely managed by herbal medicines. It is estimated that about 70-80% of the earth inhabitants residing in the huge rural areas of the developing and under developed countries still depend mostly on medicinal plants. Medicinal plants are the only inexpensive and reachable source of primary health care for them, particularly in the lack of access to contemporary medical facilities. Studies divulge that there are more conventional medicine providers than the

allopathic providers particularly in the rural areas [1]. Plant-resulting substances have lately become a great attention owing to their versatile applications. Medicinal plants are the richest bio resource of drugs of conventional systems of medicine, contemporary medicines, food supplements, folk medicines, pharmaceutical intermediates and chemical entities for synthetic drugs [2]. Medicinal plants form a huge group of inexpensively significant plants that provide the essential raw materials for indigenous pharmaceuticals [3]. Plant products still remain the most important source of

pharmaceutical agents used in conventional medicine [4]. According to the WHO the primary step for recognition and purification of herbal drugs is the pharmacognostic (macroscopic and microscopic) studies which are necessary for any phyto pharmaceutical products used for standard formulation [5]. Preliminary phytochemical studies are obliging in finding out chemical constituents in the plant material that may fine lead to their quantitative estimation [6, 7].

Lately much concentration has directed towards extracts and biologically active compounds isolated from accepted plant species. In the present age of drug development and discovery of newer drug molecules, a lot of plant products are assess on the basis of their conventional uses. The healing properties of medicinal plants are mostly due to the occurrence of various multifaceted chemical substances of dissimilar compositions which happen as secondary metabolites [8]. The most significant of these bioactive constituents of plants are steroids, tannins, alkaloids, flavonoids and phenolic compounds. Therefore, it is enviable to know the phytochemical composition of the plant material before testing its effectiveness for medicinal purpose. Plants are also main natural sources of medicinal compounds in present pharmacopoeias [9]. Indian Materia Medica comprises about 2000 drugs of natural origin and most of them are resulting from different conventional system and myths practices [10].

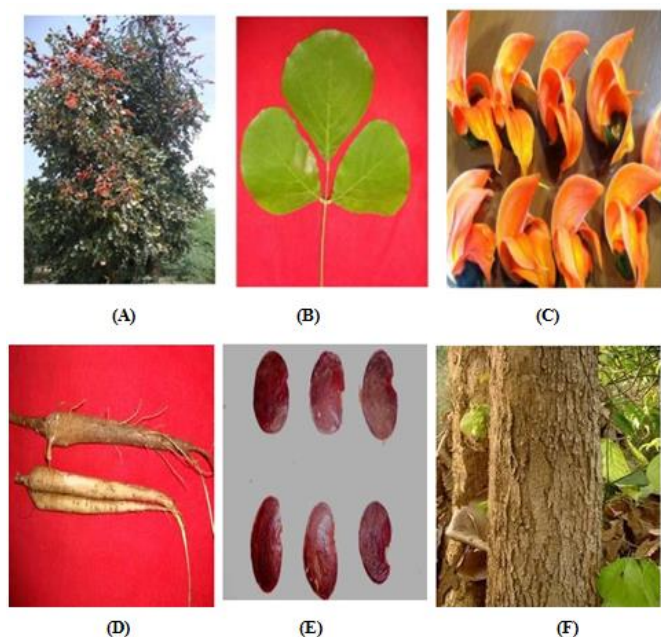
However, there are large numbers of plants, which have not been mentioned in these reports, in malice of their usage in the conventional and folk medicinal systems. *B. monosperma*, is a moderate sized deciduous tree, belonging to *fabaceae* family. The genus *Butea* refers to beautiful appearance of flowers. The specific name *monosperma* means 'one seeded and refers to the fruit with a single seed near its apex' is commonly known as Flame of forest, belonging to the family Fabaceae [11]. They consists one of the largest families of flowering plants with 630 genera and 18000 species. The genus *Butea* includes *B. monosperma* parviflora, *Butea minor* and *Butea superba* widely distributed throughout India. It is elucidated in Upanishads, Vedas, Susripta Samhita, Charaka Samhita, Astanga Sangraha, Ashtanga Hrdaya [12].

This is a moderate sized deciduous tree which is widely distributed throughout India, Burma and Ceylon extending in the North West Himalayas as far as Jhelum except in very acrid parts [13]. It is considered as a sacred tree (Fig.1). It grows well in the alkaline, marshy condition in sunny location. The number of different chemical constituents obtained from various parts of the plant are used as anti-inflammatory, anti-diabetic, anti-fungal, anti-asthmatic, astringent, aphrodisiac [14]. The gum which is obtained from the slit made on the bark of the tree is known as 'kamarkas' or Bengal Kino which is rich source of tannins. The dyeing agent present in the flowers that imparts its color is used as insecticide and coloring agent. The flavonoids Butin, Butein, Butrin, Isobutrin, Palasitrin, Coreopsin, Isocoreopsin, Sulphuresin, Monospermoside, Isomonospermoside and 7,3,4-trihydroxyflavone have been isolated from the flower of this plant. From the stem and the pods of this plant species Euphane triterpenoid 3a-hydroxyeuph-25-ene and the alcohol 2, 14-dihydroxy-11, 12-dimethyl-8-oxo-octadec-11-enylcyclohexane and Imide palasimide has been isolated respectively [15]. It acts as the host for lac insect and plays a role in the production of lac [16]. Bark fibers are utilized for making cordage. Wood pulp is useful for newsprint manufacturing [17].

According to the traditional system of medicine the plant is a revitalizer. Owing to its multifaceted attributes, this plant is a multifunctional tree with massive therapeutic and commercial value. The classification of *B. monosperma* consists of domain: Eukaryota, Subkingdom: Viridiplantae, Infrakingdom: Streptophyta, Superdivision: Embryophyta, Division: Tracheophyta, Subdivision: Spermatophytina, Class: Magnoliopsida, Sub-Class: Rosidae, Superorder: Rosanae, Order: Fabales, Family: Fabaceae, Genus: *Butea*, Species: *B. monosperma* [18] and Synonyms: *Butea frondosa* Roxb. ex Willd, *Erythrina monosperma* Lam, *Plaso monosperma* [19].

The vernacular names of the plant are **Hindi:** Chichra tesu, polak, dhak, palas, desuka jhad, **English:** Flame-of-the-forest, Parrot Tree, **Sanskrit:** Brahmopadapa, lakshataru, Palasha, **Bengali:** Palas, kinaki, peras, polashi, **Assam:** Polash, **Gujarati:** Khakra, phullas, kakria, **Kannada:** Muthuga **Odia:** Palash, **Marathi:** Palash **Tamil:** Porasum, Parasu,

**Telugu:** Mooduga, Palasamu, **Urdu:** Palash, papra, **Punjabi:** Chichra, dhak, palas, **Malyalam:** Brahmavriksham, Kimshuka [20]. Therefore, in this study, the ethnopharmacological review of *B. monosperma* was carried out aimed at providing a detailed précis of the botany, ethnomedicinal uses, pharmacological activities and chemical composition of the species.



**Figure 1. (A) Healthy *Butea monosperma* plant, (B) Leaf, (C) Flowers, (D) Root, (E) Seeds, (F) Stem**

### Research done

To recognize pertinent information on the phytochemistry, botany, medicinal uses and biological activities of *B. monosperma*, a review was amassed based on scientific literature from a variety of sources including Google Scholar, Science Direct, PubMed, Scielo, Springerlink, Google Patents, Web of Science, SciFinder, Scopus, Espacenet, BioMed Central (BMC) and Medline. The keywords used for recognition of relevant data included dissimilar scientific name and synonyms, common English names, and the terms: biological activities, ethnobotany, medicinal uses, medicinal, ethnopharmacology, pharmacology, phytochemistry and therapeutic value, *B. monosperma*, *Butea frondosa* Roxb. ex Willd, *Erythrina monosperma* Lam, *Plaso monosperma* palas, etc. Further literatures were finding from books, book chapters, theses, websites and conference proceedings.

### Occurrence and distribution

This plant is widely distributed in tropical and subtropical regions of Indian subcontinent. It is common in the south-East Asia ranging from India, Bangladesh, Pakistan, Nepal, Sri Lanka, Myanmar, Indonesia, Malaysia, and Vietnam [21]. It is very common throughout the greater part of the India, Burma and Ceylon up to 1000 MSL (minimum sea level) or higher in the outer Himalaya, Khandesh Akrani up to 1200 and Hill of South India up to 1300 m. It is especially found in Maharashtra: Kolhapur, Karnataka: Chikmagalur, Coorg, Mysore, Shimoga, Kanara, Kerala: Alapuzha, Idukki, kasaragod, kollam, Kozhikode, Malapuram, Palakkad, Rajasthan, Jaipur, Udaipur, Kota in throughout India [22, 23].

### Species of *Butea*

The plant, *Butea* belong to family fabaceae and it is widely distributed throughout the world. Till date approximately, 33 species of *Butea* has been reported. *Butea acuminata*, *Butea africana*, *Butea affinis*, *Butea apoensis*, *Butea braamiana*, *Butea balansae*, *Butea bracteolate*, *Butea crassifolia*, *Butea cuneiformis*, *Butea dubia*, *Butea frondosa*, *Butea ferruginous*, *Butea gyrocarpa*, *Butea harmandii*, *Butea laotica*, *Butea loureirii*, *Butea littoralis*, *Butea listeria*, *Butea minor*, *Butea macroptera*, *Butea merguensis*, *Butea maingayi*, *Butea oblong folia*, *Butea parviflora*, *Butea pulchra*, *Butea purpuea*, *Butea riparia*, *Butea rosea*, *Butea suberecta*, *Butea superba*, *Butea volubilis*, *Butea varians* [24]

### Ecology

*B. monosperma* is a plant which is generally found in the drier parts of the India. Despite the fact that the tree is drought resistant but the leaves turn white and fall off. The plant can sustain in those areas which have an annual rainfall of 450-4500 mm [25]. It can also grow on various types of soils like black cotton soil, clay loam, shallow and even waterlogged soils. It shows capability to reproduce from seed and root sucker. The seedling of this plant can flourish best in rich loamy soil with pH ranging 6 to 7 under high temperature and relative humidity [26]. For cultivation; the pods may be planted at a distance of 25-30 cm apart along the lines and lightly covered with soil. Another way, the plants are raised at 10 x 10 cm distance in the nursery by dispersing the ripe seeds before the rainy season. Daily watering and weeding is carried out and the seedlings are transplanted during the rainy season



after the stem is trimmed to 5 cm. Clonal propagation by air layering aids in the quick formation of plantation of this tree. It was discovered that the growth of seedlings of palash was better in pure black soil [27].

### Morphology

It is an erect, medium sized tree of 12-15 m high, with a crooked trunk and irregular branches. The shoots are clothed with gray or brown silky pubescence. The bark is ash coloured. The leaves 3 foliate, large and stipulate. Petiole is 10-15 cm long. Leaflets are obtuse, glabrous above, finely silky and conspicuously reticulately veined beneath with cuninate or deltoid base. From January to March the plant is bald. Flowers in rigid racemes of 15 cm long, densely brown velvety on bare branches. Calyx is dark, olive green to brown in colour and densely velvety outside. The corolla is long with silky silvery hairs outside and bright orange red. Stamens are diadelphes, anthers uniform. Ovary has 2 ovule, style filiform, curved and stigma capitate. Pods argenteocanescent, narrowed, thickened at the sutures, splitting round the single apical seed, lowest part indehiscent. The seeds are flat, reniform, curved. The bole is twisted and gnarled and the branching too follows no particular pattern. It is slow growing and attains a height of about 5 to 8 m and diameter of about 20 to 40 cm when mature at the age of about 50 years or so. The bark of palas is fibrous and bluish gray to light brown in color. It exudes a kind of red juice when injured. The leaves are compound. Each has three leaflets. The texture of the leaflets is fairly tough. These are coriaceous with the surface glabrescent above and hairy silken beneath. The size varies from 15 cm to 20 cm by 10 cm x 15 cm.

The shape is obliquely ovate and broadly elliptic. The leaves fall off by December and reappear during spring. When the tree is leafless, it bears flaming orange to red-colored flower. These flowers start appearing in February and stay on nearly up to the end of April. The size is nearly 2 to 4 cm in diameter. The calyx i.e. the lower whorl of the flower tends to be darkish gray like the supporting branch itself. The upper parts are brick red. These give the plant so handsome a look despite it is leafless during spring season when entire terrain having palas trees wears a kind of exquisite orange

and red hue. The flowers form a gorgeous canopy on the upper portion of the tree, giving the appearance of a flame from a distance. The fruit of palas is a flat legume; a pod, nearly 15 cm long and 3 to 5 cm wide. Young pods have a lot of hair a velvety cover. The mature pods hang down like peculiar legumes. The seeds are flat, from 25 to 40 mm long, 15 to 25 mm wide, and 1.5 to 2 mm thick. The seed-coat is reddish-brown in color, glossy, and wrinkled, and encloses two large, leafy, yellowish cotyledons. The hilum is conspicuous, and situated near the middle of the concave edge of the seed. The odor is faint, and the taste slightly acrid and bitter. The wood is greenish white in color. It is porous and soft in texture and has annual rings though not very distinct. It generally perishes fast when used at sites open to vagaries of weather, but lasts much longer when used under water. It is therefore used for making well curbs and piles [28-33].

### Ayurvedic Preparation

*B. monosperma* (Lam.) Taub is used as one of the important ingredients in most commonly used Ayurvedic preparations such as Kunkumadi Taila, Vanda Bhasma, Krmimudgara Rasa, Ayaskrti and Palasa Arka [34].

### Mythological history

It is perceptually believed that the palash is a form of agnidev, and known as God of fire. It was a punishment given to him by Goddess parvati for disturbing her and lord shiva's privacy. In Telangana, flowers of *B. monosperma* are specially used in the worship of Lord Shiva on occasion of Shivratri. In West Bengal, Nobel Laureate Rabindranath Tagore mentioned this flower in poems and in songs and linked with bright orange flame-like flower to fire [24].

### Microscopic characters

The microscopic evaluation of the powdered plant material (Flower, Leaf and Stem) was carried out with the help of microscope. The plant material was soaked in a solution of 20% chloral hydrate and then mounted on a glass slide with the help of glycerine. The mounted slides were then observed under a photographic microscope with a magnification of 400X. The powder microscopy of all the three plant

parts revealed peculiar characteristics. The flower powder of *B. monosperma* showed the presence of trichomes, which were unbranched and unicellular in nature having a narrow lumen. Single layer epidermal cells and parts of cuticle were also observed. Microscopy of the leaf powder showed cells of the upper epidermis, unicellular trichomes, which tapered towards the ends and annular vessels. The stem powder under the microscope shows traces of parenchymatous cells, phloem fibres and outer cork cells [35].

### Phytochemical constituents

**Flower-** The flower contain triterpenes [36], flavonoids like butein, butin isobutrin, isobutrin, coreospin, isocoreospin, sulphuretin, monospermoside and isospermoside, dihydromonospermoside, chalcones, aurones, isobutyne [37]. The major glycoside of the flower is butrin. The bright color of the flower is due to the presence of chalcones and aurones [38]. It also contains paltitrin, histidine, aspartic acid, alanine of phenyl-1-alanine, myricylalcohol, stearic, palmitic, arachidic and lignoceric acids, fructose, glucose, aspartic acid, alanine and phenylalanine [39,40] and a new bioactive flavones glycoside(5,7-dihydroxy-3,6,4'-trimethoxyflavone-7-O-alpha-L-xylopyranosyl-(1-->3)-O-alpha-L-arabinopyranosyl-(1-->4)-O-beta-D-galactopyranoside) [38].

**Bark-**The bark contains Kino-tannic acid, gallic acid, pyrocatechin, paltitrin and major glycosides like butrin, alanine, allophonic acid, butolic acid, cyaniding, histidine, lupenone, lupeol, miroestrol, palasimide, shelloic acid, medicarpin [27, 28, 29, 30]. Two compounds, 3, 9- dimethoxypterocarpin, and triterpenoid ester, 3 $\alpha$ - hydroxyeuph-25-enyl heptacosanoate [41].

**Leaf-** The leaves contains glucoside, kino-oil that containing palmitic acid, lignoceric acid, oleic and linoleic acid [40].

**Seed-** The seeds contain up to 20% of a fatty oil known as Moodooga Oil or Kino-Tree oil. The fresh seeds contain lipolytic and proteolytic enzymes plant proteionase and polypeptidase [42]. A nitrogenous

acidic compound, along with palasonin and monospermoside (butein-3-e-D-glucoside) is also present in the seeds [44].  $\alpha$ -amyrin,  $\beta$ -sitosterol,  $\beta$ -sitosterol-  $\beta$ -D-glucopyranoside and sucrose [43], monospermin, phosphatidyl choline, phosphatidyl lethanolamine and phosphatidylinositol [44]. Fatty acids like myristic acid, palmitic acid, stearic acid, arachidic acid, oleic, linoleic acid and linolenic [43].

**Stem:** It contains two iso flavones: prunetin and 5-methoxy genestein along with lupenone and lupeol and stigmasterol, stigmasterol- $\beta$ -D-glucopyranoside and nonacosanoic acid [45].

Flavonoid 8-C-prenylquercetin 7,4'-di-O-methyl-3-O- $\alpha$ -L-rhamnopyranosyl(1-4)- $\alpha$ -L-rhamnopyranoside[44], 3-hydroxy-9-methoxypterocarpin [(-)-medicarpin]. In addition to stigmasterol-3- $\alpha$ -L-arabinopyranoside, four compounds isolated from the stem of *Butea monosperma* have been characterized as 3-methoxy-8,9-methylenedioxypterocarp-6-ene, 21-methylene-22-hydroxy-24-oxooctacosanoic acid Me ester, 4-pentacosanylphenol and pentacosanyl- $\beta$ -D-glucopyranoside [41].

**Resins:** The resins contain Z-amyrin, e-sitosterone glucoside and sucrose, lactone-nheneicosanoic acid-delta-lactone, laccijalaric esters I, II (Terpenic laccijalaric acid), jalaric esters I, II [44].

**Roots:** Plant's root contains glucose, glycine and an aromatic hydroxy compound [44].

### Medicinal/ Traditional uses

**Flowers:** Flowers are astringent to bowel in cure Kapha, leprosy, strangury, gout, skin diseases, thirst, sensation; flower juice is useful in eye diseases. Flower is bitter, aphrodisiac, expectorant, tonic, emmenagogue, diuretic and good in biliousness, inflammation and gonorrhoea. The dye is useful in enlargement of spleen. Flowers are depurative, as a poultice they are used to disperse swelling and to promote menstrual flow. They are given to pregnant women in case of diarrhea. It is also useful to prevent us from urinogenital tracts of males. Flowers are crushed in milk and sugar is added, 3- 4 spoons if drunk per day for a month helps to reduce body heat and chronic fever. Flowers are soaked in

water overnight and a cup of this infusion is drunk every morning against leucorrhoea till cure.

**Seeds:** Powdered seeds are consumed by children as remedy against intestinal worms. Seeds are crushed in milk and this mixture about 2 spoons is taken orally to treat urinal complaints and also against urinary stones. Fruit and seed are digestible, aperient, cure Vata and Kapha, skin diseases, tumours and abdominal troubles and as per Ayurveda are given for Scorpion-sting. Fruit and seed are useful in piles, eye diseases and inflammation. When pounded with lemon juice and applied seeds act as powerful rubefacient and they have been successfully used in curing a form of herpes, known as Dhobie's itch.

**Leaves:** Leaves are good for the disease of the eye. Leaf is an appetizer, astringent, carminative, anthelmintic, aphrodisiac, tonic, lessens inflammation and lumbago, cures boils and piles. Petiole is chewed and the juice is sucked to cure cough, cold and stomach disorders. Leaf powder about 2 spoons per day for a month is drunk mixed with a cup of water to cure diabetes. Leaf extract is used as gargle in case of sore throat. Leaf extract about 3-4 spoons is drunk at night for 2-3 months. It checks irregular bleeding during menstruation.

**Gum:** Gum is applied for cracks on foot sole. 2 spoons of diluted gum are advised for dysentery until cure. Gum is astringent to bowel, good in stomatitis, cough, pterygium, corneal opacities and cures excessive perspiration.

**Roots:** The root cures night blindness and other defects of sight, useful in elephantiasis. Root pieces are heated and then 2-3 spoons of extract are advised at night as a remedy against impotency and it is administered for one month. Spoonful of root powder mixed with water is drunk as an antidote for snake bite.

**Stem bark:** Stem bark powder is used to apply on injury caused due to axe. Stem juice is applied on goiter of human being. Paste of stem bark is applied in case of body swellings. Bark is acrid, bitter, appetiser, aphrodisiac, and laxative, anthelmintic, useful in fractures of the bones, diseases of the anus,

dysentery, piles, hydrocele, cures ulcers and tumours. Bark is useful in biliousness,

dysmenorrhea, liver disorder, gonorrhea and it also purifies the blood. The ash of young branch is prescribed in combination with other drugs in case of scorpion sting. Ayurvedic literature extensive mention of this drug is available in the treatment of Krimi Roga. It enters into the composition of some very important and widely used recipes of Ayurvedic medicines used in the treatment of Krimi Roga. In Sushruta samhita this drug has been described under four different groups of herbal medicines eg. Rudaradigana, Musakadigana, Amabasadigana and Nyagrodhabigana dealing with different disorders eg. Medoroga, Striroga, Prameha and also credited with Kapha and Pitta properties. The first mention of its Krimighna property is available in Sushruta samhita and the later Ayurvedic authors have also described its efficacy in Netraroga and its astringent action in different conditions. Ancient and later Ayurvedic literature this drug has been mentioned either alone or as a constituent of many prepared medicines used in the treatment of Krimi Roga. A clinical trial of the plant in worm infestation proved its effectiveness in cases of round worm and thread worm infestations and drug was found to be ineffective in the only case of tape worm infestation [46].

## Pharmacological activity

### Anti hyperglycemic Activity

The ethanolic extract of *B. monosperma* was studied in glucose-loaded and alloxan-induced diabetic rats for anti hyperglycemic activity [47]. Single dose treatment of extract (200 mg/kg, p.o.) significantly improved glucose tolerance and caused decrease in blood glucose level in alloxan-induced diabetic rats. Repeated oral treatment with *B. monosperma* (200 mg/kg/day) for 2 weeks exhibited reduced blood glucose, serum cholesterol and improved HDL-cholesterol and albumin as compared to diabetic control group [48].

### Hepatoprotective Activity

The study was carried out to evaluate the effect of extract of *B. monosperma* on the tumor promotion related events of carcinogenesis in rat liver. Thioacetamide (TAA) was used to trigger tumor

promotion response and oxidative stress and caused significant depletion in the detoxification and antioxidant enzyme armory with concomitant increase in malondialdehyde (MDA) formation, hydrogen peroxide ( $H_2O_2$ ) generation, ornithine decarboxylase (ODC) activity and unscheduled DNA synthesis [49]. The alcoholic extract of *B. monosperma* used in the study seems to contribute dose-dependent protection and maintain the structural integrity of hepatic cells. This was evident from the significant depletion in TAA-induced serum GOT, GPT, Lactate dehydrogenase (LDH) and  $\alpha$ -Glutamyl transpeptidase activity (GGT) activities ( $p < 0.001$ ). The alcoholic extract possesses hepatoprotective effects and also it might suppress the promotion stage via inhibition of oxidative stress and polyamine biosynthetic pathway [50].

#### Antiestrogenic and antifertility activity

The methanolic extract of flowers of the title plant has also been reported to exhibit antiestrogenic and antifertility activities. The active constituent Butin isolated from its flowers show both male and female contraceptive properties [51]. It has been reported to exhibit effect on uterotrophic and uterine peroxidase activities in ovariectomized rats & determine estrogenic/antiestrogenic potential of antifertility substances using rat uterine peroxidase assay [52].

#### Radical scavenging activity

Evaluation for radical scavenging activity of various extracts such as ethyl acetate, butanol and aqueous fractions derived from total methanol extract of *B. monosperma* flowers using different in vitro models like reducing power assay [53]. Scavenging of 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical, nitric oxide radical, superoxide anion radical, hydroxyl radical and inhibition of erythrocyte hemolysis using 2, 2'-azo-bis (amidinopropane) dihydrochloride (AAPH). Methanolic extract along with its ethyl acetate and butanol fractions showed potent free radical scavenging activity. The observed activity could be due to higher phenolic contents in the extracts [54].

#### Antitumor activity

The aqueous extract of flowers of *B. monosperma* was administered via intra-peritoneal route to the X-

15-myconco mice showed antitumorigenic activity by maintaining liver architecture and nuclear morphometry but also down regulated the serum VEGF levels. Immuno-histochemical staining of liver sections with anti-ribosomal protein S27a antibody showed post-treatment termination of this proliferation marker from the tumor tissue [55].

#### Wound healing Activity

The efficacy of topical administration of an alcoholic bark extract of *B. monosperma* on cutaneous wound healing in rats. Full thickness excision wounds were made on the back of rat and *B. monosperma* extract was dispensed topically. The granulation tissue formed on days 4, 8, 12 and 16 (post-wound) was used to estimate total collagen, hexosamine, protein, DNA and uronic acid [56]. The extract elevated cellular proliferation and collagen synthesis at the wound site, as evidenced by increase in DNA, total protein and total collagen content of granulation tissues. It also possesses antioxidant properties, by its ability to reduce lipid per oxidation. The results clearly substantiate the beneficial effects of the topical application of *B. monosperma* in the acceleration of wound healing [57].

#### Anticonvulsive activity

The anticonvulsive activity is due to the presence of a triterpene [58]. The petroleum ether extract of flowers of *B. monosperma* exhibited anticonvulsant activity. The acetone soluble fraction of petroleum ether extract of *B. monosperma* flowers exhibited anticonvulsant activity. The fractions protected animals from maximum electro shock, electrical kindling and pentylenetetrazol-induced convulsions in mice [59]. However, they failed to protect animals from strychnine-induced convulsions. The fractions antagonized the behavioral effects of -amphetamine and potentiated the pentobarbitone induced sleep. The fractions raised brain contents of gamma-aminobutyric acid (GABA) and serotonin [49].

#### Thyroid inhibitory and hypoglycemic effects

Stigmasterol, isolated from the bark of *B. monosperma* was examined for its thyroid hormone and glucose regulatory efficacy [57]. The mice was administered with 2.6 mg/kg/d for 20 days which



decreased serum tri iodothyronine (T3), thyroxin (T4) and glucose concentrations as well as the activity of hepatic glucose-6-phosphatase (G-6-Pase) with a concomitant rise in insulin level exhibiting its thyroid inhibiting and hypoglycemic properties [62].

### Anti-inflammatory activity

The leaves of *B. monosperma* showed ocular anti-inflammatory activity in rabbits. The anti-inflammatory activity of methanolic extract of *B. monosperma* evaluated by carrageenin induced paw edema and cotton pellet granuloma [61]. In carrageenin induced paw edema at 600 and 800 mg/kg inhibition of paw edema, by 26 and 35% and in cotton pellet granuloma suppression of granuloma tissue formation, by 22 and 28% [62].

### Antifungal activity

The ethyl acetate and petroleum extracts of stem bark of *B. monosperma* showed antifungal activity against *Cladosporium cladosporioide*. An active constituent (-)-medicarpin is responsible for the antifungal activity. The seed oil of *Butea monosperma* also showed significant bactericidal and fungicidal effect in in-vitro testing [62, 63].

### Diarrhea

*B. monosperma* gum has also been found to be of great use in cases of chronic diarrhea. It is a strong astringent and also lowers bilirubin level [64]. The ethanolic extract of stem bark of *B. monosperma* at 400 mg/kg and 800mg/kg inhibited castor oil induced diarrhea due to inhibiting gastrointestinal motility and PGE2 induced enteropooling. It is used as nonspecific anti-diarrheal agent in folk medicine [65].

### Anthelmintic activity

The seeds of the plant possess the anthelmintic activity. It eliminates the parasitic worms from the Gastro-intestinal tract. Seeds of *B. monosperma* extract when tested in vitro, showed the anthelmintic activity. Crude powder of Palash seeds given at the doses of 1, 2, 3 g/kg to sheep with mixed species of gastro-intestinal nematodes or round worms; it showed a dose and time dependent anthelmintic activity [66, 67].

### Hemagglutinating activity

The lectins such as *B. monosperma* agglutinin (BMA) isolated from the seeds of *B. monosperma* showing specificity towards human erythrocytes are responsible for agglutinating property; this property was only shown by seeds. Human blood group-A-specific agglutinins have been displayed in some of the N-acetyl galactosamine/galactose-binding lectins, such as the lectins. Hemagglutination test showed that N-acetyl galactosamine is the strongest inhibitor of agglutination [68].

### Anti-stress Activity

The ethanolic extract of the part of *B. monosperma* that is water soluble was found to be useful in reducing the water immersion stress induced high concentration of serotonin and plasma corticosteroidal hormone [69].

### Conclusion

In the current review, we have made an endeavor to give the morphological, phytochemical, ethnopharmacological and pharmacological information on *B. monosperma*. The plant *B. monosperma* has an excellent potential against various ailments and have been experimentally and clinically utilized in both animals and man. A variety of extracts and chemical compounds of the plant have shown aphrodisiac, antioxidant, antibacterial, cytotoxic, anti-inflammatory and hypoglycaemic activities ect. A huge number of compounds have been remote from *B. monosperma* and shown to possess assorted biological properties. There is lack of management and conservation plan from the government side. Similarly, lack of awareness of importance regarding *B. monosperma* among rural villagers is leading towards the destruction of this valuable species. Due to the overexploitation of one of the critically endangered plants, there is a requirement to focus on conservation, upgradation and sustainable utilization of this wonder plant.

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