

MAHUA (MADHUCA LONGIFOLIA, SAPOTACEAE): A REVIEW OF ITS PROPERTIES AND EFFECTS

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Article Received on
09 April 2023,

Revised on 29 April 2023,
Accepted on 19 May 2023

DOI: 10.20959/wjpr20239-28291

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ABSTRACT

Madhuca longifolia (*M. longifolia*), commonly known as Mahua, belonging to the family sapoteace family tree is a medium to large sized deciduous tree. *M. longifolia* is a highly nutritious tree used in traditional and folklore system of medicine widely across India, Nepal, and Sri Lanka. This paper reviews the earlier work done on madhuca and summarizes the traditional, common uses of various parts of plant, its phytochemical constituents and various reported pharmacological activities alongwith focusing on income generation & employment through commercial use of its parts in food and medicine industry.

Madhuca longifolia is reported to contain chemical constituents like saponins, triterpenoids, steroids, saponins, flavonoids and glycosides. After a lot of therapeutic research on mahua, it is shown that it has ethnomedicinal properties such as antibacterial, anticancer, hepatoprotective, antiulcer, antihyperglycemic and analgesic activities. The tribal regions of India use the oil in cooking and it is also used in manufacturing of laundry soaps and detergents. *M. longifolia* can be considered as a therapeutic agent for specific diseases as its non-toxic effect even at larger doses are revealed in toxicity studies. For deeper traditional knowledge, further exploration on *M. longifolia* for its therapeutic potential is required. Mahua oil is used for manufacturer of laundry soaps and detergent, and also used as cooking oil in various.

KEYWORDS: *Madhuca longifolia*, Mahua, butter nut tree, Phytochemistry, Ethnomedicinal Uses.

INTRODUCTION

The Indian subcontinent is enriched by variety of flora in aromatic and medicinal plants both due to wide diversity of climatic conditions that are available ranging from deserts to swap lands in India.^[1]

The world health organization has identified 3000 plants from forest of India as they are now actively emphasizing on the developing countries to encourage the use of herbal medicine which has been used for centuries traditionally.^[2]

The plants are believed to be an important source of nutrition along with chemical substances having necessary potential of therapeutic effects. These plants are therefore an effective source of both traditional and modern medicines. They have always been a rich source of medicine as wide range array of bioactive molecules are being produced by them.^[3] The use of plants as a source of medicine has been inherited and is an important component of the health care system in India and abroad in the present times.

Since Ayurvedic era, herbal medicines have been considered as the backbone of traditional system of medicine, as they have efficacy in their pharmacological properties and more than 75% of the population in developing countries still depends on it, therefore are considered to be the potential source of new drug development.^[4] Thus there is a need to increase screening of plants having medicinal value.^[5,6]

For they have an utmost important from pharmacy to pharmaceutical industry.^[7]

Since the last few years, there has been an exponential growth in the field of herbal medicine and these drugs are continuously gaining popularity in developing and developed countries both and the reason being their origin and lesser side effects. The knowledge of traditional medicine emphasizes on the discovery of new and potent medicine.

The treatments in Ayurveda for various ailments have focused on the need of investigating new but efficacious and safe herbal medicines for use of the public in general.^[8] Banerji and Mitra^[9] in their study mentioned that Mahua (*Madhuca longifolia*) which belongs to the family Sapotaceae, is one of those forest tree species with a multipurpose that provides an answer for the 3 major F's which are food, fodder and fuel. *Madhuca* is commonly known as Mahua or Butternut tree which is 17 m high and has a large top.^[10] Mahua is widely

distributed in the South Asian countries and produces edible flowers and fruits that have high medicinal value.^[11]

The Mahua tree has approximately 20 meters height and possesses evergreen or semi evergreen foliage. Its seeds have abundant amount of oil bearing capacity for which it is generally valued and flowers are mostly used in the production of alcoholic beverages and sweet candy. The estimated production of Mahua flowers as reported is more than one million tons in the country.^[12]

Historical background

Since long time, Madhuca tree has been a source for various edible products as well as in medicinal purposes. Tribals worship Mahua because all parts of this plant have been used for the well-being of humans. The flower of Madhuca longifolia is also used as a flavoring agent in dishes and rice and Pickles are also made from it. It has also been used as feed for the cattle. As it increases the milk production hence it is used by the lactating mothers.^[16]

Tribals believe in conserving this tree as they believe it is sacred for them. In their culture, these trees drink also prevails.^[17]

Mahua, a large deciduous tree grows extensively under sub tropical and dry tropical climatic conditions. It can be found in forests, revenue, and private land. Distributed in Andhra Pradesh, Gujarat, Madhya Pradesh, Orrisa, Chhatisgarh, Jharkhand, Bihar, Uttar Pradesh, Madhuca Longifolia is an important tree for poor, highly valued for its flowers for its medicinal uses and its seeds known as tora. In the tribal culture, this tree has religious as well as aesthetic value. The trees with best girth in forests are often Mahua trees as forest dwellers protect and provide care to them. The early settlers even had rights for Mahua trees for its harvesting flowers and fruits to specific growing near the village in private, revenue and forestlands. Some trees could be located at a long distance from the village but well recognized as being associated to the concerned family. The rights used to pass from generation to generation as when father divides the property among his sons, he used to divide Mahua tree between them and keeps some for himself till the end, as it becomes one of the easy sources of income. In the absence of sons, daughters were given harvesting rights at the time of their marriage.^[18]

Description

Belonging to the family Sapotaceae, *Madhuca longifolia* (Mahua) is commonly known as the Butter nut tree which has been gifted with many chemical ingredients responsible for numerous medicinal properties. It is a medium to large sized deciduous tree distributed in Nepal, India and Sri Lanka.^[13] It is found mainly in Asian and Australian forests, deciduous forests of West Bengal, Orissa, Madhya Pradesh, Uttar Pradesh, Bihar, Punjab and also the sub mountainous region of the Himalaya. It has been reported that it consists of terpenoids, proteins, starch, anthraquinone glycosides, phenolic compounds, mucilage, cardiac glycosides, tannins and saponins and possesses wound healing, antimicrobial, antioxidant, anti-inflammatory, anticancer activity and antidiabetic activities.^[14]

The antioxidant activity which is necessary to combat the oxidative stress due to free radicals is a power that *Madhuca indica* has been gifted with. The free radicals are responsible to damage chemical species which makes the other molecules unstable such as superoxide anion (Reactive oxygen species). The property of its flowers are tonic, aphrodisiac, astringent and cooling and can be used to cure acute and chronic tonsillitis, helminthes, pharyngitis as well as bronchitis. Its leaves have been used as expectorant, Cushing's disease and chronic bronchitis and in the form of poultice, to cure eczema. Aerial parts of the plant can be used to cure inflammation. The stem bark powder is used to strengthen gums in the form of tooth powder. The bark infusion can be used for the treatment of diarrhea and diseases such as phlegm, itching, swelling, fractures, snake-bite, diarrhoea, chronic tonsilitis, leprosy and fever and rheumatism can be cured by the bark as well.^[14]

The leaves of Mahua tree contain saponin, an alkaloid glucoside. Its seeds contain Sapogenin and other basic acid. Mahua flowers are edible and are well known for their high reducing sugar and nutrient content. In the mahua production belt of India, they are used as a sweetener in preparation of many local dishes such as halwa, kheer, puri and burfi. However, they are collected and subjected to open yard sun drying till about 80% moisture is lost, before storage due to the lack of proper scientific investigation and post harvest processing technologies.^[15]

Cultivation and Collection

Mahua seeds production is about 0.12 million tons and flowers production is about 1 million tons in India which are used for extraction of the oil. As it is a source of employment for many people, therefore the state government of India motivates collection of mahua seeds and flowers.

It can be self sown or can be planted. From March till April, the flowering of this plant takes place.^[19] The seeds are generally collected in the months of May, June and July. In this period, it has been seen that flowering is more than the seed production. 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 obtained can be sold after vacuum purification to the soap industries and can be preserved in airtight earthen pot/basket from not being destroyed by fungus.^[20]

The desired dose of Madhuca is 10-15 g as mentioned in The Ayurvedic Pharmacopoeia of India.

Distribution and Habitat

Madhuca longifolia is distributed in northern, central and southern part of peninsular India, Southern India extending northwards to Maharashtra and Gujarat Sri Lanka and Burma. It is found in some parts of central and north India and Burma. In dry mixed deciduous forests, dry forest and dry teak forests it is common. The tree grows on a wide variety of soils such as shallow, boulder, clayey and calcareous soils but thrives best on sandy soil. It is found up to an altitude of 1200 m, mean annual maximum temperature 28-50°C, minimum 2-12°C; annual rainfall from 550-1500 mm. The species is not frost-hardy, drought-resistant, strong light demander and readily suppressed under shade.^[21]

Botanical description

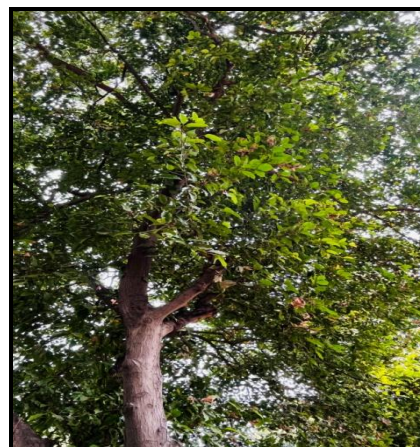
Madhuca longifolia, a medium to large sized deciduous tree with a large top is distributed in Nepal, India and Sri Lanka.^[22] It is 10-15 m tall with a spreading, dense, round and shady canopy.

1. Bark is rough and brownish to yellowish grey in colour.^[23] It is fissured and slightly cracked. Inner bark is red and when it is cut, it exudes white and milky sap.
2. 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 is 2-4 cm in length and reddish in colour.

4. Flowers are white, numerous and about 2 cm long. They are present in bunches at the end of the branches drooping on pedicels and are pointed, sweet scented as well as fleshy.
5. Fruits are 1-4 seeded, 2-4 cm across and are ovoid, fleshy, greenish in colour.
6. Seeds are 2 cm long, elongate, shining and brown in colour.^[24]
7. Calyx is densely clothed rusty tomentum and is coriaceous.^[22]
8. Corolla is yellowish-white and fleshy.
9. Stamens are 20- 30, usually 24 or 26, anthers hispid at the back with stiff hair.



Flowers of Madhuca



Madhuca Tree



The flowers are used as cooling agent, aphrodisiac, astringent, demulcent, tonsillitis, helminthes, pharyngitis, bronchitis, impotency, inflammation, eczema. Flowers are used in the cure of eye diseases. Flower juice is beneficial for the treatment of skin disease. The bark is useful for the treatment of itching, swelling, fractures and snake-bite poisoning.^[22]

Taxonomy

Botanical profile of Mahua (*Madhuca longifolia*).^[25]

Botanical Name	Madhuca longifolia
Family	Sapotaceae
Subfamily	Caesalpinioideae
Tribes	Caesalpinieae
Genus	Madhuca
Species	longifolia
Order	Ericaleae

Synonyms^[26]

English	South Indian Mahua
Hindi	Mahva, Mohva
Kannada	Erappe
Telegu	Ippa
Tamil	Iluppai
Sanskrit	Madhukah
Malayam	Irippa

Classical categorisation

1. Charaka^[27] – Charak Chikitsa 19
2. Sushruta^[28] – Sushruta Sutra 46
3. Dhanvantri Nighantu^[29] – Aamraadi Varga
4. Bhavprakash Nighantu^[30] – Aamradi Phalavarga
5. Kaiyadev Nighantu^[31] – Aushadhadi Varga
6. Madanapal Nighantu^[32] – Phaladi Varga
7. Raj Nighantu^[33] - Aamradi Varga
8. Dravyaguna Sangraha^[34] – Phaladi Varga

Ayurvedic pharmaco-dynamics^[35]

Rasa	Madhura, Kashaya
Guna	Guru, Snigdha
Veerya	Sheeta
Vipaka	Madhura
Doshaghnta	Vatapittashamaka
Karma	Balya, Brimhana, Vrishya
Part Used	Pushpa, Beeja, Taila

Phytochemistry of different parts of mahua^[38]

Phytochemistry has undergone significant development as a distinct discipline in the past years. It deals with the structural characterization of these molecules with the concern of enormous variety of compounds which are synthesized and accumulated by plants.^[36,37]

1.	Flower	Vitamins A and C
2.	Bark	Ethylcinnamate, sesquiterene alcohol, α -terpeneol, 3 β -monocaprylic ester of erythrodiol and 3 β -capryloxy oleanolic acid. α - and β - amyryl acetates, α -tocopherol
3.	Fruits	α - and β - amyryl acetates, quercetin, β -sitosterol and its 3 β -D-glucoside, n-hexacosanol and dihydroquercetin.
4.	Nut –shell	n-hexacosanol quercetin and dihydroquercetin, β -sitosterol and its 3 β -Dglucoside.
5.	Seeds	Arachidic, linoleic, oleic, myristic, palmitic and stearic acids, α -alanine, aspartic acid, cystine, glycine, isoleucine and leucine, lysine, methionine, proline, serine, threonine, myricetin, quercetin, Mi-saponin A & B.
6.	Leaves	β -carotene and xanthophylls; erythrodiol, palmitic acid, myricetin and its 3-O-arabinoside and 3-O-L-rhamnoside, quercetin and its 3-galactoside; 3 β -caproxy and 3 β -palmitoxy-olean-12-en-28-ol, oleanolic acid, β -sitosterol and its 3-O- β -Dglucoside, stigmasterol, β -sitosterol- β -D glucoside, n-hexacosanol, 3 β -caproxyolcan- 12-en-28-ol, β -carotene, n-octacosanol, sitosterol, quercetin.

Phytochemical properties of mahua

Phytochemical constituents are responsible for definite physiological action of the human body.^[39] According to their functions in plant metabolism, phytochemicals are basically divided into two groups, i.e., primary and secondary

Constituents^[40]

1. Primary constituents comprise of common sugars, amino acid, proteins and chlorophyll
2. Secondary constituents consist of alkaloids, terpenoids, saponins, phenolic compounds, flavonoids, tannins.

The phytochemical screening of plants gives the general idea about the class of compounds present in those plants.^[41] Since many years, many plants are screened and with each passing day, newer bioactive compounds are being isolated. Since utility of medicinal plants has been organized by almost all therefore plants are screened for phytochemicals. These tests are either general or specific. Chemical tests are essential to identify the various constituents or

groups present in the plants although the utility of plants depends upon therapeutically effective active principles.^[42,43]

Preliminary phytochemical studies performed for methanolic extract of *Madhuca longifolia* are the result are as follows.^[44]

Alkaloids	+
Tannins	+
Proteins	+
Flavonoids	-
Carbohydrates	+
Amino acids	-
Volatile oils	-

Different species of madhuca

The genus *Madhuca* belongs to the family Sapotaceae. This genus has various species (The Plant List, 2013); some of it are listed below:

1.	<i>Madhuca alpinia</i>	53.	<i>Madhuca macrophylla</i>
2.	<i>Madhuca aristulata</i>	54.	<i>Madhuca magnifolia</i>
3.	<i>Madhuca aspera</i>	55.	<i>Madhuca malaccensis</i>
4.	<i>Madhuca barbata</i>	56.	<i>Madhuca microphylla</i>
5.	<i>Madhuca bejaudii</i>	57.	<i>Madhuca mindanaiensis</i>
6.	<i>Madhuca betis</i>	58.	<i>Madhuca mirandae</i>
7.	<i>Madhuca burckiana</i>	59.	<i>Madhuca montana</i>
8.	<i>Madhuca calcicola</i>	60.	<i>Madhuca monticola</i>
9.	<i>Madhuca cheogiana</i>	61.	<i>Madhuca moonii</i>
10.	<i>Madhuca clavata</i>	62.	<i>Madhuca motleyana</i>
11.	<i>Madhuca coriacea</i>	63.	<i>Madhuca multiflora</i>
12.	<i>Madhuca costulata</i>	64.	<i>Madhuca multinervia</i>
13.	<i>Madhuca crassipes</i>	65.	<i>Madhuca neriifolia</i>
14.	<i>Madhuca cuneata</i>	66.	<i>Madhuca oblongifolia</i>
15.	<i>Madhuca cuprea</i>	67.	<i>Madhuca obovatifolia</i>
16.	<i>Madhuca curtisii</i>	68.	<i>Madhuca obtusifolia</i>
17.	<i>Madhuca daemonica</i>	69.	<i>Madhuca ochracea</i>
18.	<i>Madhuca decipiens</i>	70.	<i>Madhuca orientalis</i>
19.	<i>Madhuca diplostemon</i>	71.	<i>Madhuca ovate</i>
20.	<i>Madhuca dongnaiensis</i>	72.	<i>Madhuca pachyphylla</i>
21.	<i>Madhuca dubardii</i>	73.	<i>Madhuca palembanica</i>
22.	<i>Madhuca elliptica</i>	74.	<i>Madhuca pallida</i>
23.	<i>Madhuca elmeri</i>	75.	<i>Madhuca pasqueiri</i>
24.	<i>Madhuca endertii</i>	76.	<i>Madhuca penangiana</i>
25.	<i>Madhuca engleri</i>	77.	<i>Madhuca penicillata</i>
26.	<i>Madhuca erythrophylla</i>	78.	<i>Madhuca pierrei</i>
27.	<i>Madhuca esculenta</i>	79.	<i>Madhuca platyphylla</i>

28.	Madhuca firma	80.	Madhuca primoplagensis
29.	Madhuca floribunda	81.	Madhuca prolixa
30.	Madhuca fulva	82.	Madhuca pubicalyx
31.	Madhuca fusca	83.	Madhuca punctata
32.	Madhuca glabrascens	84.	Madhuca ridieyi
33.	Madhuca hainanensis	85.	Madhuca rufa
34.	Madhuca heynei	86.	Madhuca sandakanensis
35.	Madhuca hirtiflora	87.	Madhuca sarawakensis
36.	Madhuca insignis	88.	Madhuca sepilokensis
37.	Madhuca kingiana	89.	Madhuca stipulacea
38.	Madhuca klackenbergii	90.	Madhuca stylosa
39.	Madhuca korthalsii	91.	Madhuca sessiliiflora
40.	Madhuca krabiensis	92.	Madhuca sessilis
41.	Madhuca kuchingensis	93.	Madhuca silamensis
42.	Madhuca kunstleri	94.	Madhuca spectabilis
43.	Madhuca lanceolata	95.	Madhuca stipulaceae
44.	Madhuca lancifolia	96.	Madhuca takensis
45.	Madhuca lanuginose	97.	Madhuca thorelii
46.	Madhuca laurifolia	98.	Madhuca tomentosa
47.	Madhuca lecomtei	99.	Madhuca tubulosa
48.	Madhuca leucodermis	100.	Madhuca utilis
49.	Madhuca ligulata	101.	Madhuca vulcania
50.	Madhuca lobbii	102.	Madhuca vulpina
51.	Madhuca longifolia	103.	Madhuca woodii
52.	Madhuca longistyla		

Common uses of mahua^[45]

1.	Fodder	Seed cake is also fed to cattle and leaves, flowers and fruits are lopped for goats and sheep.
2.	Timber	The heartwood being reddish brown, strong, hard and durable is very heavy approximately 929 kg/cu. m and takes a fine finish. It is used for construction of house, cartwheels naves and felloes, window frames and doors.
3.	Erosion control	Madhuca holds soil together as it has a large spreading superficial root system.
4.	Shade or shelter	It provides shade for animals because of its wide spreading crown. Reclamation: Madhuca is planted on wasteland with hard lateritic soils in India
5.	Nitrogen fixing	It has been observed that madhuca has Vesicular-arbuscular mycorrhizal associations and root colonization.
6.	Soil improver	The seed cake is used as fertilizer.
7.	Ornamental	Madhuca is occasionally planted as avenue tree.
8.	Boundary or barrier or support	It is planted along the boundaries of fields.
9.	Intercropping	M. latifolia can also be raised with agricultural crops.

Nutritional aspects of mahua^[46]

1. Madhuca flowers

Dependin on the need of the family, Mahua flowers are stored in appropriate quantity. The poorer the family more is the storage. The tribes consume the storage products in off season. As they generate earnings to them during lean periods, the tribals do not store these products for long and as they are hygroscopic and absorb atmospheric moisture and get spoiled. An alcoholic drink called Mahua, country liquor is produced by fermenting flowers of Madhuca tree. As part of their cultural heritage, tribal men and women of Bastar in Chhattisgarh, Odisha. Santhals (Jharkhand) and North Maharashtra consider the tree and consume Mahua drink which is an obligatory item during celebrations and evening activities.

S. no.	Constituents	Flower
1.	Moisture	19.8 %
2.	Protein	6.7 %
3.	Fat	0.5 %
4.	Reducing Sugar	50.62 %
5.	Total Inverts	54.24 %
6.	Cane Sugar	3.43 %
7.	Total Sugar	54.06 %
8.	Ash	4.36 %
9.	Calcium	8 %
10.	Phosphorus	2 %

2. Mahua seed oil

Mahua seeds contain approximately 40% pale yellow semi-solid fat. Mahua Butter, the seed oil of Madhuca varied from 33 to 43% weight of the kernel. It is by far one of the most precious seed oils in India for its tribals as it is used as cooking oil by them in Orrisa, Chhattisgarh, and Maharashtra. It is yellow in colour and has an unpleasant taste if stored properly from the seeds. It has used such as in the manufacture of soaps, particularly laundry chips, as illuminant and hair oil, especially in rural parts in the neighborhood of production centers and is also an ingredient of hydrogenated Vanaspati.

S. No	Properties	Value
1.	Refractive index	1.452-1.462
2.	Saponification value	187-197
3.	Iodine value	55-70
4.	Unsaponifiable matter (%)	1-3
5.	Palmitic C 16:0 (%)	24.5
6.	Stearic Acid C 18:0 (%)	22.7
7.	Oleic Acid C C18:0 (%)	37.0
8.	Linolic Acid C18:2 (%)	14.3

Traditional uses of *madhuca longifolia*^[47]

Place, Country	Part(s) Used	Ethnomedicinal Uses	Preparation(s)	Reference(s)
India	Seeds cake	Anti-inflammatory, anti ulcer, and hypoglycaemic activity	Ethanollic & crude alkaloid extract	Seshagiri M. <i>et al</i> 2007
India	Bark	Antidiabetic Activity	Methanol, water, & petroleum ether	K Pavan Kumar <i>et al</i> 2011
India	Bark	Antihyperglycemic and antioxidant	Ethanollic extract	Srirangam Prashanth <i>et al</i> 2010
India	Flowers	Analgesic Activity	Aqueous and alcoholic extracts	Dinesh Chandra <i>et al</i> 2001
India	Leaves & Bark	Wound healing activity	Ethanollic extract	Smita Sharma <i>et al</i> 2010
India	Leaves	Nephro and hepato protective activity	Ethanollic extract	S. Palani <i>et al</i> 2010
India	Leaves	Antioxidant Activity	Ethanollic extract	S. Palani <i>et al</i> 2010
India	Leaves	Cytotoxic Activity	Petroleum ether, chloroform, ethanol acetone and water	Saluja. M.S. <i>et al</i> 2011
India	Bark	Antibacterial activity	Aqueous, ethanol, methanol and acetone	Tambekar D.H. <i>et al.</i> 2010
India	Leaves & Stem Bark	Antimicrobial activity	Hexane, ethanol chloroform,	Mangesh Khond <i>et al.</i> 2009
India	Bark	Antioxidant Activity	acetone and water	acetone and water
India	Aerial part	Anti inflammatory, analgesic and antipyretic activity	70% ethanollic extract	Samaresh Pal Roy <i>et al</i> 2010
India	Flowers	hepato protective activity	Methanollic extract	Neha Shekhawat <i>et al.</i> 2010
India	Seeds	Anti inflammatory	Methanollic activity	M. Umadevi <i>et al</i> 2011
India	Leaves and stem bark	Astringent, Stimulant, Emollient, Demulcent, Rheumatism, Piles and Nutritive.	Ethanol extract and saponin mixture	Ramchandra D. <i>et al</i> 2009
India	Leaves	Verminosis, gastropathy, Dipsia, bronchitis, consumption, dermatopathy, rheumatism, cephalgia and hemorrhoids	ND	Mangesh Khond <i>et al.</i> 2009
India	Bark	Rheumatism, bleeding	ND	Y. Vaghasiya <i>et al</i>

		and spongy gums		2009
India	Bark	Rheumatism, ulcer and tonsillitis	Decoction	Tambekar D.H. <i>et al.</i> 2010
India	Flower	Skin diseases	ND	Srirangam Prashanth <i>et al</i> 2010
India	Seeds	Effective to alleviate pain	Juice	Srirangam Prashanth <i>et. al</i> 2010
India	Bark	Itch, swelling, fractures and snake-bite poisoning	Oil	Srirangam Prashanth <i>et al</i> 2010
India	Leaves	Expectorant, chronic bronchitis and cushing's disease	ND	K Pavan Kumar <i>et al</i> 2011
India	Flowers	Tonic, analgesic and diuretic	ND	Saluja. M.S. <i>et al</i> 2011
India	Flowers	Cure cough	ND	Saluja. M.S. <i>et al</i> 2011
India	Fruits	Asthma and phthisis	Roasted flowers	S. Palani <i>et al</i> 2010
India	Leaves	Antihyperglycemic activity	Roasted fruits	Rumi Ghosh <i>et al</i> 2009

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ND: Not Defined

Health benefits of madhuca^[48]

Madhuca has following health benefits:

1. *Bronchitis*

Its flowers of Madhuca are used in treatment of cough and chronic bronchitis.

2. *Orchitis (Testis inflammation)*

Madhuca leaves after boiling are used for relief from orchitis.

3. *Rheumatism*

To get relief from rheumatism, a decoction is prepared by boiling its bark in water and then taken internally. The seed oil can also be applied on the areas that are affected.

4. *Diabetes*

To cure of diabetes, bark decoction is proven to be effective.

5. *Piles*

As oil extracted from seeds has laxative properties hence it helps to cure chronic constipation and piles.

6. Eczema

Madhuca leaves are coated with sesame oil is heated over fire and applied on the affected area to get relief from eczema.

7. Gums

In order to get relief from spongy and bleeding gums, 4 ml of the liquid extract obtained from bark is mixed with 300 ml of water and used for gargling.

8. Tonsillitis

The above preparation used for relief in spongy and bleeding gums is also used for curing chronic and acute tonsillitis and pharyngitis.

9. Burns

Its bark paste is applied locally to get relief from itching and ash of leaves is mixed with ghee and used for cure of scalds and burns.

10. Lactation

Madhuca flowers and seeds have lactation properties hence are used to increase the milk production in feeding mothers.

Pharmacological uses of madhuca

Antioxidant activity

The primary cause in initiation of cellular damage which results in pathological changes and many diseases is the free radicals including active nitrogen species and reactive oxygen species as proven by various scientific works. Ethanolic extract of bark of Madhuca exhibits significant antioxidant potential as mentioned in studies of Roy *et al.* and Agrawal *et al.*^[49,50] Lipid peroxidation which is done for in-vivo assessment is also averted by the extract. The in-vitro free radical scavenging capacity of leaves is studied by Palani *et al.* and subsequently the in-vivo antioxidant assessment was carried out by glutathione.^[51]

Anti-Inflammatory activity

Inflammation is a complex response of body to the external stimuli. In this process, the formation of inflammatory leukocytes leads to the excess generation of free radicals that in turn alters the cellular function and damages the organs by initiating and promoting various diseases.^[52] Several scientific studies had proven anti-inflammatory activity on ethanolic extract of Madhuca bark and seeds. Study of Agrawal *et al* and Gaikwad *et al* prove that the crude ethanolic extract, methanolic bark extract and saponin mixture of *M. longifolia* extract has shown significant effect on inflammation induced by carrageenan.^[53,54]

Similar research shows that it also exhibits potent anti-inflammatory activity by its crude alkaloid extract. The ethanolic extract and saponin mixture is proven to reduce the rat paw oedema induced by formaldehyde, carrageenan and cotton pellet granuloma at dose of 10–15 mg/kg but only on the carrageenan induced model the dose-dependent activity was found. The constituents of *Madhuca* inhibit the prostaglandin synthesis as well as its mediators in synthesis and by reducing the intercellular cell adhesion molecule-1 expression induced by tumor necrosis factor are the probable proposed mechanisms of action.^[55]

Analgesic activity

The drugs used to prevent algesia are termed to be analgesic. Analgesic activity of *Madhuca* is mediated by central or peripheral mechanism as suggested by the studies. Experimental work in the study of Chandra states that the alcoholic extract of flowers has good analgesic activity against hot plate and tail flick method highlighting central analgesic activity in dose-dependent manner.^[56] There was a marked increase in analgesic efficacy at a dose of 4–64 mg/kg on all nociceptive methods. The methanolic extract markedly reduces acetic acid induced pain at dose of 50–200 mg/kg i.p in a dose dependent manner which shows the extract possessed peripheral analgesic activity.^[55]

Antipyretic activity

Elevation of body temperature from normal is termed as pyrexia. *Madhuca* also exhibits febrifuge action. Methanolic extract of aerial part, when evaluated by Brewer's yeast induced pyrexia model has shown significant dose-dependent inhibition on temperature elevation.^[55]

Anti-Ulcer activity

Peptic ulcer is chronic inflammatory condition referring to the sores and ulcer in the lining of stomach and duodenum.^[57] Experimental works done by Kalaivani and Jegadeesan had shown that it possess significant antiulcer action through its ethanolic extract of bark.^[58] Mohod and Bodhankar in their study had proven the antiulcer activity of aqueous extract of leaves. There was a significant protective effect in pylorus ligation induced gastric ulcer model with a marked decrease in ulcer index as compared to vehicle shown by crude ethanolic extract of seeds of *Madhuca*.^[59]

Immunosuppression

A wide range of immunosuppressive drugs to control unwanted immune responses have now been adopted, particularly those which are giving autoimmune disease and transplant

rejection.^[60] The immunosuppressant activity of *M. longifolia* was explored by administering methanolic extract of *M. longifolia* to murines and it was found to decrease the total WBC count and spleen leukocyte count significantly indicating that it could suppress the non-specific immune system by its extract alongwith a decrement in the relative spleen weight and thymus weight.^[61,62]

Anti-Hyperglycaemic activity

Diabetes mellitus is a metabolic disorder which is the most prevailing problem and is increasing rapidly worldwide.^[63] Dahake et al and Seshgiri et al. in their study investigated hyperglycemic effects of methanolic extract of *Madhuca* bark.^[64,65] Bark extract of *M. longifolia* has shown significant antidiabetic activity in rats which may be due to its effect on glucose utilization indicating its potential role in treatment and management of diabetes.^[64] The dose-dependent antihyperglycaemic activity of ethanolic extract of bark in rats was proven by Prashanth et al. at a dose of 100–200 mg/kg against streptozotocin-induced diabetes.^[66]

Ghosh et al. in its study showed that the hydroethanolic extract of *Madhuca* leaves against alloxaninduced diabetic rats had significant anti-hyperglycaemic activity.^[67] Seshgiri et al studied that the methanolic and ethanolic extracts of *Madhuca* seeds exhibited the antidiabetic activity.^[65] It was postulated that these effects of phytoconstituents may be due to alteration in glucose utilization and insulin levels. The extract also affects the rat intestinal enzymes in in-vitro studies.^[68]

Neuropharmacological activity

By investigating anticonvulsant effect of *Madhuca*, it has been observed that there is prolongation on the onset of a seizure and also decrease in the seizure duration. at a dose of 400 mg/kg suggesting that it may help in the treatment or management of absence seizures which is possessed by an active constituent entity with anticonvulsant property. Its traditional use as an anti-epileptic agent is proven by the in-vivo study showing the anti-convulsant potential of *Madhuca*.^[69,70]

Madhuca as Anti-Neoplastic

Chemoprevention is prominence effect of natural or pharmacological agents on reversing, blocking or delaying the onset of cancer with least adverse effect serving in the reduction of cancer related mortality.^[71] The chemopreventive action of *Madhuca* on human cancer cell

lines has been also showed by few scientific investigations alongwith its cytotoxic potential against the carcinoma cell.^[72] In-vitro cytotoxic assay of Madhuca proves its anticancer efficacy against the Ehrlichascites and carcinoma cell lines. The crude acetone and ethanolic extract of stem and leaves at dose 200 µg/mL showed cytotoxic effect and are used for in-vitro study at different dose.^[73]

Antihelminthic activity

Evaluation of antihelminthic activity of Madhuca was done by incubating *Ascardiagalli* with the alcoholic leaf extract. Akhil et al. investigated methanolic extracts of *M. longifolia* and found there was significant anthelmintic activity when compared to standard drug (Piperazine) at a dose of 60 mg/ML.^[74] It inhibits the glucose uptake and lactic acid content and decreases the glycogen content which might be the probable mechanism as found by the scientists. Due to inhibition of energy metabolism or ATP production, it was observed that there was loss of motility as well.^[75]

Hepatoprotective and Nephroprotective activity

Hepatoprotective effects of the ethanolic extract of *M. longifolia* bark on D-galactosamine induced liver hepatitis was studied based which showed significant reduction in the rise in serum glutamic-oxaloacetic transaminase, serum glutamic pyruvic transaminase, alkaline phosphatase, and bilirubin levels induced by D-galactosamine administration.^[76] Might be due to its effect against cellular leakage and loss of functional integrity of the cell membrane in hepatocytes, its hepatoprotective activity is peculiar.^[76,77,78]

Wound healing

In comparison to standard betadine, Sharma et al. in his investigation deduced the notable wound healing property of Madhuca. It may be due to constituents present in Madhuca that are responsible for promotion of wound healing. In this study, it was shown that there was a significant increase in the rate of wound closure and epithelisation rate and a marked reduction in wound healing time with respect to control in excision wound model by ether-benzene-95% crude ethanolic extract of leaves and bark of *M. longifolia*.^[79]

Anti-Fertility activity

Due to presence of bioactive entity, the extract of crude seeds sows possess anti fertility action when administration to male albino rats. May be due to low plasma level of testosterone, it caused decrease in weight of testis, epididymis, seminal vesicle, vasa deferens

and ventral prostrate which. Marked reduction in weight of accessory sex organs indicating the atrophy of glandular tissue and secretory cells hence reflecting the decrease level of testosterone was also observed. Thus proving anti fertility potentials in male albino rats by the seeds of Madhuca.^[80,81]

Toxicity

In order. Sometimes plants are used directly or along with the formulated drugs which make it mandatory to minimize the risk aspect associated with it and assess the toxic behaviour of plants therefore Toxicity is an important parameter that needs to be evaluated. Saponins are extremely toxic on parenteral administration with respect to oral route.^[82] The median lethal dose LD50 dose on oral administration was found to be 1000 mg/kg in mice found in saponin extracted from Madhuca. Morphological and histopathological changes were observed after administering ethanolic leaves extract of *M. longifolia* to male Wistar rats at a dose of 175 mg/kg for 14 days. There were no toxicity effect upto dose of 2000 mg/kg on liver and kidney. It has been reported that there were no toxic effects of methanolic extract of *M. longifolia* bark and were safe upto dose level of 2000 mg/kg.^[82,83] European Food Safety Association however proved that excess dose of mahua oil may lead to antifertility suggesting that it causes testicular atrophy and degenerative changes in rats; whereas till date no mutagenic or genetic toxicity has been reported in literature.^[84]

Non-Medical and Commercial Uses

M. longifolia leaves have also been proven to be a useful adsorbent and has anticorrosive nature. Studies showed that *M. longifolia* leaves along with polyaniline can be used for purification as it adsorbs cadmium and lead from water. It protects the mild steel from corrosion in 1 mol/L HCl solution.^[85,86] For the production of Tassar silk, a wild silk that is used commercially, leaves of *M. longifolia* are fed on moth *Antraxia paphia*.^[87] For preparation of distilled liquor, flowers are used.^[88] Mahua oil yielded by seeds kernel is utilized for cooking and fuel purposes.^[89]

M. Longifolia in Preclinical and Clinical studies

To study the efficacy and safety of Chandrakanthi chooram, an open clinical trial was performed on 40 subjects with oligospermia. Chandrakanthi chooram, a formulation containing 25 ingredients including flowers of *M. longifolia* was provided. The sperm count, its morphology and motility was primary outcome of this study.^[90]

In Santhal tribes, clinical studies and surveys on *M. longifolia* for its anti-venom activity, dyslipidemia have been performed. The study suggests that there was improvement in blood sugar and lipid profile after regular consumption of Madhuca drink by them.^[91] Different parts of *M. longifolia* for many pharmacological activities like hepatoprotective, anti-epileptic, antimicrobial, analgesic, and anti-diabetic have been tested preclinically.^[92]

Kutajarista, used for the treatment of amoebiasis and bacterial dysentery, amoebic dysentery, and blood diarrhea is one of the ayurvedic marketed products consisting of *M. longifolia*.^[92] Preclinical study of administration of kutajarista at the dose of 40 mL/kg was performed in male Sprague Dawley rats. The results of the experiment concluded that it will alter the biochemical profile if administered for chronic period at higher dose.^[93]

CONCLUSION

Madhuca longifolia is highly regarded as a versatile plant which is one of the universal plants having medicinal activities. Review shows that mahua flower is used commercially widely in manufacturing liquor apart from preparation of food and medicine. However due to lack of appropriate knowledge and practices, *Madhuca* being highly nutritious and useful tree is underutilized. The development of modern drug from *Madhuca longifolia* should be emphasized for therapeutic and commercial uses as the scenario wholly is now changing towards the use of nontoxic plant product that has traditional use which may in turn increase the employment and potential of income generation. On the basis of literary review, it is concluded that *Madhuca longifolia* is a highly nutritious tree and reported to contain constituents like saponins, triterpenoids, steroids, saponins, flavonoids and glycosides with various ethnomedical properties such as antibacterial, anticancer, hepatoprotective, antihyperglycemic, analgesic activities. It is also used as spasmogenic, oxytocic, anti-implantation, anti-progestational, antiestrogenic activity against menorrhagia and uterotonic. The flowers of this plant are used as vegetable, to make cake, liquor and its flower juice is used as well in the treatment of various ailments. *Madhuca Indica* has found many of its pharmacological activities, yet several other activities are to be looked for. In this review, phytochemistry and pharmacological aspects of *Madhuca* along with its common, therapeutic and traditional uses have been highlighted. As literature shows limited research in various areas to understand its pharmacological activities therefore further exploratory work is required.

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