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PHARMACOGNOSTIC AND PHARMACOLOGICAL PROFILE OF *BOMBAX CEIBA*

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Abstract

Bombax ceiba Linn. is a tall tree buttressed at the base that is widely distributed throughout India, Ceylon and Malaya, upto 1500 m of altitude. *Bombax ceiba* is commonly known as silk cotton tree and semal which belongs to family Bombacaceae. Its medicinal usage has been reported in the traditional systems of medicine such as Ayurveda, Siddha and Unani. It has wide range of medicinal and pharmacological application. Many parts of the plant (root, stem bark, gum, leaf, prickles, flower, fruit, seed and heartwood) are used by various tribal communities and forest dwellers for the treatment of a variety of ailments. The plant literature survey shows the plant possesses astringent, cooling, stimulant, diuretic, aphrodisiac, demulcent, and tonic effects and also helps in dysentery. It also possesses important pharmacological activity such as aphrodisiac, anti-inflammatory and hepatoprotective activity in addition to anticancer and anti-HIV activity, anti-Helicobacter pylori, antiangiogenic, analgesic and antioxidant activity and hypotensive, hypoglycemic and antimicrobial activity. It is reported to contain important phytoconstituents such as naphthol, naphthoquinones, polysaccharides, anthocyanins, shamimin and lupeol. This paper provides an overview on pharmacological, phytochemical properties and therapeutic benefits of the plant.

Keywords: *Bombax ceiba*, Simbal, Simul, Ethnobotanical uses, Phytochemistry, Pharmacological activities.

INTRODUCTION

Nature has been a source of therapeutic agents for thousands of years and a tremendous number of novel drugs have been discovered from natural sources. India is known as ‘‘Botanical Garden of the world’’ as it has a huge diversity of medicinal plants. Moreover, Medicinal plants have played important role in the development of material medica. Medicinal plants are the nature’s gift to human beings to make disease free healthy life. It plays a vital role to preserve our health. India is one of the most medico- culturally diverse countries in the world where the medicinal plant sector is a part of time- honored tradition that is a respected even today. Here, the main traditional systems of medicine include Ayurveda, Unani and Siddha. [1]

Plants are potent biochemists and have been components of phytomedicine since times immemorial; man is able to obtain from them a wondrous assortment of industrial chemicals. Plant based natural constituents can be derived from any part of the plant like bark, leaves, flowers, roots, fruits, seeds, etc. i.e. any part of the plant may contain active components. *Bombax ceiba* is an important medicinal plant of tropical and

subtropical India commonly known as Silk Cotton Tree. It is the tall deciduous tree, with straight buttressed trunk and broad spreading branches. It has been claimed in Ayurveda, that *Bombax ceiba* possesses proven medicinal properties and is the ingredient of many formulations. Almost every part of this plant is used as medicine, and its roots and flowers are used for curing the maximum number of ailments. [2,3] This article aims to provide an overview of the chemical constituents present in various parts of *Bombax ceiba* and their ethnobotanical and pharmacological actions. Due to medicinal properties there is enormous scope for future research on *Bombax ceiba* and further clinical and pharmacological investigation should be conducted to investigate unexploited potential of this plant.

Habitat and distribution

Bombax ceiba Linnaeus belongs to the family Bombacaceae which contains about 26 genera and nearly 140 pantropical species.[4] It is commonly known as Simbal, Simul, Indian kapok, Katsavar, Indian bombax or Red Silk cotton tree. It is widely found in temperate Asia, tropical Asia, Africa and Australia. In India, it can be found at altitudes upto 1500 m. In peninsular India, the tree is very common in the dry as well as moist deciduous forests and near rivers. [4] The tree is a strong light-demander and fast growing. It grows best on deep sandy loams or other well-drained soils, particularly in valleys, in regions receiving 50 to 460 cm annual rainfall well distributed throughout the year.[4]

General description

The different part of *Bombax ceiba* like leaves, roots, stem bark, seed, flower, gum and fruit are reported to possess various medicinal qualities in ethnobotanical surveys conducted by ethnobotanist and in traditional system of medicine such as Ayurvedic. Semal is a lofty, deciduous tree up to 40 m tall with horizontally spreading branches and young stems covered with hard prickles. Bark is grey brown or silver grey colored with hard sharp conicles prickles. Leaves are large, spreading, glabrous, leaflets lanceolate, 3-7 and margin entire. Flowers are red numerous, appearing when the tree is bare of leaves, stamens many arranged in five bundles of 9-12 each and an inner bundle of 15. The fruits are brown capsule-like upto 15 mm long, filled with numerous black seeds. Seeds are smooth, black or grey embedded in long white wool, which are irregular obovoid in shape, smooth and oily with dense silky hair. Gum is light brown to opaque or dark brown called as semul gum.[5]

Traditional uses

Tribal people throughout India are well-acquainted with the knowledge of the plant's usage. Preparation of about 30g of seed powder of *Bombax ceiba* and about 10 g Hing (*Ferula foeitida*) are used as an abortifacient by the Oraon tribe in West Bengal.[6] *B. ceiba* is used as described: half a cup of ethanol extract of bark and flower is given for 3 days to both men and women with sexual diseases like hydrocele, leucorrhoea, gonorrhea and is also used to check menstrual disorders in women by the tribal area of

southern Rajasthan.[7] The study carried in Kandha tribe of Orissa showed that one teaspoon juice of fresh stem bark of *Bombax ceiba*, one teaspoon juice of fresh root of *Asparagus racemosus*, powder of seven black peppers (dried seed of *Piper nigrum* L., Piperaceae) and one teaspoon of processed sugar or gum taken orally on an empty stomach two times daily for 21 days to cure gonorrhoea, impotency, spermatorrhea, sterility, nocturnal emission and leucorrhoea. It is also prescribed for increasing sperm in semen and to act as aphrodisiac (Manu Vhokta).[8] The study carried out in Sitamata Wildlife Sanctuary of Chittorgarh and Udaipur district located in the southwest region of Rajasthan showed that bark, flower and powdered root barks of *B. ceiba* are used in hydrocele, leucorrhoea, gonorrhoea and to regularize menstruation, urinary problems and as a tonic. [9] The study of traditional anti-inflammatory plants used by the Lohit community of Arunachal Pradesh showed that fresh paste prepared from the bark of *Bombax ceiba* mixed with cow dung is applied over back muscle of leg at night to treat hotness and inflammation[10] Root powder of *Bombax ceiba* is used as a tonic to treat impotency, 10 g of root powder was advised daily with a glass of milk by tribes of the Sonbhadra district in Uttar Pradesh. [11] A powder of stem prickles was used to treat asthma; about 10 g (one spoonful) powders is taken with a glass of cow's milk/fresh water in the morning for 3-4 months. Seed paste prepared in water was applied on small-pox boils. [11] The paste of *Bombax ceiba* bark externally is used for cattle wounds in Mysore and Coorg districts, Karnataka. [12] The bark juice of *Bombax ceiba* is applied locally for the treatment of wounds.[13] The bark juice is mixed with the bark juice of *Magnifera indica* and *P. guajava* and drunk to cure dysentery and intestinal spasm. The resin was also taken orally to treat worms and diarrhea; root juice is consumed to treat abdominal pain and gonorrhea.[13] The native people of state Mizoram uses traditional methods of treatment based on herbal drugs. Decoction of the leaves of *B. ceiba* and the bark of *Mangifera indica* is taken (5 ml, 2-3 times daily) orally to treat diarrhea.[14] The root bark of *Bombax ceiba* is peeled with a sharp knife and the inner white portion is crushed and made into a fine paste. The paste is then added to 30–50 ml of water and administered in the morning, preferably on an empty stomach for 2 days to treat diarrhea in Parinche valley, Pune district, Maharashtra.[15]

Medicinal uses

Semal root powder, vidari (*Ipomoea digitata*) root, shatawar and misri are taken twice a day with milk to treat nocturnal emission and semen problems. Leaves of semal are grinded with water, filtered and taken orally for blood purification. Semal root powder is taken twice a day with water to treat leucorrhoea. Semal root powders (100 gm), mulethi powder (50 gm), swarngeru (25 gm) powder are taken twice a day with water or milk to treat bleeding in menstruation. A Thorny part from the stem of semal tree is taken to make a paste of root of thorn with water and applied on affected area to treat acne, skin blemish and pigmentation. This also lightens scar marks due to boils, freckles, acne vulgarise and burns. A paste of its bark is applied on the wound. The green base part of semal flower is taken, cleaned and dried in shade,

grinded to make powder. One spoon powder, honey (2 tbsp) desi ghee (1 tbsp) is mixed in milk to drink. It improves breast milk. Semal root powder with black pepper and dry ginger powder are taken in small amount to cure cold and cough.[16]

Phytochemistry

From the roots of *B. malabaricum* new glycosides 3', 4', 5, 7-tetra hydroxyl-6- methoxy flavan-3-o-β-D glucopyranosyl- α-D-xylopyranoside, tracontanol and β- sitosterol was isolated. 1, 6-dihydroxy-3-methyl-5-isopropyl-7-methoxy-8- naphthalene carboxylic acid (81) lactone was also isolated. [17] Mixture of polysaccharide (L-arabinose, D-xylose, with traces of L-rhamnose, uronic acid) along with 2, 3, 4, 6-tetra –o-methyl glucose and 2, 3, 6-tri-o-methyl glucose, 2- o-methyl glucose and 3-0-methyl glucose were also isolated from roots.[18] Phytochemical investigation of the chemical constituents of the roots of *Bombax ceiba* afforded 9 cadinane sesqui terpenoids (5 new compounds and 4 known compounds). New {(Bombamalones A-D, I-IV) and bombamaloside V} and known (isohemigossypol-1-Me ester, 2-o-methyl isohemigossylic acid lactone, bombaxquinone B, lacinilene C and checked for HGC-27 gastrointetinal cancer cell line but all were inactive.[19]

A sesquiterpene lactone isolated from *Bombax ceiba* roots was previously identified as hemigossylic acid lactone-7- methyl ether. 2D-NMR reveals that it is actually isohemigosylic acid lactone-2- methyl ether.[20] 4 new aromatic sesquiterpenoid was isolated from root bark of *B. ceiba.*[17] Lupeol, β- sitosterol, naphthaquinone and potassium nitrate was isolated from root bark. [21] Petroleum ether extract of root bark contains lupeol, β-sitosterol, and a pure crystalline compound suggesting a naphtha oquinone structure. [22] Root bark also contains isohemigossypol-1, 2-dimethyl ether, 8- formyl-7-hydroxy-5-isopropyl-2-methoxy- 3-methyl-1, 4-naphthaquinone,7- hydroxycadalene.[23] 3 new biosides isolated from flower (24β-ethyl cholest-5-en-3β-o-α-Larabinopyranosyl (16)-β-D gluco pyranoside, 3, 5 dihydroxy-4'-methoxy flavones-7-o-α-L-rhamnopyranosyl-(16)-β-D-glucopyranoside and 4, 5, 7- trihydroxy-flavone-3-o-β-Dglucopyranosyl (14)-α-L rhamnopyranoside. Anthocyanin-A and B was isolated and its structure was elucidated from flowers. [21, 24]

Flowers also contain β-D-glucoside of β- sitosterol, free β-sitosterol, hetriacontane, hetriacontanol, kaempferol, quercetin and traces of essential oil.[25] Ethyl acetate fractions of alcoholic extract of flower were investigated by GC-MS and 46 compounds were identified like palmitic acid, ethyl palmitate, β-sitosterol etc. [26] 2 unusual 9'- norneolignans i.e. bombasin and bombasin 4-o-β-glucoside and a novel D-gulono-γ- lactone derivative bombalin were isolated from flowers alongwith 3 known compounds. Dihydrodehydro di-coniferyl alcohol 4-o-β-d-glucopyranoside, trans-3- (p-coumaroyl) quinic acid and neochlorogenic acid and checked for HGC-27 gastrointestinal cancer cell line but all were inactive. [27] Quercetagetin a novel glycoside was isolated from flowers. [28] 2 new flavanoid compounds were isolated from petals of flowers and identified as pelargonidin-5-β- glucopyranoside and cyaniding-7-methyl ether-

3-β-glucopyranoside.[29] N- hexane extract of flower contain 14 compounds including cholesterol, stigmasterol, campesterol, α-amyrin and 10 were hydrocarbons.[30]

A new ferulic ester, trans-triacontyl-4-acetoxy-3- methoxy cinnamate alongwith known ferulates and triterpenes were isolated from spines of stem bark.[31] Methanolic extract of *Bombax ceiba* contains 7 flavones, vicenin 2, linarin, saponarin, cosmetin, isovitexin, xanthomicrol, apigenin.[30] It also contains various amino acids like lysine, arginine, alanine, glutamic acid, glycocol, leucine, lysine, and sugars like fructose, glucose, galactose, sucrose, lactose, arabinose.[32] N-hexacosanol and palmitic acid was isolated from seeds.[21] The seed oil contains phytosterol, palmitic acid, stearic acid, oleic acid and linoleic acid and lipase like enzyme.[33-35] Seed oil was glyceridic mixture of myristic, palmitic, arachidic, behinic and linoleic acid along with carotenoids, α-tocopherol and various amino acids and sugars [36]. Seeds contain essential amino acids like threonine, valine, methionine, isoleucine, leucine, phenylalanine, lysine, histidine, arginine and tryptophan.[37]

Hydrolysis of gum yields arabinose, galactose, galacturonic acid, rhamnose and partial hydrolysis yields 6- o-(β-D-galactopyranosyl-uronic acid)-D galacto pyranose; 2, 3, 4, 6-tetra-, 2, 6-di and 2, 4-di-o-methyl-o-D-galactose and 2, 3, 5- tri and 2, 5-di-o-methyl-L-arabinose.[38] *Bombax ceiba* gum can be substituted for gum tragacanth.[39] Methylated *Bombax ceiba* gum on hydrolysis has been found to yield 2,3,4,6-tetra-, 2,6-di-, and 2,4-di-o-methyl-D-galactose and 2,3,5-tri and 2,5-di-o-methyl-L-arabinose.[40]

Pharmacology

The antioxidant activity of a root extract of *Bombax ceiba* was evaluated using several antioxidant assays, in terms of its: ability to scavenge DPPH and reducing power assay. Methanolic extract of the roots showed high amount of phenolics (30.95% w/w) and tannins (15.45% w/w) and a very good DPPH radical scavenging activity in a dose dependent manner. [41]

In-vitro anti-inflammatory activity of extracts of *Bombax ceiba* was assessed by human red blood corpuscles membrane stabilizing method with slight modifications.[42]

The extract of stem bark of *Bombax ceiba* Linn has significant anti-obesity potential against high fat diet induced experimental obesity, possibly due to modulation of FAS and PTP-1B signaling in Wistar rats due to the presence of active flavanoids and lupeol respectively. [43]

A dose of 600 mg/kg of *Bombax ceiba* extract is the most effective to cause significant ($p<0.001$) hypoglycemic and/or hypolipidemic effects on streptozotocin-induced diabetic rats. Phytochemical and GC-MS studies confirmed the presence of the triterpenoid compounds in the extract, which may account for its significant hypoglycemic activity. [44]

Aqueous extracts of the plant *Bombax ceiba* exhibit mild cytotoxic effect in brine shrimp lethality test. [45]

Mangiferin, 2-beta-D-glucopyranosyl-1, 3, 6, 7- tetrahydroxy-9H-xanthen-9-one, obtained directly from methanolic extracts of *Bombax ceiba* leaves demonstrated strong antioxidant activity using DPPH assay. The acetyl and cinnamoyl derivatives were found to be less active than mangiferin whereas methyl and 3, 6, 7-trimethylether tetraacetate derivatives were inactive implying that for antioxidant activity, free hydroxyl groups and catechol moiety are essential. Moreover, mangiferin showed hepatoprotective activity against carbon tetrachloride induced liver injury further supporting the free radical scavenging property in the in vivo system. Additionally, crude plant extracts and purified mangiferin failed to exhibit acute anti-inflammatory activity whereas, extracts displayed significant analgesic effect in acetic acid-induced writhing and hot plate tests in mice. [46]

A methanol extract of the stem barks of *Bombax ceiba* was found to exhibit a significant antiangiogenic activity on *in vitro* tube formation of human umbilical venous endothelial cells. Bioactivity-guided fractionation and isolation carried out on this extract identified lupeol as an active principle. [47]

Shamimin, a C-flavonolglucoside from *Bombax ceiba* leaves showed significant potency as a hypotensive agent at the doses of 15 mg/kg, 3 mg/kg, 1 mg/kg and significant hypoglycaemic activity at 500 mg/kg in Sprague Dawley rats.[48]

Strong antibacterial activity was shown by the methanol extracts of *Bombax ceiba*. [49] Plant or plant parts were collected, dried, homogenized and extracted in two organic solvents viz. methanol and acetone. The antibacterial activity against *Klebsiella pneumoniae* was done by agar disc diffusion method. The activity was compared with standard antimicrobials Amikacin and Piperacillin. [50]

Aqueous extracts of the plants were screened for their cytotoxicity using the brine shrimp lethality test. [51]

The hepatoprotective activity of a methanolic extract of flowers of *Bombax ceiba* (MEBC) was investigated against hepatotoxicity produced by administering a combination of two anti-tubercular drugs isoniazid (INH) and rifampicin (RIF). MEBC was evident in all doses as there was a significant decrease in alkaline phosphatase, alanine transaminases, aspartate transaminases and total bilirubin levels, but increase in the level of total protein in comparison to control. MEBC significantly decreased the level of TBARS (thiobarbituric acid reactive substances) and elevated the level of GSH (reduced glutathione) at all doses as compared to control. The results obtained from the analysis of biochemical parameters and

histopathological studies, resulted in the conclusion that the MEBC were not able to completely revert the hepatic injury induced by INH and RIF, but it could limit the effect of INH and RIF to the extent of necrosis.[52]

The methanol extract of *Bombax ceiba* leaves (MEBM) was investigated for the antipyretic activity in rats. [53] MEBM possessed significant antipyretic activity in Baker's yeast-induced pyrexia. Phytochemical tests showed the presence of steroids, carbohydrates, tannins, triterpenoids, deoxy-sugars, flavonoids and coumarin glycosides.

The aphrodisiac activity of *Bombax ceiba* root extract was investigated. The extract (400 mg/kg body wt/day) was administered orally by gavage for 28 days. Mount latency (ML), intromission latency (IL), ejaculation latency (EL), mounting frequency (MF), intromission frequency (IF), ejaculation frequency (EF) and postejaculatory interval (PEI) were the parameters observed before and during the sexual behaviour study at day 0, 7, 14, 21, and 28 days. The extract reduced significantly ML, IL, EL and PEI ($p < 0.05$). The extract also increased significantly MF, IF and EF ($p < 0.05$). These effects were observed in sexually active and inactive male mice. [54]

Ethanolic extracts of *Bombax ceiba* evaluated strong *antiHelicobacter* pylori activities. The minimum inhibitory concentration values of the *anti-Helicobactor* pylori activity given by the ethanolic extracts ranged from 0.64 to 10.24 mg. [55]

Effects of mangiferin in rat colon carcinogenesis induced by chemical carcinogen, azoxymethane (AOM) were evaluated. They performed a short-term assay to investigate the effects of mangiferin on the development of preneoplastic lesions by AOM, aberrant crypt foci (ACF). In the short-term assay, 0.1% mangiferin in a diet significantly inhibited the ACF development in rats treated with AOM compared to rats treated with AOM alone. In continuation longstudy they evaluate the effect of mangiferin on tumorigenesis induced by AOM. In the long-term assay, the group treated with 0.1% mangiferin in initiation phase of the experimental protocol had significantly lower incidence and multiplicity of intestinal neoplasms induced by AOM. Same time the cell proliferation in colonic mucosa was reduced in rats treated with mangiferin. They opined that mangiferin has potential as a naturally occurring chemopreventive agent. [56]

Miscellaneous uses

Fruit is cooling, digestible, stimulant, diuretic, tonic, aphrodisiac, expectorant, blood purifier and good for leprosy. It has great beneficial effect over the membranes of the genitorurinary organs, It is used for chronic inflammation of bladder, kidney and for calculus affections. The flowers are bitter, acrid cooling, dry, astringent to the bowels, removes bile and phlegm, purify the blood, benefit the spleen and good for leucorrhoea. Flowers are topically applied to skin affections as cooling and astringent. Leaves is applied topically as a paste to relive inflammation as well as given in the form of decoction. Stem bark is sprinkled topically in bleeding wound and applied as a paste in water to skin eruptions, boils, acne, pimples etc. Decoction of bark is used as demulcent, styptic and used to removes phlegmatic. Aqueous extract with curd is given for dysentery with blood. Seeds are used for chickenpox, smallpox, catarrhal affections, chronic cystitis and genitourinary diseases. The gum is acrid, astringent, demulcent, tonic, aphrodisiac and removes black bile. In powder form alone or with other herbs it is used internally to treat haemoptysis, diarrhoea, dysentery, bleeding piles, menorrhagia, leucorrhoea, spermatorrhoea and blood disorders. Topically it is applied as styptic, astringent, demulcent in stomatitis, dermatological ailment and burn wound. The root is sweet and cooling, demulcent tonic, slightly diuretic and astringent to the bowels. It is useful in biliousness, inflammations and excessive heat of the body. It is also employed in low vitality and debility.

The tender twig was used as a toothbrush to cure mumps. Powdered flowers mixed with honey were given in menorrhagia. The thorn was rubbed on stone with unboiled milk, made into paste and applied for 5–6 days as ointment on the face to get rid of acne. The thorn was crushed and chewed with stem bark of *Cordia gharaf* to cure mouth sores. The roots powdered with those of *Chlorophytum*, *Capparis sepiaria* and fruits of *Pedalium murex* were taken with water as a tonic for 7–8 days to calm body heat. Root bark extract was given as a tonic in case of sexual debility and also as nervine tonic. Root powder mixed with sugar candy and milk was taken to avoid impotency.

Conclusion

The review exposes the hidden medicinal values of *Bombax ceiba* because of which it has a long history to be used by traditional healers for a extensive range of diseases. Researchers have exploited the plant to reveal its medicinal values successfully. An extensive literature survey has revealed that *Bombax ceiba* has a long history of traditional use for a wide range of diseases. Much of the traditional uses have been validated by scientific research. It is an important species that has economic and ecological importance and should be conserved for ecological perspectives. The pharmacological and clinical studies reported in the present review confirm the therapeutic value of *Bombax ceiba*. The presence of interesting/novel

chemical compounds indicates that the plant could serve as "lead" for development of novel agents in disorders in the coming years. In this regard, further studies need to be carried out to explore *Bombax ceiba* for its potential in preventing and treating diseases.

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