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Review Article

BOMBAX CEIBA LINN. : A REVIEW

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Plants have been an important source of medicines since the beginning of cultivation. There is a growing demand for plant-based medicines, health products, pharmaceuticals, food supplements, cosmetics etc. *Bombax ceiba* Linn. (Bombacaceae) is a tall tree buttressed at the base that is widely distributed throughout India, Ceylon and Malaya, upto 1500 m of altitude. 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.

KEYWORDS: *Bombax ceiba,* simbal, simul, ethnobotanical uses, phytochemistry, pharmacological activities.

INTRODUCTION

Natural products are an important source of new compounds leading to drugs in all major disease areas. They represent a pool of structures that have been optimized by evolution to interact with proteins and other molecules.[1] The starting materials for about one-half of the medicines we use today come from natural sources. The future of higher plants as sources of medicinal agents for use in investigation, prevention and treatment of diseases is also very promising.[2]

Natural products have provided some of the important life-saving drugs used in the armamentarium of modern medicine. However, among the estimated 250,000-400,000 plant species, only 6% have been studied for biological activity and 15% have been investigated phytochemically. This illustrates the need for planned activity guided phyto-pharmacological

Habitat and distribution

Bombax ceiba Linnaeus belongs to the family Bombacaceae which contains about 26 genera and nearly 140 pantropical species.[3] 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.

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.[3]

Morphology

Semal is a lofty, deciduous tree upto 40 m tall and 6 m or more in girth with horizontally spreading branches and young stems covered with stout, hard prickles. The

bark is pale ash to silver grey in color. Flowers are large in diameter, red in color and numerous with copious nectar.

30g of seed powder of *B. ceiba* and about 10 g Hing *(Ferula foeitida)* are used as an abortifacient by the Oraon tribe in West Bengal.[8]

Aphrodisiac, birthcontrol, sexual diseases and tonic

An ethnobotanical survey of the tribal area of southern Rajasthan was carried out during the year 2001–2002 for ethnosexicological herbal medicines.[9] *B. ceiba* was used as described: half a cup of ethanol extract of bark and flower was given for 3 days to both men and women with sexual diseases like hydrocele, leucorrhoea, gonorrhea and was also used to check menstrual disorders in women.[9]

Studies on the ethnomedicobotany of the Kandha tribe of Orissa showed that one teaspoon juice of fresh stem bark of *B. 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).[10]

Another study was carried out in Sitamata Wildlife Sanctuary of Chittorgarh and Udaipur district located in the south-west region of Rajasthan.[11] This study 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.[11]

An ethnobotanical study has very often resulted in the discovery of important drug plants. An infusion of the bark of *B. ceiba* is used as a tonic.[12]

Anti-inflammatory activity

An ethnobotanical study of traditional anti-infllammatory plants used by the Lohit community of Arunachal Pradesh showed that fresh paste prepared from the bark of *B. ceiba* mixed with cow dung was applied over back muscle of leg at night to treat hotness and inflammation.[13]

Impotency, asthma and small-pox boils

An ethnobotanical study examined the folk medicinal uses of certain plants by tribes of the Sonbhadra district in Uttar Pradesh.[14] Root powder of *B. ceiba* was used as a tonic to treat impotency, 10 g of root powder was advised daily with a glass of milk. A powder of stem prickles was used to treat asthma; about 10 g (one spoonful) powders was 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.[14]

Muscular Injury

An ethnobotanical study on medicinal plants around Mt Yinggeling, Hainan, China showed that *B. ceiba* barks and roots were used to treat muscular injury.[15]

Wounds

Ethnomedicinal uses of useful plants from Mysore and Coorg districts, Karnataka included using the paste of *B. ceiba* bark externally for cattle wounds.[16]

Anti-diarrheal

Field observations recorded on the use of medicinal plants in traditional health care systems of the Tharus

of three villages in Nawalparasi district of central Nepal has shown that bark juice of *B. ceiba* was applied locally for the treatment of wounds;.[17] The bark juice was 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 was consumed to treat abdominal pain and gonorrhea.[17]

The native people of state Mizoram used traditional methods of treatment based on herbal drugs. Decoction of the leaves of *B. ceiba* and the bark of *Mangifera indica* was taken (5 ml, 2-3 times daily) orally to treat diarrhea.[18]

An ethnobotanical survey of anti-diarrheal plants of the Parinche valley, Pune district, Maharashtra[19] showed that the root bark of *B. ceiba* was peeled with a sharp knife and the inner white portion was crushed and made into a fine paste. The paste was then added to 30–50 ml of water and administered in the morning, preferably on an empty stomach for 2 days to treat diarrhea.[19]

Leprosy

An ethnobotanical survey of medicinal plants used by traditional practitioners and religious healers of Bangladesh has shown that seeds and roots of *B. ceiba* were used in the treatment of leprosy.[20]

Pimples and skin disease

The ethnopharmacology of medicinal plants among the tribal communities of North-West Frontier Province, Pakistan showed applications of *B. ceiba* in the treatment of skin diseases and in folk cosmetics. Fresh bark of *B. ceiba* was crushed and applied topically on pimples, carbuncles and boils.[21]

An ethnomedicinal claim of some distinctive medicinal plants utilized by Pawara tribal in the Satpuda hills of Maharashtra showed that concentrated bark decoction of *B. ceiba* were applied in the treatment of skin diseases and pimples. Bark powder of *B. ceiba* was boiled with water and given orally twice a day for 7 days to treat leucorrhoea.[22]

Anthelmintics

A survey was conducted in southern Punjab, Pakistan, to document existing ethnobotanical knowledge by the herdsmen/key respondents about anthelmintics in ruminants. Flowers of *B. ceiba* (25–50 g as feedstuff) were fed to the animal as anthelmintics.[23]

Miscellaneous Uses

An ethnomedicinal and ethnopharmaco-statistical studies in Eastern Rajasthan shows multiple uses of *B. ceiba*.[24] 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 un-boiled 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.[24]

Phytochemistry

B. ceiba flowers have been shown to contain the β-D-glucoside of β-sitosterol, free β-sitosterol,

hentriacontane, hentriacontanol, traces of an essential oil, kaempferol, and quercetin.[25]

Shamimin, a newly discovered flavonol C-glycoside has been isolated as a pale yellow powder from the ethanolic extract of fresh, undried leaves of *B. ceiba*. Its structure has been elucidated as 2-(2, 4, 5-trihydroxyphenyl)-3, 5, 7-trihydroxy-6-C-glucopyranosyloxy-4H-1-benzopyran-4-one through extensive spectroscopic methods (IR, mass, 1H- and 13C-NMR), and 2D-NMR experiments.[26]

The Ph.D work presented by Muhammad Ali Versiani reviewed the phytochemical studies of *B. ceiba*.[27] Dried leaf extracts of the plant were subjected to chemical investigation, which led to the isolation of three new compounds [4-C-β-D Glucopyronosyl-1, 3, 6, 8-tetrahydroxy-7-O-(4"-hydroxybenzoyl)-9H-xanthen-9-One (I), 2-C-β-D Glucopyronosyl-1, 6, 7-trihydroxy-3-O-(4"-hydroxybenzoyl)-9H-xanthen-9-One (II), 4-C-β-D Glucopyronosyl-1, 6, 8-trihydroxy-3, 7-di-O-(4"-hydroxybenzoyl)-9H-xanthen-9-One (III)] and one known compound mangiferin.[27]

A sesquiterpene lactone isolated from the roots of a plant species identified as *Salmalia malbaricum* (syn *Bombax ceiba*) was previously identified as hemigossylic acid lactone-7-methyl ether. 2D NMR experiments have shown that this was a new compound, isohemigossylic acid lactone-2-methyl ether.[28] A detailed exploration of phytochemical properties along with the TLC ratios of various extracts of *B. ceiba* was also conducted which showed that the alcoholic and water extracts indicate the presence of alkaloids, flavonoids, glycosides, coumarins, proteins and amino acids.[29]

Phytochemical investigation was carried out on the gynaceum part of the flower of *B. ceiba* plant. Chromatographical techniques were employed to isolate the compound quercetagetin glycoside from the ethyl acetate fraction of an ethanolic extract of the gynaceum part of the flowers. The structure of the isolated compound was elucidated by spectroscopic methods including UV, 1H and 13CNMR.[30]

Isolation and characterization resulted in the identification of two compounds from the extracts of stem barks of *B. ceiba*. These were lup-20 (29) en-3b-ol, named BC-1 and 2-hexyl-7, 8-dimethyl-1, 4-naphthaquinone, named ceibanaphthaquinone.[31]

Pharmacology

Hypotensive activity

Shamimin along with lupeol [lup-20 (29) en-3b-ol], which possesses potent hypotensive activity, have been isolated from *B. ceiba* stem bark. BCBMM [filtrate from BCBM (Methanolic extract of defatted stem bark)] one of the most active fractions has revealed its adverse effects on heart, liver and kidneys of mice at the dose of 1000 mg/kg/d.[32]

Antioxidant activity

The antioxidant activity of a methanolic extract of *B. ceiba* was evaluated using several antioxidant assays, in terms of its: (i) ability to scavenge DPPH (1, 1-diphenyl-2-picryl-hydrazyl) and hydroxyl free radicals; (ii) action against lipid peroxidation (in rat liver microsomes and soy bean phosphatidylcholine liposomes), induced by ascorbyl radicals and peroxynitrite; and (iii) effect on myeloperoxidase activity.[33] The cytotoxicity was monitored through the mitochondrial activity in the Vero cell line. The extract showed antioxidant activity in all assays. The EC (50)

for DPPH was 87 µg/ml; lipid peroxidation of microsomes and soy bean liposomes induced by ascorbyl radicals were 141 µg/ml and 105 µg/ml, respectively, and by peroxynitrite were 115 µg/ml and 77 µg/ml, respectively. The K (0.5) value for myeloperoxidase activity inhibition by the extract was 264 µg/ml. The extract showed very low toxicity toward Vero cells.[33]

The total phenolic content present in water extracts of *B. ceiba* (ela imbul; gum), was determined by Folin-Ciocalteu method. Caffeine and gallic acid were quantified by high performance liquids chromatography (HPLC). Total free radical scavenging activity of each ingredient was investigated by 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging method and the values were compared with phenolic and gallic acid present in each plant. The polyphenol content of *B. ceiba* were 32.57 ± 5.04% of total extractable. Detectable levels of gallic acid were present only in *B. ceiba* (1.46 mg/g of total extractable). The EC50 values for DPPH radical scavenging activity for *B. ceiba* were 15.47 ± 1.80 µg cm-3, The mean values of EC50 (y) for DPPH radical scavenging activity were correlated with total phenolics (x) present in plant extracts (y = -35.417x + 1428; R = 0.9887).[34]

Analgesic activity

Mangiferin, 2-beta-D-glucopyranosyl-1,3,6,7-tetrahydroxy-9H-xanthen-9-one, obtained directly from methanolic extracts of *B. ceiba* leaves demonstrated strong antioxidant activity (EC(50) 5.8 (+/-) 0.96 mµg/ml) 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. Using naloxone, it was revealed that plant extract induced analgesia was independent of the opioid receptor; whereas, mangiferin demonstrated significant interaction with the receptor at a peripheral site, with a slight contribution at the neuronal level.[35]

Antiangiogenic activity

A methanol extract of the stem barks of *B. ceiba* was found to exhibit a significant antiangiogenic activity on *in vitro* tube formation of human umbilical venous endothelial cells (HUVEC).[36] Bioactivity-guided fractionation and isolation carried out on this extract identified lupeol as an active principle. At 50 and 30 µg/ml, lupeol showed a marked inhibitory activity on HUVEC tube formation while it did not affect the growth of tumor cell lines such as SK-MEL-2, A549 and B16-F10 melanoma.[36]

Hypotensive and hypoglycaemic activity

Shamimin, a *C*-flavonol glucoside from *B. 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.[37]

Antimicrobial and antibacterial activity

Plant extracts (methanol and aqueous) were assayed for their activity against multi-drug resistant *Salmonella*

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typhii. Strong antibacterial activity was shown by the methanol extracts of *Salmalia malabarica*.[38]

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.[39]

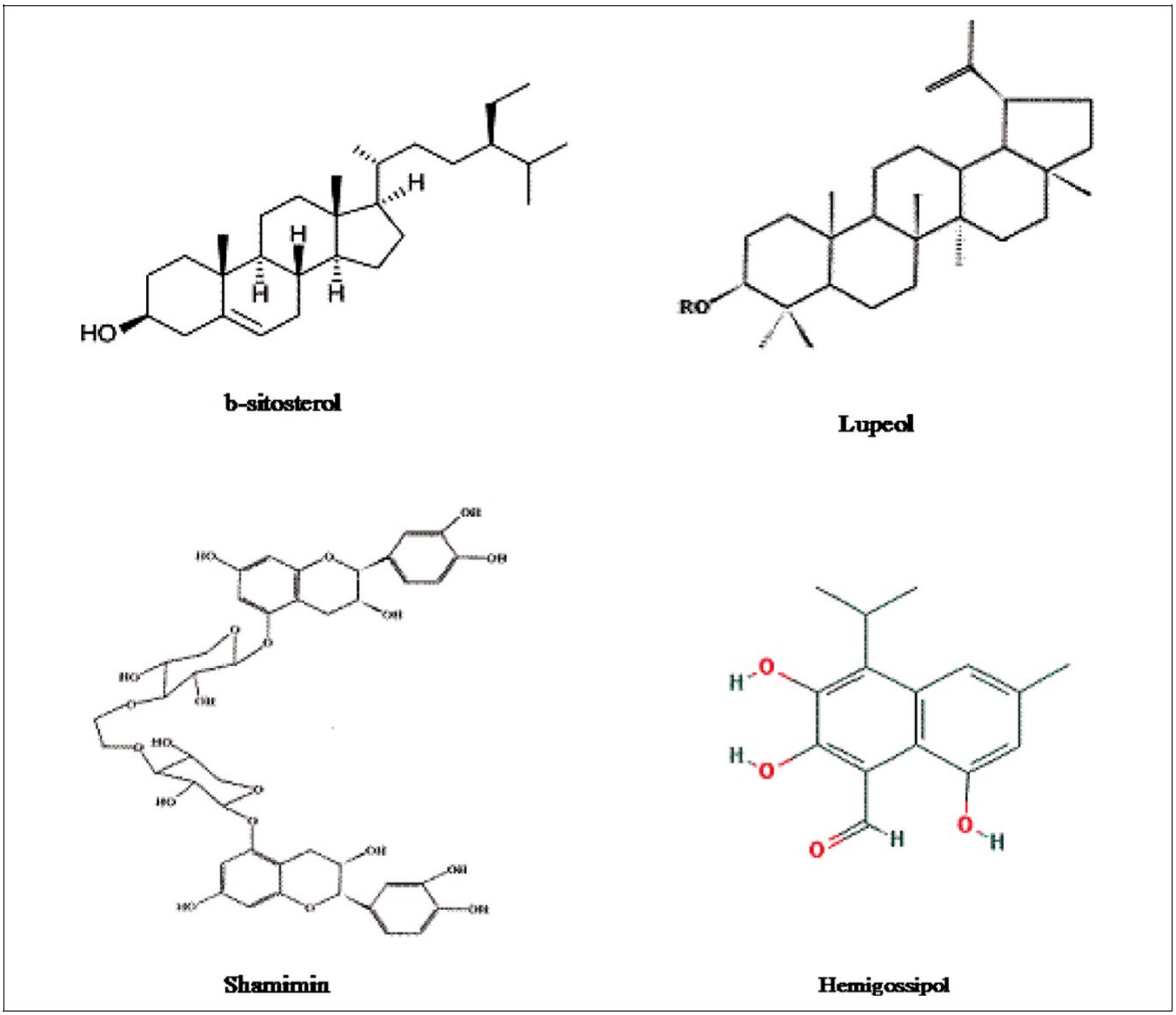

Figure 2: Structures of Phyto-constituents present in *Bombax ceiba*

Cytotoxicity

Aqueous extracts of the plants were screened for their cytotoxicity using the brine shrimp lethality test.[40] The present study supports that brine shrimp bioassay is simple reliable and convenient method for assessment of bioactivity of medicinal plants and lends support for their use in traditional medicine.

Hepatoprotective activity

The hepatoprotective activity of a methanolic extract of flowers of *B. ceiba* (MEBC) was investigated against hepatotoxicity produced by

administering a combination of two anti-tubercular drugs isoniazid (INH) and rifampicin (RIF) for 10 and 21 days by intraperitoneal route in rats. MEBC were administered at three graded dose i.e. 150, 300 and 450 mg/kg i.p. 45 min prior to anti-tubercular challenge for 10 and 21 days.[41] MEBC was evident in all doses as there was a significant decrease in alkaline phosphatase (ALP), alanine transaminases (ALT), aspartate transaminases (AST) 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.[41]

Inhibitory effects on fatty acid syntheses

Fatty acid syntheses (FAS) had been found to be over express and hyperactive in most cancers.[42] Pharmacological inhibitors of FAS activity preferentially repress cancer cell proliferation and induce cancer cell apoptosis without affecting nonmalignant fibroblasts. These made FAS an excellent drug target for cancer therapy. The FAS activity is the lowest in gastric cancer cell N87 (15.91 ± 3.61 U/mg protein) and the highest in lung cancer cell A549 (127.36 ± 10.14 U/mg protein). The cancer cell A549 was used as a cell model to test the inhibitory effort of flavonoid extracts on FAS. The minimum inhibitory concentration of *B. ceiba* Linn was 247.98 µg/ml.[43]

Antipyretic

The methanol extract of *Bombax malabaricum* (syn *Bombax ceiba*) leaves (MEBM) was investigated for the antipyretic activity in rats.[44] 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.

Aphrodisiac

The aphrodisiac activity of *B. ceiba* root extract was investigated. The extract (400 mg/kg body wt/day) was administered orally by gavage for 28 days.[45] Mount latency (ML), intromission latency (IL), ejaculation latency (EL), mounting frequency (MF), intromission frequency (IF), ejaculation frequency (EF) and post-ejaculatory interval (PEI) were the parameters observed before and during the sexual behavior 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.[45]

CONCLUSION

An extensive literature survey has revealed that *B. 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 plant is used in dysentery, menorrhagia, skin troubles, haemorrhoids, for the treatment of snake bite and scorpion sting, boils, leucorrhoea, internal bleeding, calculus affections, chronic inflammation, ulceration of bladder and kidney, gonorrhea, haemoptysis, influenza, enteritis, pulmonary tuberculosis, cystitis and catarrahal affections bleeding piles. The pharmacological and clinical studies reported in the present review confirm the therapeutic value of *B. 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 *B. ceiba* for its potential in preventing and treating diseases.

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