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Review Article

A Comprehensive Review on *Madhuca longifolia*

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ABSTRACT

Madhuca longifolia, commonly known as Mahua or the butternut tree, is a member of the Sapotaceae family. This tree holds significant economic value and is found throughout India. Mahua is not only highly nutritious but also serves as an herbal remedy for various ailments. It contains sapogenins, triterpenoids, steroids, saponins, flavonoids, and glycosides. Traditionally, it has been employed to address infections, wounds, rheumatism, heart disease, diabetes, and numerous other conditions. The bark of Madhuca longifolia is utilized in treating ulcers, tonsillitis, rheumatism, and bleeding. This tree is regarded as a blessing by the tribal communities who inhabit the forests and actively preserve it. The flowers of Mahua are extensively used in the production of liquor and various food items. This practice may enhance employment opportunities and contribute to a potential income source for the country. The commercial use of Mahua flowers in diverse food products could further boost employment and generate a viable income source for the nation. In this review, we present a compilation that focuses on the synonyms, botanical characteristics, phytochemicals, pharmacological properties, and medicinal applications of Mahua.

INTRODUCTION

Madhuca longifolia, also known as Madhuca indica, belongs to the Sapotaceae family and is native to the Indian subcontinent.[1] Mahua is a medium to large deciduous tree found in Nepal, India, and Sri Lanka. *Madhuca longifolia*, as it's scientifically known, can grow up to about 17 meters tall and boasts a broad canopy. This impressive tree is a common sight across much of central India, thriving in both wild and cultivated areas. The seeds of *Madhuca longifolia* are quite valuable, as they provide a good source of edible fats.[2] The tree thrives best in sandy soil, but it can also adapt to various other types, including shallow, rocky, clay, and calcareous soils. Typically, you'll find it growing at altitudes of up to 1200 meters, where the average maximum temperature ranges from 28 to 50°C, and rainfall varies between 550 and 1500 mm. [3] This substance is packed with a variety of chemical

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components that contribute to its impressive medicinal qualities. It contains terpenoids, proteins, starch, anthraquinone glycosides, phenolic compounds, mucilage, cardiac glycosides, tannins, and saponins.[4] Mahua is a remarkable plant that naturally offers a wealth of health benefits. Indigenous communities often turn to mahua flowers to help treat skin ailments, headaches, pitta, and bronchitis.[5] The status of anemia, iron metabolism, and absorption mechanism are examined, as are methods for treating anemia with Mahua flowers.[6] Mahua flowers' ecological sustainability depends on their hand-picked and balanced gathering from February to May. Forest Governance Learning Group India estimates that 85,000 tonnes of mahua flowers were used annually in 2018, out of 4,90,000 tonnes. Of India's overall workforce, approximately 17.55 percent work in the mahua flower collection each year.[7] People living in rural areas make use of a diverse range of plant species as natural toothbrushes. One notable example is the twig from the mahua tree, which is commonly referred to as Mahuadatun or Madkam Kaarkad by the Ho tribes in Jharkhand, India.[8] The tree is really good at handling air pollution and can actually help improve the situation by effectively soaking up greenhouse gases and other harmful air pollutants. It stands out as one of the most promising choices for street trees aimed at urban greening in humid tropical areas.[9] The antibacterial effects of Madhuca longifolia stem extract have been examined, particularly its impact on Streptococcus mutans, a bacteria linked to tooth decay. While the extract did exhibit a high minimum inhibitory concentration (MIC) value, it still showed effectiveness. This suggests that this plant could serve as a valuable natural remedy for oral health issues like dental caries.[10]

Fig.1: a] Tree b] Flowers c] Fruit d] Seeds [11]

Taxonomy

Botanical profile of Mahua *(Madhuca longifolia*) [12]

Botanical Name	*Madhuca longifolia*
Order	Ericaleae
Family	Sapotaceae
Subfamily	Caesalpiniodeae
Tribe	Caesalpinieae
Genus	*Madhuca*
Species	*Longifolia*

Vernacular names and Synonyms of *Madhuca longifolia* [13]

English	Honey tree, Butter tree
India	Mohua
Sri Lanka	Milluppai
Tamil	Illuppai
Hindi& Bengali	Mahua
Sanskrit	Madhukah
Kannada	Errape
Telugu	Ippi
Malayalam	Irippa
Gujarat	Mahuda

Its synonyms are *Macb. Bassia latifolia Roxb.* and *Mahuaindica J.F. Gmel.*

Historical Background

A variety of food goods and therapeutic uses have long been derived from the madhuca tree. Due to the fact that all elements of this plant have been utilised for the health of people. The blossom of *Madhuca longifolia* is frequently used to make pickles and as a flavouring in rice and other foods. Additionally, it has been utilised as cattle fodder. It is utilised by nursing moms because it stimulates milk production.[14] Mahua is a big deciduous tree that thrives well in subtropical and dry tropical climates. *Madhuca Longifolia* is a significant tree, especially for those in poorer communities. Its flowers are highly valued for their medicinal properties, and its seeds, known as tora, are also quite important. In tribal culture, this tree holds both spiritual significance and beauty. The Mahua trees, known for their impressive girth, are often cherished by forest dwellers who take care of them and protect them. The early settlers had specific rights to harvest flowers and fruits from Mahua trees that were grown near their village, whether on private land or in forest areas. Some of these trees might have been quite a distance from the village, but they were still well-known and linked to the families that tended to them. The rights to the land and resources were traditionally passed down from one generation to the next. For instance, when a father divided his property among his sons, he would also share the Mahua tree, keeping a portion for himself as it provided a steady source of income. If there were no sons, the daughters would receive the rights to harvest the tree when they got married.[15]

Cultivation and Collection

India produces approximately 0.12 million tons of mahua seeds and around 1 million tons of flowers, which are mainly used for oil extraction. Because this industry supports many jobs, the state government of India encourages the collection of both mahua seeds and flowers. This plant can either be sown on its own or you can choose to plant it. The flowering period usually occurs between March and April.[16] The seeds are typically gathered during May, June, and July. During this time, it's been observed that there are more flowers than seeds being produced. The fruits are collected by the villagers by hand-picking method or bamboo sticks in the morning. About 15 kg of tori could be collected in one day in the peak time. Approximately 250 ml of oil can be extracted from 1 kg of seed that is mostly used in household purposes. The seeds are separated from the fruits; and the pulp obtained is consumed as food. The indigenous methods for oil expelling can be used. The gully oil, once purified through vacuum methods, can be sold to soap industries. To protect it from fungus, it should be kept in an airtight earthen pot or basket.[17]

Botanical Description

Madhuca longifolia, a striking medium to large deciduous tree with a broad crown, can be found across Nepal, India, and Sri Lanka.[19] It reaches a height of about 10 to 15 meters, boasting a wide, thick, and rounded canopy that provides plenty of shade.[18]

1. **Bark:** The bark has a rough texture and comes in shades ranging from brown to a yellowish-grey. It features some fissures and slight cracks. The inner bark is a striking red, and when you cut into it, it releases a white, milky sap.
2. **Leaves:** Leaves are clustered at end of the branches. They measure about 15-25 cm × 8-15 cm and are about 12 in pairs, elliptic, coriaceous and tip pointed, shortly acuminate, base cuneate with a thick texture and hairy beneath. The nerves are strong and margin entire but may be wavy, tertiary nerves are oblique.
3. **Stalk:** The stalk measures between 2 to 4 cm long and has a reddish hue.[18]
4. **Flowers:** The flowers are a lovely white color, quite abundant, and measure around 2 cm in length. They cluster together at the tips of the branches, hanging gracefully on their pedicels. These flowers are pointed, have a sweet fragrance, and are pleasantly fleshy.
5. **Fruits:** Fruits typically have 1 to 4 seeds, measure about 2 to 4 cm in diameter, and are shaped like ovals. They have a fleshy texture and a greenish hue.
6. **Seed:** The seeds measure about 2 cm in length, are elongated, and have a shiny brown appearance.
7. **Calyx:** Calyx is covered in a thick layer of rusty hairs and has a leathery texture.
8. **Corolla:** The Corolla has a soft, yellowish-white hue and a fleshy texture.
9. **Stamens:** Stamens typically range from 20 to 30, with 24 or 26 being the most common. The anthers have a rough texture on the back, covered in stiff hairs.[19]

Tribal Medicine

Within the folk medicinal practices of India and Bangladesh, a variety of tree parts are employed, including whole young plants, leaves, stems, bark, roots, fruits, flowers, and seeds. These parts are effective for treating numerous ailments, such as tuberculosis, rheumatoid arthritis, cholera, paralysis, snake bites, general weakness, tonsillitis, influenza, hemorrhoids, joint pain, helminthiasis, low sperm count, headaches, flatulence, and infections. Plus, they can purify the blood and act as an antidote to poison.[20]

Parts wise use of *Madhuca longifolia* [21]

Parts of Plants	Medicinal Properties
Leaves [2]	Wound Healing, hepatoprotective, antioxidant, antimicrobial, stimulant, emollient, asringent, demulsent, nutritive, bronchitis, cushing's disease.
Roots [22]	Anti-inflammatory, antioxidant, antipyretic, diarrhea and chronic fluxes.
Flower [23]	Analgesic, diuretic, cooling agent, demulscent, helminthes, tonic, acute and chronic tonsillitis, pharyngitis as well as bronchitis
Fruit [24]	Astringent, lotion in chronic ulcer, acute and chronic tonsillitis and pharyngitis.
Seeds [22]	Emuluscent, skin disease, headache, laxative, rheumatism, galactogogue.
Bark [55]	Itch, swelling, fractures, bleeding spongy gums, epilepsy, pneumonia, ulcer, piles.

Phytochemicals

The therapeutic properties of any plant are influenced by the active constituents located in the various parts of the plant, which can be found in both small and large quantities. Secondary metabolites play a significant role as essential substances that contribute to the key medicinal properties of crude drugs. The leaves of the Mahua tree are composed of saponin, an alkaloid, and glycoside. Additionally, saprogenic and other fundamental acids are present in the seeds. A variety of phytochemical research on Mahua

involves the characterization of sapogenin, triterpenoids, steroids, saponins, flavonoids, and glycosides. In light of the supportive and recognized medicinal attributes, new compounds have been discovered, such as madhucic acid (a pentacyclic triterpenoid), madhushazone, four novel oleanane-type triterpene glycosides, along with madhucosides A and B. The newly picked flowers include 2-acetyl-l-1-pyrroline, the aromatic molecule. Additionally, they possess polysaccharides that, upon hydrolysis, yield D-galactose, D-glucose, L-arabinose, L-rhamnose, D-xylose, and D-glucuronic acid. The process of determining the pharmacological activity of specific crude drugs is referred to as pharmacological screening, which is essential for predicting their activity. [25,26,27,28,30]

Active Constituent Present in Different Parts of *Madhuca longifolia* [25,29,30]

Plant Part	Phytoconstituents
Bark	Flavonoids, Triterpene, Sterol
Latex	Soluble Resin, Insoluble Resin
Leaf	Moisture, Organic Matter, Minerals, Potas (K2O), Phosphoric Acid, Silica, Alkaloids, Flavanoids,Protobasic Acid
Flower	Carotene, Ascobic Acid, Thiamine, Riboflavine, Niacine, Folic Acid, Biotine
Ripe Seed	Moisture, Protein, Fat, Carbohydrates, Minerals, Calcium, Phosphorus, Iron, Carotine, Ascorbic Acid, Tannis

Pharmacological Activities

1. Anti-inflammatory Activity

Inflammation is a complicated bodily response to external stimuli. The formation of inflammatory leukocytes in this context leads to an overproduction of free radicals, which modifies cellular functions and inflicts damage on organs by triggering and advancing various diseases. Several scientific studies have confirmed the anti-inflammatory effects of the ethanolic extract derived from Madhuca bark and seeds.[31] At dosage levels of 10 and 15 mg/kg and 1.5 and 3 mg/kg, respectively, the ethanol extract and saponin combination significantly reduced the edema induced by carrageenan in an acute inflammation model, effectively inhibiting both phases of inflammation. In the context of the sub-acute inflammation model, both extracts showed better efficacy than the reference medication, diclofenac sodium. The results demonstrated that saponins derived from *Madhuca longifolia* significantly alleviated inflammation in the cotton pellet granuloma. [32,33]

2. Anti-hyperglycemic Activity

The remarkable hyperglycemic effects of *Madhuca longifolia* bark in diabetic rats indicate that this effect can be influenced by the promotion of glucose utilization in peripheral tissues. The findings of the current study distinctly demonstrated that the ethanolic extract of *Madhuca longifolia* bark exhibits a hypoglycemic effect on STZ-induced diabetic rats.[34] In all groups, apart from glibencyl amide, the blood glucose levels at 30 minutes after the initiation of the glucose tolerance test were higher than those recorded at zero time, yet there was a significant decrease observed from 30 minutes to 120 minutes. The methanolic extracts contributed to improved glucose utilization, leading to a significant reduction in blood glucose levels in glucose-loaded rats. [35,36]

3. Antimicrobial Activity

The acetone, aqueous and ethanolic extracts derived from the stem and leaves of *Madhuca longifolia* exhibit antimicrobial activity. The extract obtained from the stem bark of Madhuca longifolia was found to demonstrate superior activity compared to that of the leaves. The extracts of acetone and water from the plant

exhibited a wide spectrum of antibacterial activity. Additionally, the methanol extracts derived from the flowers, leaves, stem, and stem bark of *Madhuca longifolia* have been documented to possess antimicrobial properties. [37,38]

4. Analgesic Activity

Both the aqueous and alcoholic extracts of the flowers of *Madhuca longifolia* demonstrated an analgesic effect.[39] The analgesic properties were evaluated using tail flick, hot plate, and chemical methods. Graded doses of both the aqueous and alcoholic extracts of *Madhuca longifolia* (ranging from 4.0 to 64.0 mg/kg, administered intramuscularly for 3 days) resulted in a dose-dependent analgesic effect across all three nociceptive tests conducted on either rats or mice.[40] The crude Methanolic extract from the aerial part of *Madhuca longifolia* shows analgesic properties. The analgesic effects were evaluated through acetic acid-induced abdominal pain, namely, the nociceptive response. The methanolic extracts (50- 200 mg kg-1 i.p) significantly reduced acetic acid-induced abdominal constrictions and hind limb stretching in a dose-dependent manner. [41,42]

5. Antibacterial Activity

Madhuca longifolia flowers serve as a tonic, demulcent, aphrodisiac, and cooling agent, and are employed in the treatment of bronchitis, tonsillitis, and pharyngitis. In Bihar, LATTA is created using roasted maize grain and mahua flowers to relieve arthritis pain.[23] Utilizing the disc diffusion technique, it was revealed that the bark of Mahua exhibits considerable antibacterial activity when compared to E. coli, Bacillus subtilis, Staphylococcus epidermidis, S. aureus, and E. coli. Additionally, it has been confirmed that the methanolic extract displayed potent antibacterial effects.[43]

6. Wound Healing Activity

The inner part of the fruit is utilized for cake preparation, while the outer part is eaten raw. The fruits serve as an astringent, a lotion for chronic ulcers, and in the treatment of tonsillitis. Mahua oil is used in cooking, for making margarine, hair oil, soap, and for burning in lamps. The ethanolic extract derived from the bark and leaves of *Madhuca longifolia* demonstrated notable wound healing properties, evidenced by a reduction in both the duration of epithelization and the size of the wound area. A 5% w/w ointment formulated from this ethanolic extract was applied to excision wounds created on the dorsal side of experimental animals. The efficacy of this ointment in promoting wound healing was found to be comparable to that of the standard drug Betadine (5% w/w).[44]

7. Hepatoprotective Activity

The methanol extracts from the bark of *Madhuca longifolia* are prepared for hepatoprotective action against pale-skinned rodents suffering from liver damage induced by carbon tetrachloride (CCl4). It was found that the methanol extract of *Madhuca longifolia* bark, at a dosage of 300 mg/kg body weight, exhibited a moderate protective effect by significantly reducing serum levels of Glutamate Pyruvate Transaminase (SGPT), Serum Glutamate Oxaloacetate Transaminase (SGOT), Serum bilirubin, and Serum alkaline phosphatase (SALP). The current findings indicate that the methanolic bark extract of Madhuca provides substantial dose-dependent protection against CCl4-induced hepatocellular damage. [45,46]

Health Benefits of Mahua Plant

The Mahua flower (*Madhuca longifolia*) provides numerous health advantages (Figure 1), many of which have been acknowledged and employed

through generations. Below is a comprehensive description of several of its notable therapeutic applications:

- **Bronchitis:** Madhuca flowers are utilized in the treatment of chronic bronchitis symptoms. Coughs may also be alleviated with the use of these flowers.
- **Orchitis (Testis inflammation):** The leaves of Madhuca are boiled to alleviate orchitis by reducing inflammation and promoting healing. This traditional application illustrates the potential anti-inflammatory properties of the plant.
- **Rheumatism:** A decoction is created by boiling bark in water and is consumed internally to relieve rheumatism. Seed oil may also be applied to treat damaged areas
- **Diabetes:** The decoction of Madhuca bark has shown potential in regulating blood sugar levels, which is beneficial for individuals with diabetes. Regular consumption may assist in the natural stabilization of blood glucose levels.
- **Piles:** Madhuca seed oil functions as a natural laxative, providing relief for those experiencing ongoing constipation and piles. Its calming effects can support regular bowel movements and reduce pain.
- **Eczema:** Madhuca leaves can assist in treating eczema when they are cooked and then sprayed with sesame oil. Applying the prepared leaves to the affected area of the skin promotes wound healing, reduces inflammation, and alleviates irritation.
- **Gums:** To achieve relief from spongy and bleeding gums, gargle with 4 ml of the liquid extract derived from the bark mixed with 300 ml of water.
- **Tonsillitis:** The solution for gum disease also assists in the treatment of pharyngitis as well as both acute and chronic tonsillitis. It serves as a versatile remedy that alleviates inflammation and provides relief for sore throats.
- **Burns:**The treatment for scalds and burns involves a mixture of ash derived from the leaves and ghee. To relieve itching, bark paste is applied to the impacted area.
- **Lactation:** Madhuca flowers are utilized to assist nursing mothers in increasing their milk production. The seeds possess the same characteristic as well.

The mahua plant serves as a genuine reservoir of health benefits, aiding in the treatment of digestive, skin, and respiratory disorders, along with other ailments. Its applications reflect the variety found in traditional medicine and emphasize the importance of additional research to substantiate and enhance its utilization. [47,48]

Utilization of Mahua for processing of different food products

Sugar Syrup:

A variety of reports exist regarding the formulation of sugar syrup from dry mahua flowers. The water extract obtained from the dried flowers was subjected to decolorization with several agents, including slaked lime and activated charcoal, before it was concentrated to the necessary strength. Research indicated that activated charcoal, when used at a concentration of 3.5% to 5%, was the most efficient decolorizing agent for the preparation of mahua sugar syrup.[49]

Fermented Products:

Dried mahua flowers serve as an appealing source of fermented products because of their high sugar content. Preparation of mahua wine using fresh flowers.[50] A variety of products, including

alcohol, brandy, acetone, ethanol, lactic acid, and other fermented items, have been produced from the dry mahua.[51]

Jam, Jelly, Malmaade:

Fruits that are mature yet still unripe are utilized in the production of jam with the assistance of citric acid. In contrast, the pulp is transformed into marmalade or syrup, which serves as a food additive. Additionally, the pulp is employed in the creation of jelly; however, guava is occasionally incorporated to alter the astringent taste. The mahua jam and jelly, made from fresh flowers, along with the developed products, were evaluated for their color, flavor, taste, texture, and overall acceptability through a hedonic test, which indicated that the products were very well received. It was further reported that most mahua flowers are utilized in the production of distilled liquors.[52]

Bakery and Confectionary:

Confectionery items such as candy, biscuits, and cake were made utilizing mahua concentrate as a liquid sweetener.

Puree and Sauce:

The fresh flowers were utilized and crushed into a puree (with the stamens being manually removed) and then processed into a sauce.[53]

CONCLUSION

The article emphasizes the traditional, pharmacological, and commercial significance of *M. longifolia.* The Mahua tree, which is part of the Sapotaceae family, is indigenous to India. Historically, it has served as a versatile plant. Different parts of the plant have been utilized for a range of applications.[54] The advancement of contemporary pharmaceuticals derived from *Madhuca longifolia* should be highlighted for both therapeutic and commercial applications, as the current trend is shifting towards the utilization of non-toxic plant products with traditional applications, which may subsequently enhance employment opportunities and income generation potential. Based on a review of the literature, it is concluded that *Madhuca longifolia* is an exceptionally nutritious tree, known to contain compounds such as sapogenins, triterpenoids, steroids, saponins, flavonoids, and glycosides, which possess various ethnomedical properties, including antibacterial, anticancer, hepatoprotective, antihyperglycemic, and analgesic effects.[18] To enhance the potential of the mahua tree, it is essential to cultivate it through plant tissue culture utilizing micropropagation techniques. Researchers must collaborate with the local authorities to gain more valuable insights and knowledge.[16]

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