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***Madhuca longifolia*: Ethanobotanical, phytochemical studies, pharmacological aspects with future prospects**

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ABSTRACT

The aim of this article is to highlight the importance of *Madhuca longifolia* commonly known as 'Mahua'. It belongs to the Sapotaceae family, a native tree to the Indian subcontinent. Ancient medicine utilizes several parts of this plant for treating different diseases. A variety of compounds have been isolated from various parts of the plant. Flavonoids, riboflavin, triterpene, niacin, sterol, ascorbic acid, biotin, carotene, folic acid, inositol thiamine, etc are some of the isolated compounds. These compounds have been shown to have a variety of activities. Antibacterial, Antipyretic, Antioxidant, Anticonvulsant, Analgesic and Anticancer activity are a few reported activities. Numerous products obtained from the plant are utilized locally.

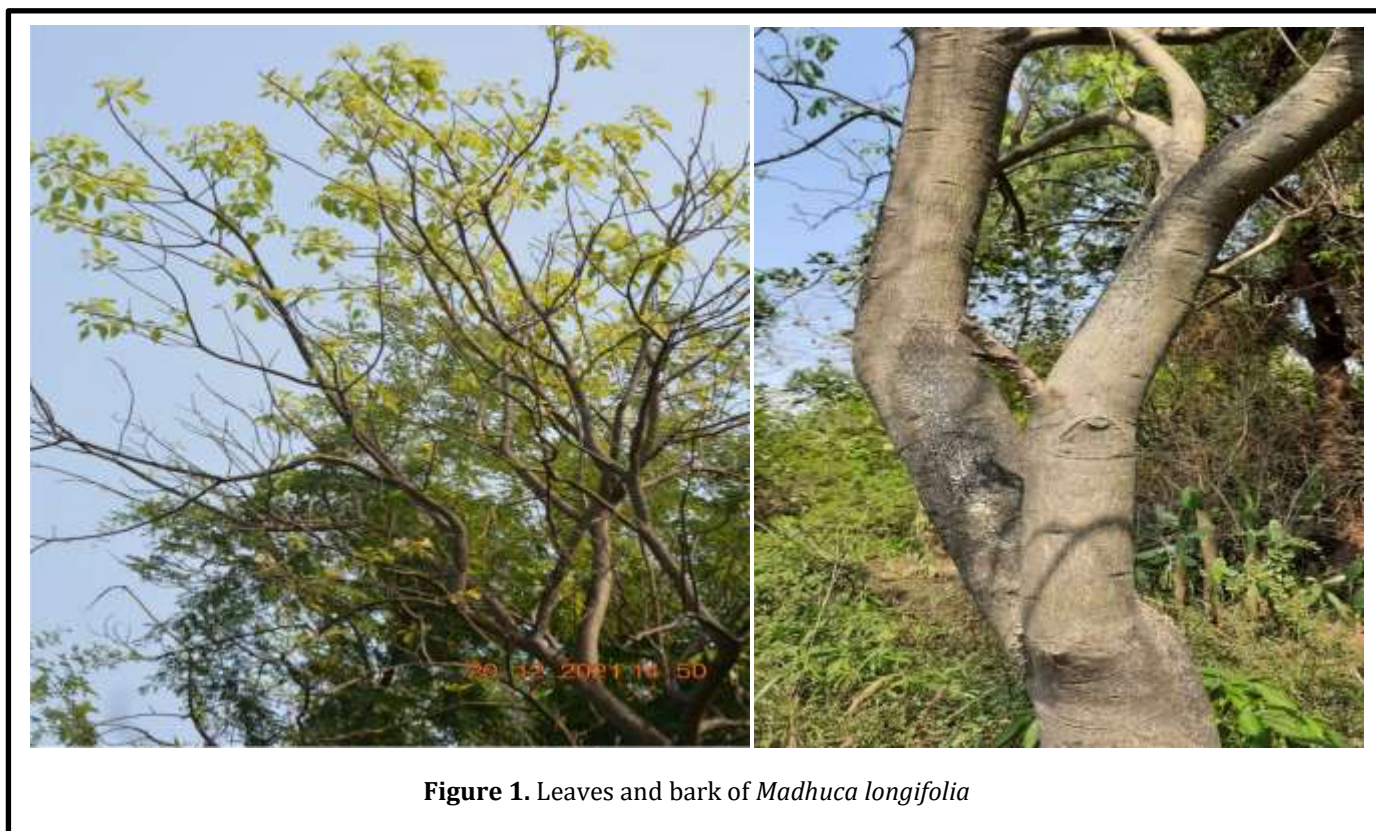
Keywords: Anti-oxidant activity, in-vitro studies, *Madhuca longifolia*, Mahua fats

1. INTRODUCTION

Plants, animals and minerals have been used as a product for the treatment of many diseases for many centuries. Recently traditional knowledge regarding phytochemical and pharmacological effects of plants has been used for a variety of medical applications. Bioactive compounds have been isolated and studied for various activities. In recent times there is a changing trend in the strategies of Pharmaceutical companies wherein the focus is on natural product research in order to bring out potential novel molecules and other sources for drug development [1]. The ethno

pharmacological knowledge of medicinal plants is rapidly fading, especially in industrialized countries, where plant knowledge is dissolving much faster than in developing countries. Given the rapid loss of such data, ethno-allied disciplines must both document it and gain a deeper understanding of its botanico-historical origins [2].

Mahua is a tree native to the Indian subcontinent. In India, it can be commonly seen in Southern, Northern and central regions which include regions of Maharashtra and Gujarat. Apart from India, it is very common in Sri Lanka and Burma. [3]. Mahua can be



found in Asian and Australian woods, as well as deciduous woods of Indian states like West Bengal, Orissa, Madhya Pradesh, Uttar Pradesh, Bihar, Punjab, and the Himalayan sub-mountainous region [4].

The review shed lights on the Traditional, Pharmacological and Commercial importance of *Madhuca longifolia*.

2. BOTANICAL DESCRIPTION

Madhuca longifolia belongs to kingdom Plantae from class Magnoliopsida, order Ericaleae and family Sapotaceae. Mahua is a deciduous tree that grows to be 10-15 meters tall with a dense, circular, shady canopy. The bark is tough, brown in color, slightly cracked and fissured, with a red inner bark that emits a white, milky sap. Leaves are elliptical, 15-25 cm long, 8-15 cm wide, with a pointed tip, angled base, thick texture, hairy underside, strong nerves (about 12 pairs), oblique tertiary nerves, and an unbroken but wavy edge. The stalk is 2-4 cm long and reddish in color. Flowers are

white, 2 cm long, pointy, perspiration scented, meaty flowers in clusters at the end of the stems. Fruits are ovoid, fleshy, 2-4 cm across, greenish in color, and contain 1-4 seeds. The seeds are 2 cm long, elongate, brown, and shiny [5].

3. ETHANOBOTANICAL DESCRIPTION

Mahua is considered to have aesthetic value and is used in religious ceremonies in the tribal communities [6]. Flowers of Mahua have been used as an analgesic, diuretic, cooling agent, aphrodisiac, astringent, tonic, carminative and demulcent. Flowers are also used in the treatment of helminths, acute and chronic tonsillitis, bronchitis, etc. [7]. Flowers have been used in augmenting breast milk in lactating mothers and also in boosting the number of seminal fluids [3]. Fruits are astringent and are used in treating chronic tonsillitis and pharyngitis [8]. Seeds are used in Skin diseases, rheumatism, headache, laxative and piles [5]. Traditionally Mahua is widely known for being a key

Table 1. Active constituents present in different part of *Madhuca longifolia*

Part/product	Chemicals found
Bark	Sterol, Flavonoids, triterpene,
Latex	Soluble resin, insoluble resin
Ripe fruit	Moisture, protein, fat, iron, carbohydrates, minerals, calcium, phosphorus, carotene, ascorbic acid, tannins.
Flower	Carotene, ascorbic acid, folic acid, thiamine, riboflavin, niacin, biotin, inositol
Leaves	Moisture, organic matter, minerals, potash (K ₂ O), phosphoric acid (P ₂ O ₅) silica, , protobasic acid, alkaloids, flavonoids.

ingredient in the treatment of snakebite and diabetes [9]. Effective fish poison is prepared from the seedcake of mahua plant. Mahua fruit kernels produce yellowish-green oil which is used by tribal people for cooking and is also used as an adulterant for ghee [10]. The bark of the Mahua plant is used to produce a decoction that has anti-diabetic activity. Leaves are effective in the treatment of eczema, Spongy and bleeding gums can be treated using bark extract of the Mahua plant [11]. Mahua flowers have a good amount of reduced sugars many tribal communities use them as a sweetener in many local dishes [12].

4. PHYTOCHEMICAL PROPERTIES

The phytochemical properties of plant gives the general idea about the class of compounds present in those plants and basically divided into two groups, i.e., primary and secondary constituents [6-7]. Some of the common primary metabolisms are amino acid, sugars, proteins and chlorophyll while secondary metabolites are alkaloids, flavonoids, terpenoids, saponins, phenolic compounds, tannins etc. The utility of medicinal plants basically depends on therapeutically active principles and therefore chemical tests are done to identify the

various constituents and groups present in that particular plants. These tests are either general or specific. *Madhuca longifolia* being the therapeutically active plant also shows many active phytochemicals. Different studies showcase the presence of phytochemicals in different parts of *M. longifolia*.

4.1. Leaves

The *M. longifolia* leaf, have different phytoconstituents such as alkaloids, carbohydrates, proteins, saponins, tannins, and triterpenoids, with the exception of gums and fixed oils [8]. Leaves contain phytochemical compounds like quercetin, β -carotene, erythrodiol, palmitic acid, myricetin, 3-O-arabionoside, 3-O-Lrhamnoside, quercetin, 3-galactoside, xanthophylls, 3 β -palmitoxy-olean-12-en-28-ol, oleanolic acid, β -sitosterol, stigmasterol, β -sitosterol, n-octacosanol [4].

4.2. Bark

The bark contains ethyl cinnamate, 3 β -monocaprylic esters of erythrodiol, sesquiterpene alcohol, α and β -amyrin acetates, α -tocopherol and 3 β -capryloxy oleanolic acid [4].

4.3. Seeds

The seeds of Mahua plants contains threonine, leucine, quercetin, aspartic acid, cystine, proline, oleic, linoleic, arachidic, stearic and palmitic aids, isoleucine, α -alanine, Mi-saponin A and B [4].

4.4. Fruit

Mahua fruit contains hexacosanol, β -sitosterol n and its 3- β -D glucoside, α - and β - amyrin acetates, quercetin and dihydroquercetin [4].

4.5. Flower

The flower of Mahua is rich with vitamins like A & C. The major chemical components present in Mahua are quercetin, β -amyrin decanate, betullic acid, tannins, β -amyrin, β -amyrin acetate, stigma sterol and β -amyrin cinamate [4].

5. TRADITIONAL KNOWLEDGE

Mahua is considered to have aesthetic value and is used in religious ceremonies in the tribal communities [9]. Flowers of Mahua have been used as analgesic, diuretic, cooling agent, aphrodisiac, astringent, tonic, carminative and demulcent. Flowers are also used in treatment of helminths, acute and chronic tonsillitis, bronchitis etc. [10]. Flowers have been used in augmenting breast milk in lactating mothers and also in boosting the quantity of seminal fluids[3]. Fruits are astringent and are used in treatment chronic tonsillitis and pharyngitis [11]. Seeds are used in Skin diseases, rheumatism, headache, laxative and piles [5]. Traditionally Mahua is widely known for being a key ingredient in treatment of snakebite and diabetes [12]. Effective fish poison is prepared from seedcake of mahua plant. Mahua fruit kernals produce yellowish green oil which is used by tribal people food cooking and is also used as an adulterant for ghee [13].The bark of Mahua plant is used to produce a decoction that has antidiabetic activity. Leaves are effective in treatment of eczema, spongy and bleeding gums can be treated using bark extract of Mahua plant [14]. Mahua flowers have good amount of reducing sugars many tribal communities use it as a sweetener in many local dishes [15].

6. PHARMACOLOGICAL ACTIVITIES

6.1. Anti-bacterial activity

The anti-bacterial activity of *M. longifolia*'s bark was tested against *Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus sp.* in different extracts. The extracts showed good efficacy in the well diffusion testing with

significant efficacy in the micro dilution experiment [16].

6.2. Antihyperglycemic activity

The ethanolic bark extract of *M. longifolia* (ML) has anti-hyperglycemic. Bark extract of *M. longifolia* has shown significant anti-diabetic activity in rats indicating its potential role in diabetes treatment and management. Streptozotocin-induced diabetic rats were studied and the extract showed dose-dependent hypoglycemic efficacy when compared to the standard anti-diabetic medication glibenclamide. The hypoglycemic activity of the extract could be a result of improved pancreatic-cell function and/or increased glucose uptake at the tissue level or it due to suppression of glucose absorption at intestinal level and a decrease in insulin production [17]. Another study showed that the hydroethanolic extract of *M. longifolia*'s leaves had significant anti-hyperglycaemic activity against alloxan- induced diabetic rats. The methanolic and ethanolic extracts of Madhuca seeds also exhibited the anti-diabetic activity [18]. The study postulated that these effects of phytoconstituents may be due to the altering of glucose utilization and insulin level.

6.3. Anti-inflammatory

Inflammation is a complex response of a body to the external stimuli. Several scientific studies on the ethanolic extract of *M. longifolia* bark and seeds had proven anti-inflammatory activity. Carrageenan-induced oedema in the right hind paw volume was used to test the activity in a dose-independent manner [19]. The bark extract has considerably reduced carrageenan-induced paw edoema in rats, comparable to indomethacin [16]. Similar research was carried out and has shown that the crude alkaloid extract of Madhuca species also exhibits potent anti- inflammatory activity. The proposed mechanism of action was that

constituents of *Madhuca* inhibit the prostaglandin synthesis as well as its mediators in synthesis. It may also act by reducing the intercellular cell adhesion molecule-1 expression which is induced by tumor necrosis factor [20].

6.4. Analgesic activity

Studies suggest that analgesic activity of *Madhuca* is mediated by central or peripheral mechanism. The studies on the flower extract of *M. longifolia* suggests that the acetic acid-induced stomach aches, or nociception response, were used to assess the analgesic effect [19]. In the nociceptive procedures the calibrated dosages of *M. longifolia* aqueous and alcoholic extract demonstrated dose dependent analgesic effects. Both aqueous and alcoholic extracts have an analgesic action that is not mediated by opioid receptors [10]. Madlongoside, an isolated compound obtained from the *Madhuca* bark, showed a significant central analgesic activity when assessed by hot plate method [21].

6.5. Immunosuppressive activity

A wide range of immunosuppressive drugs have now been adopted to control unwanted immune responses, particularly those giving autoimmune disease and transplant rejection. Studies show that the Methanol extract of *M. longifolia* bark has immunological responses on mice, which contains saponins, flavonoids, tannins, steroids, phenol, and glycosides. The impact on hematological markers and relative organ weight was also investigated in the studies. MML significantly

reduced the delayed type hypersensitivity (DTH) reaction after oral treatment, but had no effect on the humoral response to sheep RBCs. As MLL decreased, the cellular immunity in sensitized mice by lowering the footpad thickness response to sheep RBCs [21].

6.6. Anti-oxidant properties

Many scientific works prove that free radicals including active nitrogen species and reactive oxygen species are the primary cause in initiation of cellular damage resulting pathological changes and many diseases. The antioxidant potential was reported from the bark of *M. longifolia* using the DPPH 1, 1-diphenyl-2-picrylhydrazil (DPPH) free radical scavenging activity, reducing power test, and superoxide scavenging activity [17]. Some studies on the alcoholic and aqueous extracts of fresh flowers and fruits of *M. longifolia* were conducted to evaluate the antioxidant potential. Total flavonoid content (TFC), total phenolic content (TPC), and total antioxidant capacity (TEAC) were determined by DPPH radical scavenging assay and the Trolox equivalent antioxidant capacity (TEAC) test. The highest content phenol and flavonoid were found in the acetone extract which had stronger antioxidant potential compared to standards [23].

6.7. Antipyretic effect

The leaf extract and aerial part extract of *M. longifolia* has significant antipyretic agent by using the brewer's yeast-induced pyrexia model. The studies show that the extract lowered the brewer's yeast-induced increased

Table 2. Pharmacological activities from different part of *Madhuca longifolia*

Plant part	Pharmacological activities
Bark	Antibacterial activity , Anti hyperglycemic activity, Anti-inflammatory activity, Immunosuppressive activity, Anti-oxidant activity, Analgesic activity
Flower	Analgesic activity, Anticancer activity, Antioxidant activity
Leaves	Antipyretic activity, Anti fertility activity, Anti-oxidant activity, Antiulcer activity
Heartwood	Anticonvulsant activity, Cytotoxic activity

body temperature in rats [19, 24].

6.8. Antifertility effect

The antifertility potential of alcoholic leaf extract was tested in male albino rats in some studies. The body weight, mean weight of the testis, and accessory reproductive organs of the treated group animals decreased [25]. Studies showed that decrease in weight of accessory sex organs was also observed indicating the atrophy of glandular tissue and also reduction in secretory cells thus reflecting the decrease level of testosterone. The crude seeds extract possess antifertility action when administration to male albino rats due to presence of bioactive entity. It caused weight decrease of testis, epididymis, seminal vesicle, vasa deferens and ventral prostate which may be due to low plasma level of testosterone.

6.9. Anti-ulcer activity

Peptic ulcer is chronic inflammatory condition referring to the sores and ulcer in the lining of stomach and duodenum. Investigation of the antiulcer potential of ethanolic extract of *M. longifolia* flowers in albino rats was carried out using pylorus ligated ulceration, stomach fluid volume, free acidity, and total acidity. The extract's antiulcer potential may be the result of presence of phytochemicals such as flavonoids (quercetin), alkaloids, and tannins in the plant [26]. Another investigation was done to find the antiulcer potential of various doses (100, 200, and 400 mg/kg, p.o) of methanolic extract of *M. longifolia*, using the pylorus ligated ulcerated, naproxen-induced and ethanol-induced stomach ulcer models in rats. The methanolic extract showed strong Anti-ulcer effect after pylorus ligation. Furthermore, in all three models, the ulcerated area was significantly reduced [27]. The crude ethanolic extract of seeds of *Madhuca* showed significant protective effect in pylorus ligation induced gastric ulcer

model with a marked decrease in ulcer index as compared to vehicle. This action may be due to its activity through prostaglandin [28].

6.10. Anticonvulsant activity

Anticonvulsant effect of *M. longifolia* has been investigated using the methanolic extract of heart wood in mice. The pentylenetetrazole (PTZ)-induced convulsions were used for the test with benzodiazepine as the control medication. Flumazenil which is a GABA A-benzodiazepine receptor complex site antagonist, and naloxone (non-specific opioid receptor) antagonist, were used in mechanistic research. The Anticonvulsant effect was inhibited by flumazenil and naloxone. *Madhuca longifolia* appears to be effective in the treatment of absence seizures, with these effects possibly linked to its GABAergic and opioid systems [29]. The studies also suggest that it may possess an active constituent entity having anticonvulsant nature which may help in the treatment or management of absence seizures.

6.11. Cytotoxic effect

Cytotoxicity is an important parameter to evaluate the effectiveness of any herbal product. The use of plants in pharmacological activities or products are used directly which make it mandatory to assess the toxic behaviour of plants. To test the cytotoxicity effect the Brine shrimp lethality was used for the crude extracts of *M. longifolia*, with Vincristine sulphate was used as a standard. The crude extracts of leaves and barks, showed comparable results in LC_{50} values with the standard (LC_{50} of standard-8.84g/ml, LC_{50} of leaf extracts-17.09g/ml and LC_{50} of bark extract-45.96 g/ml) thus demonstrating substantial cytotoxicity [30].

6.12. Anti-cancer effect

Cancer is the most fatal and common chronic disease of all time, and many herbal as well as chemical medications are available in market. For the same *M. longifolia* has also been shown to have chemo preventive properties on the human cancer cell lines. In vitro cytotoxic test against Ehrlich ascites, carcinoma cell lines was used to measure the anticancer activity of *M. longifolia*. The in-vitro investigation of crude acetone and ethanolic extract of stem and leaves at various doses were carried out and the results revealed most impact at dose 200 g/mL. In comparison to the acetone extract, the ethanolic extract was more potent [12].

7. POTENTIAL APPLICATIONS

Edible oil and whole seeds of Mahua tree have been seen to have good nutritional and medicinal activities. The Mahua butter which has been used traditionally used as supplementary diet. But recent studies have reported its use in variety of commercial applications. The high levels of steric and oleic acids in the triglyceride composition are comparable to that of cocoa butter therefore it can be used for production of chocolates and confectionary products. It can be also used as a base for production of cosmetics and pharmaceuticals. Variety of dairy products can also be enhanced by using it in the production process. Further investigation of these properties would lead to increase the use of Mahua fats on the commercial level [31].

8. CONCLUSION

The article highlights the traditional, pharmacological and commercial importance of *M. longifolia*. Mahua tree belonging to family Sapotaceae is native to India. Traditionally it has been a multiutility plant. Various parts of the plant have been used for variety of application. Flowers, fruits and seed have been used for medicinal and dietary applications. It is also been effective in treatment against snakebite. A variety of

phytochemicals have been isolated from various extracts of different parts of the plant. Owing to these biochemical various pharmacological activities have been reported by various researchers. Antibacterial, Antipyretic, Antioxidant, Anticonvulsant, Analgesic, Anticancer activity are few of the reported activities. On a commercial level there is very limited exploration. Various products obtained from the plant are utilized on local level. But recent studies have reported its use in variety of commercial applications. Further investigation of the reported properties would lead to increase the use of Mahua on the commercial level.

9. ACKNOWLEDGEMENT

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10. CONFLICT OF INTEREST

The authors have declared that there is no conflict of interest.

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NA

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