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An overview on Mahua (*Madhuca indica*): Underutilized important minor fruit crop of India

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Abstract

Mahua, also known as *Madhuca latifolia* or *Madhuca indica*, is a tree which is being used by indigenous people' in their daily lives. It is a significant economic tree that grows all throughout India and is a member of Sapotaceae family. Medium to large in size, the mahua tree is a deciduous that typically has a wide, rounded crown and a short bole. In tribal and rural communities, Mahua flowers are used as food and as a medium of exchange. Additionally, wild animals eat it. Mahua seeds are economically important because they contain a lot of edible oil. Fruits of the mahua plant are used as vegetables. *Madhuca longifolia* is also regarded as a medicinal tree and has ethnomedical qualities such as antibacterial, anticancer, hepatoprotective, antiulcer, antihyperglycemic, and analgesic effects. It can also be applied externally to treat skin conditions, rheumatism, headache, chronic constipation, piles, and hemorrhoids. In addition to being used to make whiskey, mahua flowers can be used as a food ingredient to make biscuits, cakes, laddus, candies, bars, jams, jellies, sauces, and more. In many tribal areas of India, mahua oil is utilized as cooking oil in addition to being used to make detergent and laundry detergents. Numerous scientists have found that *Madhuca longifolia* contains flavonoids, glycosides, triterpenoids, steroids, and sapogenins. Tribes who live in forests view the tree as a boon and take great care to preserve it. The mahua drink and tree are regarded by the tribes as part of their cultural heritage. Therefore, raising public awareness of the need to preserve the forest is crucial.

Keywords: Tree, vegetable, sapotaceae, flavonoids, mahua, skin conditions

Introduction

One of Central India's most significant trees is the mahua. Although many of the roots of the mahua trees are superficial, they have a vast, spreading system. Wood with extensive sapwood is hard to very hard. The color of hardwood is reddish brown. It is a big, deciduous tree with a rounded crown and a short bolt. Due to its various connections to the tribal livelihood systems, mahua enjoys a unique position among NTFPs. In addition to providing for basic needs like food, it is a significant source of seasonal revenue. Its flowers are used to make country whiskey, which is highly well- liked among the nation's tribal regions. In tribal culture, the tree has aesthetic and sacred significance. Mahua seeds and petals are gathered and dried because they are nutritious and therapeutic. In addition to numerous other material and immaterial advantages, a single mature tree gives about Rs. 1500/- income from its blossoms and seeds (Kulkarni *et al*., 2013) [16]. Mahua gives impoverished households a stable source of revenue, which they may utilize to buy everyday necessities as well as for their own use and sale.

Mahua gatherers, who typically barter for everyday grocery items, seldom receive the real worth of crops in the majority of tribal regions (FGLG, 2008) [12]. The Indian Butter Tree, or Mahua (*Madhuca longifolia* (Koenig) J.F. Macribide), is a significant tree that grows throughout the tropical and subtropical regions of the Indian subcontinent and has significant economical importance. This tree is deciduous and grows extensively in arid tropical and subtropical climates. Even in pockets of soil between voids of stony rock, it is extremely resilient and grows well in rocky, gravely, saline, and sodic soils (Singh, 1998) [34]. According to Banerji and Mitra (1996), Mahua (*Madhuca indica* J.F. Gmel. syn. *Madhuca latifolia* Macb.) is a member of the Sabotaceae family [8]. It is one of those multifunctional forest tree species that can be used for fuel, fodder, and food (Patel *et al*., 2011) [25]. Raw or cooked fruits are consumed. While the dry husk is a good source for alcoholic fermentation, the fruit pulp can be used as a source of sugar. Oil can be found in seeds (Singh *et al*., 2005). Mahua is the name of the tree that bears edible fruits and blossoms (Jayasree *et al*., 1998). The alkaloid glucoside saponin is found in the leaves of the Mahua tree. The seeds contain sapogenin and other basic acids. Mahua flowers are renowned for having a high nutritional and lowering sugar content. The plant's flowers can be eaten. The corolla, also known as mahua flowers, is a significant source of sugar and a good source of minerals and vitamins (Singh and Singh, 2005). [35, 36] Additionally, the blossoms are used to make vinegar, distilled liquor, portable spirits, and animal feed (Adhikary and Adhikary, 1989) [2]. According to Midya and Brahmachary (1996) [19], 2acetyl1pyrroline (2AP), the

substance that gives basmati and other scented rice their pleasant scent, is present in fresh Mahua (*B. latifolia* Roxb.) blossoms that release fragrance. It was discovered that only the fleshy corolla of mature flowers synthesizes 2AP (Wakte *et al*., 2011) [41]. In the Indian mahua production area, they are edible and used as a sweetener in a variety of regional foods, including halwa, kheer, puri, and burfi (Patel and Naik, 2008) [25].

Climate and soil: Mahua trees thrive in tropical climates and can tolerate drought well; they do not thrive in wet environments. They can grow in pockets of soil between bare rock fissures and even on degraded rocky areas, including soils affected by salt. However, well-drained, deep loam soil is best for their growth and productivity.

Cultivation and Collection: According to Behl and Sriwasrawa (2002), this plant can be self-sown or grown [9]. During the months of March through April, this medium-sized tree flowers every year.

Botanical Description and Identification Features: A medium-sized to large deciduous tree, typically with a large rounded crown and a short hole, that grows throughout India's green forest region up to 1,200 meters in elevation and 12 to 15 meters in height; it has thick, darkly cracked bark, dark red inner bark, milk, a short trunk, and many branches (Behl and Sriwasrawa, 2002) [9]. The thick, leathery, 10-30 cm long leaves are mostly pointed at the tip, clustescent, glabrous near the end of branches, epileptic or elliptic, oblong, 7.5-23 cm into 3.8-11.5, coriaceous pube, and nearly juvenile. Small, fleshy flowers with a dull or pale white hue are found in distinct fascicles close to the ends of branches. According to Variers and Vaidyarathanam (1995), corolla is tubular, freshly pale, golden, scented, and caduceus [40]. Fruits are greenish, meaty, and 2-6 cm long. Dark-colored, fractured bark (CSIR, 2006) [4]

Used in tribal medicine: Tribals consume a cup of bark infusion orally twice a day to treat diarrhea. In addition, stem bark is used to treat fever, leprosy, and chronic tonsillitis (Kirtikar and Basu, 2001) [15]. In the southern region of Tamilnadu, India, it is frequently used as an antidote for snakebite (Ramar *et al*., 2008). [28]. According to Ayyanar and Ignacimuttu (2005) and Joseph (2008), stem bark decoction is used to treat skin conditions and hydrocoel [7, 14]. Bark that has been powdered is used to cure scabies. The expectorant leaves of *Madhuca longifolia* are also used to treat Cushing's illness and chronic bronchitis (Prajapati *et al*., 2008). To treat eczema, the leaves are administered as a poultice.

Phytochemical: The active ingredients found in the various plant parts, which may be present in tiny or big quantities, determine the plant's medicinal usefulness (Sardana and Sharma, 2009) [30]. The key ingredient in crude medicines that gives them their primary therapeutic qualities are the secondary metabolites (Sengar and Agarwal, 2009) [31]. The Mahua tree's leaves contain glucoside, an alkaloid, and saponin. The seeds contain sapogenin and other basic acids. The characterisation of sapogenin, triterpenoids, steroids, flavonoids, and glycosides are among the many photochemical investigations conducted on Mahua. Given the aids and ascribed therapeutic qualities, new ingredients such as madhushazone, four new oleanane type triterpene glycosides, madhucic acid (penta cyclic triterpenoids), and madhucosides A and B (Siddiqui *et al*., 2010) [10]. The fragrance molecule, 2 acetyl 1 pyrroline, is present in fresh Mahua flowers. According to Miller (2005), they also include polysaccharides, which hydrolyze to produce D-galactose, Dglucose, L-araninose, Lrhamose, D-xylose, and D-glucuronic acid [20].

Pharmacological screening is the process of determining the pharmacological activity of a certain crude drug and is crucial for activity prediction (Ansari, S.H. 2007). [6].

Active Constituent Present in Different Parts of *Madhuca indica* (Source-Wealth of India, 2007)

Plant Parts	Phyto-constituent
Bark	Flavonoids, Triterpene, Sterol
Latex	Soluble Resin, Insoluble Resin
Leaf	Moisture, Organic Matter, Minerals, Potas (K2O) Phosphoric Acid (P205) Silica, Alkaloids, Flavonoids, Protobasic Acid
Flower	Carotene, Ascobic Acid, Thiamine, Riboflavine, Niacine, Folic Acid, Biotine, Inositole
Ripe Seed	Moisture, Protein, Fat, Carbohydrates, Minerals, Calcium, Phosphoras, iron, Carotine, Ascorbic Acid, Tannins

Table 1: Traditional uses of *Madhuca longifolia* in India

S. No.	Tree Part	Ethno-medical Uses	References
1	Seed Cake	Anti-inflammatory, anti ulcer, and hypoglycaemic activity	Seshagiri M. *et al* 2007
2	Bark	Antidiabetic activity	K Pavan Kumar *et al*. 2011 [17]
3	Flower	Analgesic activity	Dinesh Chandra *et al*. 2001
4	Leaves & Bark	Wound healing activity	Smita Sharma *et al*. 2010 [37]
5	Leaves	Nephro and hepato protective avtivity, antioxidant and cytotoxic activity	S. Palani *et al*. 2010
6	Leaves & Stem	Antimicrobial activity	Mangesh Khond *et al*. 2009
7	Seeds	Effective to alleviate pain	Srirangam Prashanth *et al* 2010

Utilization

Use of sugar syrup: Since the sweet quality of dry Mahua flowers is used in the fermentation process, there have been multiple reports on making sugar syrup from them (Benerji *et al*., 2010, Sriwastaea *et al*., 1970, Madhumita and Naik, 2010) [33, 24].

Before being concentrated to the appropriate concentration, the dried flower water extract is decolored using various decolorizing agents, such as slacked lime and activated charcoal. Madhumita and Naik (2010) [24] discovered that

the optimal agent for making the Mahua sugar syrup was activated charcoal at a concentration of 3.5% to 5.0%. The syrup that is thus extracted from the Mahua flower is used for a variety of purposes, such as as a sweetener or in the production of chocolate (CSIR, 2006) [4].

Fermented items: Because dried mahua flowers have high sugar content, they are an appealing source of fermented products. Mahua wine is prepared with fresh flowers. (Yadav and others, 2009) [42]. The dry Mahua has been used to make a variety of products, including lactic acid, ethanol, acetone, brandy, alcohol, and other fermented products (Fowler *et al*., 1920) [13].

Mahua's Use as Food

Raw Mahua consumption: Although these blossoms are readily available in rural regions and are a great source of nutrients, they are not highly popular as food. In various regions of India, only a little amount of flowers are eaten raw, cooked, or fried (Wealth of India, 1962) [3].

Making use of mahua to process various food products

Sugar syrup: Abhyankar and Narayana's 1942 report describes how to make sugar syrup from dried mahua flowers, which may then be added to various foods as a sweetener.

Jam, jelly, marmalade, and pickle: According to Reuther *et al*. (1967), unripe but mature fruits can be turned into jam by adding citric acid. Additionally, the pulp is transformed into syrup or marmalade, which is used as food. In order to alter the astringent flavor, jelly can also be prepared from the pulp by itself or in combination with guava. Additionally, the pulp is pickled. Distilled liquors are made using a significant amount of flowers (Wealth of India, 1962) [3]. Patel (2008) used fresh flowers to make the mahua jam and jelly. Using the hedonic test, the created items were evaluated for color, flavor, taste, texture, and general acceptance.

Bakery and confectionery: Mahua concentration was used as a liquid sweetener to make candy, biscuits, and cakes.

Puree and sauce: Using fresh flowers, Patel (2008) [25] mashed them into a puree (after removing the stamens by hand) and then processed them into a sauce.

Use in Medicine and Nutrition: The Mahua tree has many nutritional benefits. It yields fruit that is prized for its seeds, which are used to make biodiesel, several edible and medicinal products, and a large amount of fat that is commercially referred to as Mahua butter or mowrah butter. Its fat has been utilized in place of ghee and cocoa butter. It is among the most abundant natural sources of hard fat. The fat that is thus extracted from Mahua fruit oil is utilized in chocolate production, cooking, and frying. A small number of pharmaceutical enterprises primarily use seed fat as an emulsifying ingredient due to its emulsion properties. Because it works so well to hydrate skin, it is typically used as massage oil in various parts of the nation. Mahua has industrial uses in addition to culinary and therapeutic ones, since it may be used to make lubricants and laundry soaps. Additionally, the seed cake is utilized as organic manure in crops like rice, sugarcane, and others and is said to possess insecticidal and insecticide qualities. This herb has the following therapeutic qualities: warm, emollient, demulcent, and stimulating. Skin conditions, rheumatism, headaches, piles, laxatives, and occasionally as an astringent galactogogue, among many more. The great nutritional value of Mahua flowers is revealed by a review of the literature based on their chemical composition. The flowers are a rich source of protein and sugar, and they also include vital minerals including calcium, phosphorus, iron, and potassium. A vital component of bone, calcium aids in the growth of teeth. Because of the strong relationship between phosphorus and calcium use, phosphorus is next in significance to calcium. Calcium phosphate makes up the majority of the calcium in the body.

Mahua flower's nutritional qualities (Source: Kureel *et al*., 2009) [18]

Constituent (%)	Amount present in Mahua Flower
Moisture	19.8
Protein	6.37
Fat	0.50
Total Sugar's	54.06
Calcium	8
Phosphorus	2
Ash	4.36

Tree-Borne Oilseed Mahua: Many tree species' seeds have high oil content, and using them to produce bio-energy has long been a hot topic (Raina, 1986). Tribal cultures use Mahua oil, which is also edible. All of the TBOS have several uses, which makes them ideal for Agroforestry systems. However, care must be used while determining whether all of the applications will materialize simultaneously.

Mahua seed oil: Around 40% of mahua seeds are made up of pale yellow, semi-solid fat. "Mahua Butter" is the common name for the seed oil. The seed's oil content ranged from 33 to 43 percent of the kernel's weight. Mahua oil is by far the most significant tree seed oil for the Indian tribal people. When fresh Mahua oil is extracted from seeds that have been properly preserved, it has a golden hue and a mild flavor. The majority of the tribes in states like Odisha, Chhattisgarh, and Maharashtra use the oil for cooking.

Mahua seed's nutritional qualities (Source: Kureel R.S. *et al*., 2009) [18]

Properties	Oil Content (%)
Refractive index	1.452-1.462
Saponification value	187-197
Iodine value	55-70
Unsaponifiable matter (%)	1-3
Palmitic C 16:0 (%)	24.5
Stearic Acid C 18:0 (%)	22.7
Oleic Acid C C18:0 (%)	37.0
Linolic Acid C18:2 (%)	14.3

Conclusion

The Mahua tree produces a remarkably large amount of oil. The oil is high in polyunsaturated fats (PUFAs) and contains a suitable amount of oleic and stearic acid to be utilized as a cocoa alternative in the manufacturing of margarines, confections, cosmetics, and pharmaceuticals. Additionally, mahua oil may be used as a diesel fuel substitute. The blooms are used to make cakes, liquor, and other vegetables. Mahua is used to treat rheumatism, diabetes, piles, eczema, burns, gum disease, and bronchitis, while flower juice is used to treat a number of illnesses. As a result, the seeds are useful for both industrial applications and satisfying consumer demand for food and dietary supplements with useful, health-promoting qualities. Regarding the improved potential, high-quality mahua trees should be grown via plant tissue culture and micro propagation.
In order for the members of the tribal community to gain more and useful knowledge, the research staff must accompany them. The significance of plants and mahua trees will grow in the upcoming generation due to their efficiency, accessibility, affordability, and relative lack of harmful effects. Given the many uses and potential of *Madhuca indica*, plants are a significant and affordable source of several well-known medications. It makes sense to grow this plant extensively, particularly on waste and unproductive land.
This will assist in providing the impoverished and landless families with complete financial support. From a therapeutic perspective, the Mahua tree is kept out of the public sight. Regarding the greater potential, high-quality mahua trees ought to be grown via plant tissue culture and micro-propagation. The inhabitants of the rulers' territory must accompany the researchers in order for them to gain more knowledge that is important. Plants and mahua trees will become more important in the upcoming generation because to its effectiveness, accessibility, affordability, and relative lack of harmful effects. Several pharmacological properties of *Madhuca indica* have been discovered, but more needs to be discovered.

References

1. Abhyankar VS, Narayana N. Reports on preparation of sugar syrup from dry mahua flowers which can be further used as a sweetening agent - preliminary note on the preparation of syrup from mahua flowers. Poona Agric Coll Mag. 1942;33:168-172.
2. Adhikary S, Adhikary J. Sal olein and mahua olein for direct edible use. J Am Oil Chem Soc. 1989;66(11):1625-1630.
3. Anonymous. Wealth of India: A dictionary of Indian raw materials and industrial products - raw materials. Publications and Information, Directorate Council of Scientific and Industrial Research. CSIR, New Delhi. 1962;VI:207-215.
4. Anonymous. The Useful Plants of India. Publication and Information Directorate, CSIR, New Delhi. 2006.
5. Anonymous. The Wealth of India: Raw Material. Council of Scientific and Industrial Research, New Delhi. 2008;6.
6. Ansari SH. Essentials of Pharmacognosy. 2nd ed. Birla Publications, New Delhi. 2007-08;2:575-576.
7. Ayyanar M, Ignacimuthu S. Traditional knowledge of Kani tribals in Kouthalai of Tirunelveli hills, Tamil Nadu, India. J Ethnopharmacol. 2005;102:246-255.
8. Banerji R, Mitra R. Mahua (*Madhuca* species): uses and potential in India. Appl Bot. 1996:260-277.
9. Behl PN, Sriwasrawa GS. Herbs Useful in Dermatological Therapy. 2nd ed. CBS Publishers and Distributors, New Delhi. 2002;2:94-95.
10. Siddiqui BS, Khan S, Kardar NM. A new isoflavone from *Madhuca latifolia*. Nat Prod Res. 2010;24:76-80.
11. Chandra D. Analgesic effect of aqueous and alcohol extract of *Madhuca indica* longifolia. Indian J Pharmacol. 2001;33:108-111.
12. FGLG India. NTFP enterprises and forest governance: Mahua. Centre for People and Forests. 2008.
13. Fowler GJ, Behram JDE, Bhate SR, Hassan HK, Mahdihassan S, Inuganti NN. Biochemistry of mahua flower. J Indian Inst Sci. 1920;3:81-118.
14. Joseph J. Siddha medicine: background and principles and their application for skin diseases. Clin Dermatol. 2008;26:62-78.
15. Kirtikar KR, Basu BD. Indian Medicinal Plants. 7th ed. Oriental Enterprises. 2001;VII:2058-2061.
16. Kulkarni PS, Kulkarni SG, Kulkarni RMR. Mahua (*Madhuca indica*) as a source of biodiesel in India. Int J Sci Eng Res. 2013;4(7):2319-2329.
17. Kumar PK, Vidyasagar G. Screening of *Madhuca indica* for antidiabetic activity in streptozotocin and streptozotocin-nicotinamide induced diabetic rats. Int J Pharm Tech Res. 2011;3:1073-1077.
18. Kureel RS, Kishor R, Dutt D, Ashutosh P. Mahua - a potential tree-borne oilseed. National Oilseeds and Development Board, Ministry of Agriculture, Govt. of India, Gurgaon. 2009;1-27.
19. Midya S, Brahmachary R. The aroma of *Bassia* flower. Curr Sci. 1996;71:430.
20. Miller LG. Herbal Medicinals: A Clinician's Guide. 2nd ed. Viva Books Pvt. Ltd., New Delhi. 2005;1(2-3).
21. Palani S, Raja S, Karthi S, Selvi A, Sendhil Kumar B. *In vivo* analysis of nephro and hepatoprotective effects and antioxidant activity of *Madhuca longifolia* against acetaminophen-induced toxicity and oxidative stress. J Pharm Res. 2010;3(1):9-16.
22. Patel M. Biochemical investigations of fresh mahua (*Madhuca indica*) flowers for nutraceuticals. 2008.
23. Patel M, Naik SN. Biochemical investigations of fresh mahua (*Madhuca indica*) flowers for nutraceuticals. PhD thesis, Centre for Rural Development and Technology, IIT Delhi, India. 2008.
24. Patel M, Naik SN. Flowers of *Madhuca indica* J.F. Gmel: Present status and future perspectives. Indian J Nat Prod Resour. 2010;1:438-443.
25. Patel M, Pradhan RC, Naik SN. Physical properties of fresh mahua. Int Agrophys. 2011;25:303-306.
26. Prajapati V, Tripathi AK, Khanuja SPS, Kumar S. Antiinsect screening of medicinal plants from Kukrail forest, Lucknow, India. Pharm Biol. 2003;4:166-170.
27. Raina AK. A critical appraisal of the potential petroplantations for tomorrow. In: Srivastava HC, Vatsya B, Menon KKG, editors. Plantation Crops - Opportunities and Constraints. Oxford & IBH Publishing Co., New Delhi. 1986;1.
28. Ramar PS, Thwina MM, Gopalakrishnakone P,

Ignacimuthu S. Ethnobotanical survey of folk plants for the treatment of snakebites in southern Tamil Nadu, India. J Ethnopharmacol. 2008;115:302-312.
29. Reuther W, Webber HJ, Batcher LD. The Citrus Industry. University of California, USA. 1967;407-409.
30. Sardana S, Sharma OP. Fundamentals of Pharmacognosy. 1st ed. Birla Publications, Delhi. 2009-10;1:40-42.
31. Sengar NPS, Singh R. A Textbook of Pharmacognosy. 1st ed. Pharmamed Press, Hyderabad. 2009;1:44-45.
32. Seshagiri M, Gaikwad RD. Anti-inflammatory, anti-ulcer and hypoglycemic activities of ethanolic and crude alkaloid extracts of *Madhuca indica* seed cake. Orient Pharm Exp Med. 2007;7:141-149.
33. Shriwastava RK, Sawarkar SK, Bhutey PG. Decolorization and deodorization studies on mahua extract. Res India. 1970;15:114-117.
34. Singh IS. Mahua: an oil-bearing tree. Technical Bulletin, ND University of Agriculture and Technology, Kumarganj, Faizabad, UP, India. 1998;3-11.
35. Singh S, Singh AK. Genetic diversity in mahua (*Bassia latifolia*) under semi-arid ecosystem of Gujarat. Indian J Agric Sci. 2005;75(8):519-523.
36. Singh S, Singh AK, Apparao VV, Bagle BG, Dhandar DG. Genetic divergence in mahua (*Bassia latifolia*) under semi-arid ecosystem of Gujarat. Indian J Plant Genet Resour. 2005;18(3):244-249.
37. Sharma S, Sharma MC, Kohli DV. Wound healing activity and formulation of ether-benzene-95% ethanol extract of *Madhuca longifolia* leaves in albino rats. J Optoelectron Biomed Mater. 2010;19(1):13-15.
38. Prashanth S, Kumar AA, Madhu B, Kumar YP. Antihyperglycemic and antioxidant activity of ethanolic extract of *Madhuca longifolia* bark. Int J Pharm Sci Rev Res. 2010;5(3):89-94.
39. Prashanth S, Kumar AA. Antihyperglycemic and antioxidant activity of ethanolic extract of *Madhuca indica* bark. Int J Pharm Sci Rev Res. 2010;5:89-94.
40. Variers PS. Vaidyaratnam: Indian Medicinal Plants. Orient Longman, New Delhi. 1995;1(3):362-366.
41. Wakte KV, Kad TD, Zanan RL, Nadaf AB. Mechanism of 2-acetyl-1-pyrroline biosynthesis in *Bassia latifolia* Roxb. flowers. Physiol Mol Biol Plants. 2011;17(3):231-237.
42. Yadav P, Garg N, Diwedi DH. Effect of location of cultivar, fermentation temperature and additives on the physicochemical and sensory qualities of mahua (*Madhuca indica* J.F. Gme-l) wine preparation. Nat Prod Radiance. 2009;8:406-418.