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Review Article

Butea monosperma (Lam.) Taub: Review on its chemistry, morphology, ethnomedical uses, phytochemistry and pharmacological activities

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Abstract

Plants have been employed for their therapeutic and aesthetic benefits since ancient times. Traditional herbal medicine is well-documented and practised in India. The goal of the current review is to provide current information on botany, morphology, ecological biodiversity, medicinal uses, phytochemistry, and pharmacological activity on various portions of Butea monosperma (Lam.) Taub because there haven't been many studies done on it (B. monosperma). Technical literature from electronic search engines like Springerlink, BioMed Central, PubMed, Scopus, ScienceDirect, Scielo, Medline, and Science domain was used to compile this review. Books, book chapters, dissertations, websites, and other scientific publications served as the source of the supplemental texts. B. monosperma, a member of the Fabaceae family, is found throughout the Indian Subcontinent and Southeast Asia, including in Bangladesh, Nepal, Sri Lanka, Myanmar, Thailand, Laos, Cambodia, Vietnam, Malaysia, and western Indonesia. It is also known as Flame of the Forest, Dhak, Palash, or Bastard teak. It is an herb that has long been used voluntarily in traditional Asian treatments. It has been used to treat a variety of illnesses, including diabetes, cancer, diarrhoea, dysentery, fever, and jaundice. Recent in vivo and in vitro research have shown that it has hepatoprotective, anti-cancer, anti-diabetic, anti-inflammatory, anti-asthmatic, anti-oxidant, anti-convulsant, and anti-microbial effects. Many phytochemicals, primarily flavonoids, lactones, diterpenoids, diterpene glycosides, and phytosterols, are present in the plant's aerial portion. Bark produces a red fluid called "Butea gum" or "Bengal kino" that is produced. This complementary medical approach is becoming more and more well-known worldwide. Isolating the active components, testing them biologically, understanding their molecular mechanisms, mounting an experimental defence, and getting B. monosperma's medicinal usage approved are all necessary. The information gathered will be required to identify up study protocol for modern medications and Ayurveda formulation extension in luxurious and remedial a number of illnesses. To further validate the claims on humans, clinical trials for the stated preclinical investigations should be started right away.

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

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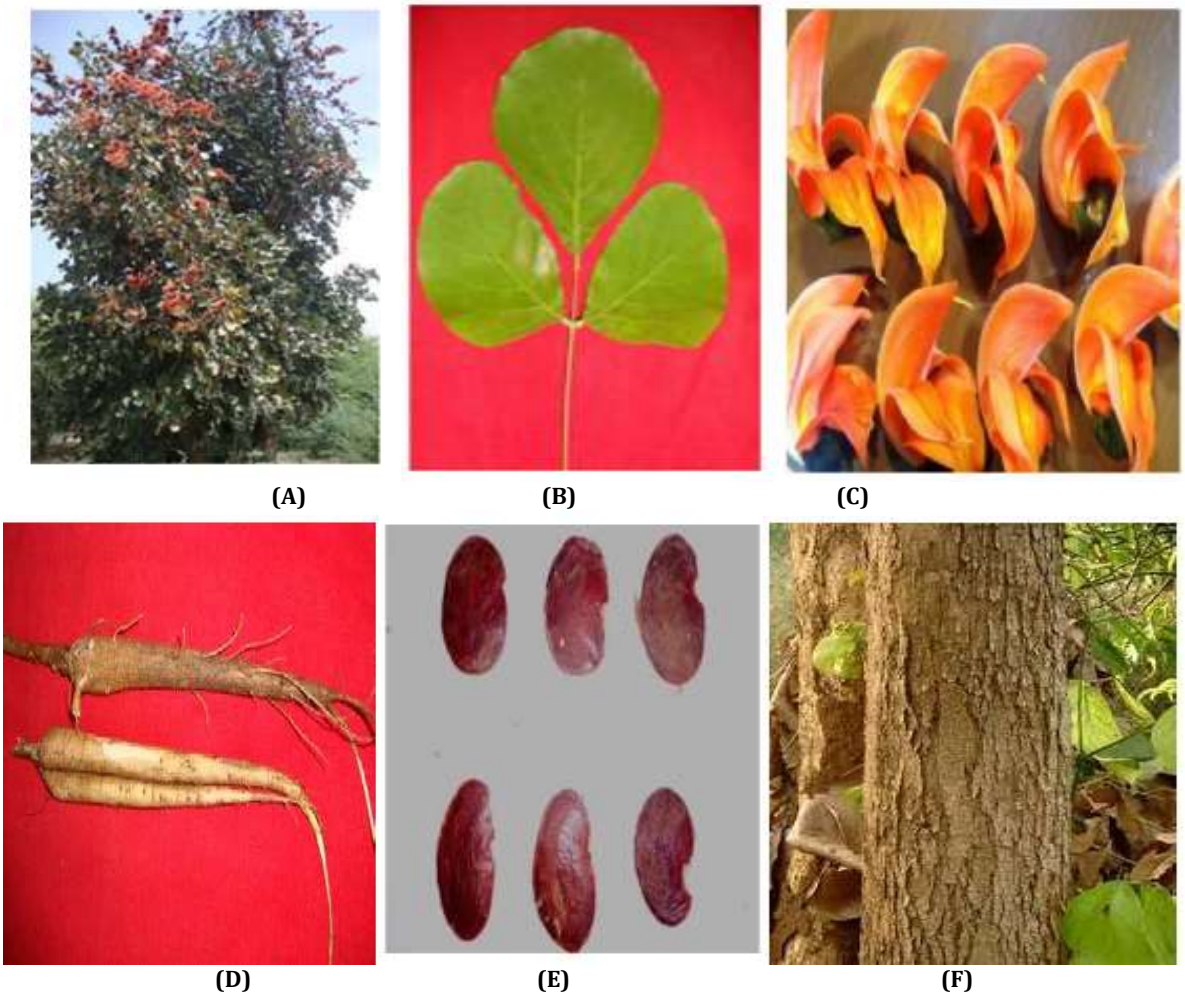
Introduction

Before the advent of modern medicine, herbal remedies handled all aspects of disease management. 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. Upanishads, Vedas, Susrirta Samhita, Charaka Samhita, Astanga Sangraha, and Ashtanga Hrdaya[12] all explain it. Except in extremely acrid regions[13], this moderately large deciduous tree is extensively found throughout India, Burma, and Ceylon. It also extends in the North West Himalayas as far as Jhelum. It is regarded as a holy tree (Fig.1). It thrives in an alkaline, swampy environment with plenty of sunlight. Many chemical components that can be extracted from different plant sections are employed as aphrodisiacs, astringents, anti-inflammatory, anti-diabetic, anti-fungal, and anti-asthmatic medications[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 This plant's blossom has been used to isolate 7,3,4-trihydroxyflavone. Euphane triterpenoid 3a-hydroxyeuph-25-ene, the alcohol 2, 14-dihydroxy-11, 12-dimethyl-8-oxo-octadec-11-enylcyclohexane, and Imide palasimide have all been isolated from the stem and pods of this plant species, 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]. The herb is a revitalizer, according to conventional medicine. This plant is a multipurpose tree with significant medicinal and economic significance because of its many facets. 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:** C h i chra, 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.



(A) (B) (C) (D) (E) (F)

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

Research methodology

A review of the scientific literature was compiled using data fr om a number of sources, including Google Scholar, Science Dir ect, PubMed, Scielo, Springerlink, Google Patents, Web of Scien ce, SciFinder, Scopus, Espacenet, BioMed Central (BMC), and M edline, to identify pertinent information on the phytochemistr y, botany, medicinal uses, and biological activities of B. monos perm

The terms biological activities, ethnobotany, medicinal uses, m edicinal, ethnopharmacology, pharmacology, phytochemistry, and therapeutic value, as well as B. monosperma, Butea frondo sa Roxb. ex Willd, Erythrina monosperma Lam, Plaso monospe rma palas, and others, were used to identify pertinent data. Bo oks, book chapters, theses, websites, and conference proceedi ngs were found to include additional literature.

Occurrence and distribution

In the tropical and subtropical areas of the Indian subcontinent, this plant is extensively dispersed. It is common in the south-East Asia ranging from India, Bangladesh, Pakistan, Nepal, SriLanka, 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 is widespread around the world and is a member of the fabaceae family. There have been reported to be 33 species of Butea to date. *Butea acuminate, Butea africana, Butea affinis, Butea apoensis, Butea braamiana, Butea balansae, Butea bracteolate, Butea crassfolia, Butea cuneiforms, 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

A plant known as B. monosperma is typically found in the drier regions of India. The tree can withstand droughts, but its leaves still turn white and drop 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. Ash-colored bark can be seen. The three foliate, big, and stipulate leaves. Petiole length is 10 to 15 cm. The bases of the leaflets are cunnate or deltoid, and they are obtuse, glabrous above, delicately silky, and prominently reticulately veined beneath. The plant has bald patches from January through March. Flowers grow in 15 cm long, stiff racemes that are covered in dark brown velvet. Calyx has a dense outside covering of velVet and is dark, olive green to brown in colour. The corolla is lengthy and has bright orange red and silky silvery hairs on the outside. Anthers are uniform, while stamens are diadelphes. The ovary has two ovule, a capitate stigma, and a filiform, curving style. The lower half of the argent eocanesent, constricted, thicker at the sutures pods break around the single apical seed. The seeds are reniform, flat, and curled. 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 coriascious 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. By December, the leaves are lost, and they come back in the spring. The tree produces bright orange to red flowers when it is leafless. 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. Brick red dominates the higher areas. They make the plant appear so lovely even though it is without leaves in the spring, when the entire area covered in palas trees takes on a gorgeous orange and scarlet tint. At a distance, the tree's upper canopy of blossoms, which is stunning, appears to be a flame. The palas fruit is a flat legume in the shape of a pod that is roughly 15 cm long and 3 to 5 cm wide. Young pods have a velvety covering and a lot of hair. When ripe, the pods droop like strange legumes. The flat, 15 to 25 mm wide, 1.5 to 2 mm thick seeds range in size from 25 to 40 mm. The two large, leafy, yellowish cotyledons are enclosed by a reddish-brown, glossy, and wrinkled seed coat. Towards the centre of the seed's concave edge, the hilum is clearly visible. The flavour is mildly acidic and harsh, and the aroma is weak. The colour of the wood is a greenish white. It contains annual rings, albeit they are not particularly prominent, and is porous and soft in texture. When utilised in locations subject to weather changes, it often deteriorates quickly; however, when used underwater, it lasts much longer. Thus, it is utilised to create effective curbs and piles.[28-33].

Ayurvedic Preparation

Monosperma, B. (Lam.) One of the key ingredients in several popular Ayurvedic remedies, including Kunkumadi Taila, Vanda Bhasma, Krmimudgara Rasa, Ayaskrti, and Palasa Arka, is taub [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. B. monosperma flowers are specifically utilised in Telangana to honour Lord Shiva on the occasion of Shivratri. Rabindranath Tagore, a Nobel Prize winner from West Bengal, made

reference to this flower in poems and songs and associated it with 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 has triterpenes[36], flavonoids such as butei, butin, isobutrin, coreospin, and isocoreospin, as well as monospermoside and isospermoside, dihydromonospermoside, chalcones, aurones, and isobutyine[37]. Butrin is the flower's main glycoside. Chalcones and aurones are what give the bloom its vivid color[38]. It also contains palsitrin, 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-Oalpha- L-xylopyranosyl-(1—>3)-O-alpha-L-arabinopyranosyl-(1-- >4)-O-beta-D-galactopyranoside) [38].

Bark- The bark includes significant glycosides like butrin, alanind, allophonic acid, butolic acid, cyaniding, histidin, lupenone, lupeol, miroestrol, palasimide, shelloic acid, and medicarpin, as well as kino-tannic acid, gallic acid, pyrocatechin, and palsitrin. Two substances: triterpenoid ester 3, 9-hydroxyeuph-25-enyl heptacosanoate and 3, 9-dimethoxypterocarpan[41].

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

Seed- Up to 20% of a fatty oil known as Moodooga Oil or Kino-Tree Oil is found in the seeds. Plant proteionase and polypeptidase [42], two lipolytic and proteolytic enzymes, are present in fresh seeds. Together with palasonin and monopermoside (butein3-e-D-glucoside), a nitrogenous acidic substance is also present in the seeds. α -amyrin,β-sitosterol, β-sitosterol- β-D-glucopyranoside and sucrose, monospermin, phosphatidyl choline, phosphatidy lethanolamine and phosphatidylinositol. Fatty acids like myristic acid, palmitic acid, stearic acid, arachidic acid, oleic, linoleic acid and linolenic[43, 44].

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

Flavonoid 8-C-prenylquercetin 7,4'-di- O-methyl-3-O-α-L-rhamnopyranosyl(1-4)-α-L-rhamnopyranoside[44], 3-hydroxy- 9~ methoxypterocarpan [(-)-medicarpin]. Four substances, including stigmasterol-3-L- arabinopyranoside, 3-methoxy-8,9-methylenedioxypterocarp-6-ene, 21-methylene-22-hydroxy-24-octacosanoic acid Me ester, 4-pentacosanylphenol, and pentacosanyl-D-glucopyranoside, have been identified from the stem of Butea monosperma[41].

Resins: The resins contain Z-amyrin, e-sitosterone glucoside and sucrose, lactone-nheneicosanoic acid-delta-lactone, laccijalaric esters I, II (Terpenic lac 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 the bowel and can be used to treat conditions including Kapha, leprosy, gout, strangury, skin problems, and thirst. Flower juice can also be used to treat eye conditions. Flower has a bitter taste and functions that include aphrodisiac, expectorant, tonic, emmenagogue, diuretic, and benefits for biliousness, inflammation, and gonorrhoea. The dye aids in spleen expansion. Flowers are depurative; they are applied as a poultice to reduce edoema and encourage menstrual flow. When pregnant women get diarrhoea, they are given these. Also, it helps to protect us from male urinogenital systems. Three to four spoons of the mixture, if consumed daily for a month, can help lower body temperature and persistent fever. Flowers are crushed in milk with sugar added. A cup of the flower infusion is consumed every morning till the leucorrhoea is cured after being immersed in water for the previous night.

Seeds: Children take powdered seeds as a preventative measure for intestinal worms. To cure urinal issues and prevent urinary stones, seeds are crushed in milk and eaten orally in a dose of around two spoons. According to Ayurveda, fruit and seeds are provided for scorpion stings because they are easily digestible, aperient, and heal Vata and Kapha, skin conditions, tumours, and gastrointestinal problems. Fruit and seeds are helpful for inflammation, eye conditions, and piles. A variant of herpes known as Dhobie's itch has been effectively treated using seeds that have been mashed with lemon juice and applied.

Leaves: Children who are at risk for intestinal worms ingest powdered seeds. The seeds are crushed in milk and taken orally in a dose of about two spoons to treat urinal problems and avoid urinary stones. Fruit and seeds are given for scorpion stings in Ayurveda because they are easily digestible, aperient, and treat Vata and Kapha, as well as skin disorders, tumours, and digestive issues. Fruit and seeds are beneficial for piles, eye disorders, and inflammation. Dhobie's itch, a type of herpes, has been successfully treated by applying seeds that have been mashed with lemon juice.

Gum: For fissures on the sole of the foot, gum is used. For dysentery, 2 spoons of diluted gum are recommended daily till recovery. Gum is beneficial for stomatitis, cough, pterygium, ocular opacities, and excessive sweating. It also has astringent properties for the gut.

Roots: The root is helpful in treating elephantiasis and treats night blindness among other vision abnormalities. During a month, heated root pieces and two to three spoons of the resulting extract are recommended as a treatment for impotence at night. A spoonful of root powder diluted with water is consumed as a snake bite remedy.

Stem bark: Stem bark powder is applied on axe-related wounds. Human goitres are treated using stem juice. Applying stem bark paste helps reduce body swells. Theanus, dysentery, piles, hydrocele, ulcers, and tumours can all be treated with bark, which is also aphrodisiac, bitter, appetising, laxative, and anthelmintic. In addition to purifying the blood, bark is helpful for biliousness, dysmenorrhea, liver disorders, and gonorrhoea. In the event of a scorpion sting, young branch ash is recommended in addition to other medications. This medication is extensively mentioned in the Ayurveda literature when treating Krimi Roga. It is incorporated into the

formulation of various crucial and often used Ayurveda drug recipes used to treat Krimi Roga. This medication is mentioned in the Sushruta Samhita under four different categories of herbal remedies, including Rudaradigana, Musakadigana, Amabasatadigana, and Nyagrodhabigana, which treat various disorders like Medoroga, Striroga, and Prameha. It is also said to have Kapha and Pittanasak properties. The Sushruta Samhita contains the earliest reference to its Krimighna quality, and later Ayurveda writers also discussed its effectiveness in netraroga and its astringent impact under various circumstances. This substance has been mentioned in ancient and modern Ayurvedic literature, either on its own or as a component of numerous prepared remedies used to cure Krimi Roga. In a clinical study on worm infestations, the plant was found to be successful in cases of round worm and thread worm infestations, while the medicine was useless in the one and only instance 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.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. When compared to a diabetic control group, repeated oral administration of B. monosperma (200 mg/kg/day) for two weeks resulted in lower blood sugar, serum cholesterol, and enhanced HDL-cholesterol and albumin[47, 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 induce oxidative stress and the tumour promotion response, and it significantly depleted the detoxification and antioxidant enzyme arsenal, increasing the production of ornithine decarboxylase (ODC), malondialdehyde (MDA), hydrogen peroxide (H2O2), and unscheduled DNA synthesis[49]. The alcoholic B. monosperma extract utilised in the study appears to provide dose-dependent protection and uphold the hepatic cells' structural integrity. This was demonstrated by the TAA-induced significant decrease in serum GOT, GPT, Lactate dehydrogenase (LDH), and -Glutamyl transpeptidase activity (GGT) activities ($p< 0.001$). The alcohol extract has hepatoprotective properties and may also impede the promotion stage by inhibiting oxidative stress and the route for the biosynthesis of polyamines[50].

Antiesterogenic 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 uterotropic and uterine peroxidase activities in ovariectomized rats & determine estrogenic/antiestrogenic potential of antifertility substances using rat uterine peroxidase assay[52].

Radical scavenging activity

Several in vitro methods, such as the reducing power assay, were used to test the radical scavenging capacity of various extracts, including ethyl acetate, butanol, and aqueous fractions produced from total methanol extract of B. monosperma flowers. Use of 2, 2' azo-bis (amidinopropane) dihydrochloride for the scavenging of 2, 2 diphenyl-1-picrylhydrazyl (DPPH), nitric oxide, superoxide anion, and hydroxyl radicals as well as the suppression of erythrocyte hemolysis (AAPH). The ethyl acetate and butanol fractions of methanolic extract demonstrated strong free radical scavenging activity. Higher phenolic levels in the extracts54 may have contributed to the reported activity[53, 54].

Antitumor activity

The X-15-myc onco mice received an intraperitoneal injection of an aqueous extract of B. monosperma flowers, which demonstrated antitumorgenic action by maintaining liver architecture and nuclear morphology while also lowering serum VGEF levels. Anti-ribosomal protein S27a antibody immunohistochemical examination of liver sections revealed post-treatment removal of this proliferation signal from the tumour 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 amount of total collagen, hexosamine, protein, DNA, and uronic acid was calculated using the granulation tissue that developed on days 4, 8, 12, and 16 (post-wound). Increases in DNA, total protein, and total collagen content in granulation tissues show that the extract increased cellular proliferation and collagen synthesis at the location of the wound. It also has antioxidant qualities since it can lessen lipid peroxidation. The outcomes unequivocally demonstrate the advantages of topical B. monosperma treatment in promoting wound healing[56, 57].

Anticonvulsive activity

Because to the inclusion of a triterpene58, the substance has anticonvulsant properties. B. monosperma flower petroleum ether extract showed anticonvulsant properties. The petroleum ether extract of B. monosperma flowers' acetone-soluble portion had anticonvulsant properties. The percentages shielded animals from electrical kindling, maximum electroshock, and mouse convulsions brought on by pentylenetetrazol[59]. They did not, however, prevent the convulsions that strychnine causes in animals. The fractions enhanced pentobarbitone-induced sleep and counteracted the behavioural effects of -amphetamine. Gamma-aminobutyric acid (GABA) and serotonin levels in the brain were increased by the fractions[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-phophatase (G-6-Pase) with a concomitant rise in insulin level exhibiting its thyroid inhibiting and hypoglycemic properties[62].

Anti-inflammatory activity

In rabbits, the leaves of B. monosperma had anti-inflammatory effects on the eyes. The anti-inflammatory efficacy of B. monosperma's methanolic extract was assessed using cotton pellet granuloma and carrageenin-induced paw edema[61]. Inhibition of paw edoema by 26 and 35% in carrageenin-induced paw edoema at 600 and 800 mg/kg, and suppression of granuloma tissue development by 22 and 28% in cotton pellet granuloma[62].

Antifungal activity

The stem bark of B. monosperma exhibited antifungal action against Cladosporium cladosporioide when extracted with ethyl acetate and petroleum. The antifungal activity is caused by an active component called (-)-medicarpin. In-vitro study of Butea monosperma seed oil revealed considerable bactericidal and fungicidal effects[62,63].

Diarrhea

Also, it has been discovered that B. monosperma gum is quite effective in treating chronic diarrhoea. It has a potent astringent effect and reduces bilirubin levels64. Castor oil-induced diarrhoea was prevented by the ethanolic extract of B. monosperma stem bark at 400 mg/kg and 800 mg/kg via reducing gastrointestinal motility and PGE2-induced enteropooling. In traditional medicine, it serves as an all-purpose anti-diarrheal agent[65].

Anthelmintic activity

The plant's seeds have anthelmintic properties. The parasitic worms are removed from the gastrointestinal tract. When examined in vitro, the seeds of B. monosperma extract exhibited anthelmintic action. Sheep with mixed species of gastro-intestinal nematodes or round worms were administered crude Palash seed powder at doses of 1, 2, or 3 g/kg; it demonstrated 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 cortico-steroidal hormone[69].

Conclusion

In the current review, we have made an endeavor to give the mophological, 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 require to focus on conservation, upgradation and sustainable utilization of this wonder plant.

Conflict of interest

The authors declare that there are no competing interests with this work.

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