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Mahua: A versatile Indian tree species

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Abstract
Mahua (*Madhuca longifolia*) belonging to family sapotaceae is found in different regions of India is known for its multipurpose uses for benefiting the tribal population in the country. It fulfills the basic requirement of food, fodder and fuel of the poor tribal population besides providing huge economic benefits from the different products made from it. Mahua is one of the naturally occurring plants which possess numerous health benefits. However, due to the availability for short time at limited places and highly perishable nature of this flower, it is not yet much explored by researchers and food processors except few for its value addition. Therefore, this review has been designed in such a way to focus on recent advancement in utilization of mahua.

Keywords: Mahua, sapotaceae, phytochemicals and ethnomedical uses

Introduction
Nature has blessed us extensively with the wide range of diversified plants used for various purposes like decoration, flowering, fruiting and medicinal, etc. Adoption and utilization of medicinal uses of many plants for commercial purposes have become emerging trend among most of the people and because of that, underutilized plants which are being utilized traditionally have gathered potential focus by researchers and industry people (Pinakin *et al*., 2018). India is known for wide diversity of such plants, which are utilized traditionally and have significance of being commercialized such as mahua, rhododendron, kachnar, moringa, gulmohar, palash, etc. Mahua is one of those plants which are occupying novel space in the ethnic as well as economical life of the traditional people.
Mahua (*Madhuca longifolia*) belongs to family sapotaceae and finds origin in different regions of India, Sri Lanka, Myanmar and Nepal (Saluja *et al*., 2011) [1]. It is a multipurpose tree which fulfils three fundamental needs of tribal individuals i.e. Food, Fodder and Fuel (Patel *et al*. 2011) [2]. Flowers of plant are edible and have high nutritive value majorly high amount of sugars and subsequently having good amount of vitamins, proteins, minerals and fats. Because of the higher amount of sugar, the flowers are utilized as a sweetener in preparation of numerous traditional dishes like halwa, kheer, meethi puri and barfi in mahua production belt of India (Patel, 2008) [3].
The Mahua tree is approximately 20 meters in height, and possesses evergreen or semi-evergreen foliage (Tengenakai, 2013) [15]. Mahua tree is generally valued for its seeds which have abundant amount of oil bearing capacity and flowers which are mostly used in the production of the alcoholic beverage and sweet candy (Patel *et al*., 2012) [30]. Spent flowers (after fermentation) are also used as animal feed. About 0.12 million tones seeds of Mahua tree are produced in India, after collecting it from different part of the country in organized sectors and utilized for oil extraction (Singh and Singh, 1990) [4]. The estimated production of Mahua flowers is more than one million tons in the country. The collection of Mahua flower and seed are encouraged by the state government of India, as they provide the basic support price for it, on the other way it is source of income for the poor people as they collect it and then sell it to the government agency or local buyer (Patel and Naik, 2010) [5]. With development of photochemical industries in India, domestic requirements for various medicinal plants grow considerably (Kokate, 2008) [6].
India is considered as a treasure of various medicinal and aromatic plant species which are being utilized since ancient time. According to WHO (2003) [6] approximately 65% of the world's population integrate the medicinal plant for treatment. Mahua is one of the naturally occurring plants which possess numerous health benefits. Tribal people use mahua flowers for curing of skin diseases, headache, pitta and bronchitis (Sinha *et al*., 2017) [7]. Flower juice is supplemented to lactating women for augmentation of breast milk (Sunita and Sarojini, 2013) [8]. Due to the availability for short time at limited places and highly perishable nature of this flower, it is not yet much explored by researchers and food processors except few for its value

addition. Therefore, this review has been designed in such a way to focus on recent advancement in utilization of *mahua* flowers as food and medicine and its future prospective regarding its value addition.

Area and Production

Mahua is a frost resistant species that can grow in marginal areas of dry tropical and subtropical forests up to an altitude of 1200-1800 m, in India. It requires mean annual temperature of 2-46^{0}C, mean annual rainfall ranging from 550-1500 mm and mean annual humidity from 40-90 percent (Thorat and Patil, 2016) [9]. Mahua trees are distributed from India to other Asian countries like The Philippines, Pakistan, Sri Lanka to Australia. It can be found scattered in pasture lands in central India, and on river banks in semi-evergreen forests (Behera *et al*., 2016) [10]. The tree grows on a wide variety of soils but thrives best on sandy soil. It also grows on shallow, boulder, clayey and calcareous soils (Akshatha *et al*., 2013) [14]. In India, large quantities of mahua trees are found in the states of Uttar Pradesh, Madhya Pradesh, Orissa, Jharkhand, Chhattisgarh, Andhra Pradesh, Maharashtra, Bihar, West Bengal, Karnataka, Gujarat, Rajasthan and the evaluated annual production of mahua flowers is 45000 Million tonnes during (Behl and Sriwasrawa, 2002; Siddiqui *et al*., 2010) [13, 12] The yield of mahua flowers varies from 80-320 kg for every tree. Madhya Pradesh is the most astounding mahua developing state with average trade volume of 5,730 metric tonnes and worth about Indian rupees 8.4 million (Thakor and Babu, 2008) [11].

Taxonomy and Botanical Description

Botanical profile of mahua (Banerji and Mitra, 1996) [16].
Botanical Name: *Madhuca spp.*
Family: Sapotaceae
Subfamily: Caesalpinioideae
Tribes: Caesalpinieae
Genus: *Madhuca*
Species: *longifolia*
Order: Ericaleae

Description

A medium sized to large deciduous tree, usually with a short, hole and large rounded and shady crown found throughout the green forest part of India up to an altitude of 1,200 meter and having 12 to 15 meter height. Bark is rough, thick and dark colored having cracks and fissured. Whereas, the inner bark is dark red and exudes white milky sap when cut. Trunk is short with numerous branches (Behl and Sriwasrawa, 2002) [13]. Leaves are elliptical, leathery with hairy under surface and 10-30 cm long with pointed tips having strong nerves. Further, leaves are clustescent glabrred near end of branches, epileptic or elliptic oblong 7.5 to 23 cm into 3.8 to 11.5 cm with entire but wavy margins (Verma *et al.*, 2010) [19]. Flowers are small, scented and fleshy, dull or pale white in color and in define fascicles near end of branches. Corolla tubular, freshly pale, yellow aromatic and caduceus (Vaidyarathanam, 1996). Fruits are ovoid 2-6 cm long, fleshy and greenish. While, the seeds are elongate, 2 cm long, brown and shining (Erik and Michael, 2004) [18].

Phytochemical properties of Mahua

Many medicinal plants constitute a rich source of bioactive chemicals or phytochemicals that are largely free from adverse effects and are responsible for definite physiological action of the human body and could lead to the formation of new classes of possibly safer and useful drugs Akinmoladun *et al*., (2007) [39]. Phytochemicals are basically divided into two groups, i.e., primary and secondary constituents; according to their functions in plant metabolism. Primary constituents comprise common sugars, amino acid, proteins and chlorophyll while secondary constituents consists of alkaloids, terpenoids, saponins, phenolic compounds, flavonoids, tannins and so on Cohen (1992) [40]. The phytochemical screening of plants reveales the presence of β-carotene and xanthophylls; erthrodiol, palmitic acid, myricetin and its 3- O-arabinoside and 3-O-L-rhamnoside, quercetin and its 3-galactoside; 3β-caproxy and 3β-palmitoxy- olean-12-en-28-ol, oleanolic acid, β-sitosterol and its 3-O-β-Dglucoside, stigmasterol, β-sitosterol- β-Dglucoside, nhexacosanol, 3β-caproxyolcan- 12-en-28-ol, β- carotene, n-octacosanol, sitosterol and Quercetin in leaves Khatibi *et al.*, (1978) [41] and Sarma *et al.* (2013) [42]. While the trunk bark contained lupeolacetate, α-amyrin acetate, α-spinasterol, erythrodiol monocaprylate, betulinic acid and oleanolic acid caprylates (Khare, 2007) [43]. Some of the important phytochemicals extracted from different parts of mahua are presented in Table 1.

Table 1: Phytochemistry of Mahua

Plant parts	Phytochemicals
Flower	Vitamin A and C
Bark	Ethylcinnamate, sesquiterene alcohol, α-terpeneol, 3β-monocaprylic ester of eythrodiol and 3β-capryloxy oleanolic acid. α- and β-amyrin acetates
Fruits	α- and β- amyrin acetates
Nut-shell	*n*-hexacosanol quercetin and dihyroquercetin, β-sitosterol and its 3β-Dglucoside.
Seeds	Arachidic, linolelic, oleic, myrisic, palmitic and stearic acids, α-alanine, aspartic acid, cystine, glycine, isoleucine and leucine, lysine, methionine, proline, serine, threonine, myricetin, quercetin, Mi-saponin A & B.
Leaves	β-carotene and xanthophylls; erthrodiol, palmitic acid, myricetin and its 3- O-arabinoside and 3-O-L-rhamnoside, quercetin and its 3-galactoside; 3β-caproxy and 3β-palmitoxy- olean-12-en-28-ol, oleanolic acid, β-sitosterol and its 3-O-β-Dglucoside, stigmasterol, β-sitosterol- β-Dglucoside, n-hexacosanol, 3β-caproxyolcan- 12-en-28-ol, β-carotene, n-octacosanol, sitosterol, quercetin.

Composition of Flower

Flowers of this versatile tree species are a good source of sugars which make it an important constituent of indigenous and modern alcoholic beverages (Yeo-Chang, 2009) [20]. Further, the mahua flowers contains a good amount of Vitamin-C which is responsible for its antioxidant activity (Indu and Annika, 2014) [21]. Flowers also contain a good amount of minerals such as calcium and phosphorus with a good amount of carotene which acts as a precursor of Vitamin-A. Table 2 shows a brief composition of mahua flowers. Several studies have also been done to study the medicinal properties of mahua flowers such as antihelmenthic, antibacterial, analgesic, hepatoprotective, antioxidant and anticancer (Table 3).

It is observed that the flowers are used as tonic, analgesic and diuretic. Flowers have also been traditionally used as cooling

agent, tonic, aphrodisiac, and astringent, demulcent and for the treatment of various diseases such as helminths, acute and chronic tonsillitis, pharyngitis as well as bronchitis. Further, fomentation with dried flowers produces relief in orchid, decoction used as expectorant; beneficial in impotence due to general debility when administered with milk. (Yadav *et al.*, 2012) [22].

Table 2: Composition of Mahua Flower

Sr. No.	Constituents	Fresh Flowers	Dry Flowers
1	Moisture	73.6-79.82 (%, d.b.)	11.61-19.8 (%, w.b)
2	pH	4.6	-
3	Strach (g/100g)	0.94	-
4	Ash (%)	1.5	1.4-4.36
5	Total Sugars (g/100g)	47.35-54.06	41.62
6	Total Inverts (%)	54.24	-
7	Cane Sugars (%)	3.43	-
8	Reducing sugars (g/100g)	36.3-50.62	28.12
9	Proteins (%)	6.05-6.37	5.62
10	Fats (%)	1.6	0.09-0.06
11	Fibers (%)	10.8	-
12	Calcium (mg/100g)	45	0.14-8
13	Phosphorus (mg/100g)	22	0.14-2
14	Carotene (µg/100g)	307	-
15	Vitamin-C (mg/100g)	40	7

[**Source:** Gopalan *et al.*, (2007) [23]; Swain *et al.*, (2007) [24]; Hiwale, (2015) [25]; Patel *et al.*, (2011) [2]; Pinakin *et al.*, 2018]

Table 3: Medicinal properties of Mahua flower

Medicinal properties	Types of extract	Remarks	References
Hepatoprotective activity	Methanolic	Methanolic extract of flower showed potential protective effect by lowering the levels of Serum glutamic oxaloacetic transaminase, Serum glutamic pyruvic transaminase, Alkaline phosphatase and total bilirubin by increasing serum level of total proteins and albumins	Umadevi *et al.*, (2011) [29], Patel *et al.*, (2012) [30], Yadav *et al.*,(2012) [22], Mishra and Pradhan (2013) [32], Sinha *et al.*,(2017) [7]
Antihelmenthic activity	Both methanolic and ethanolic	Among both extracts methanolic extract of flower demonstrated best anti helmenthic activity against Indian earth worm	Katiyar *et al.*, (2011) [34], Yadav *et al.*, (2012) [22], Sinha *et al.*, (2017) [7]
Antibacterial activity	Both aqueous and methanolic	Aqueous extract showed more antibacterial activity than methanolic one for *Bacillus subtilis* and *Klebsiella pneumonia*	Verma *et al.*, (2010) [19], Patel *et al.*, (2012) [30], Yadav *et al.*, (2012) [22], Sinha *et al.*, (2017) [7]
Analgesic activity	Both aqueous and alcoholic	Analgesic effect was studied through tail flick, hot plate and chemical graded doses on mouse which shows analgesic effect as per dose value	Chandra *et al.*, (2001) [36], Saluja *et al.*, (2011) [1], Patel *et al.*, (2012) [30], Yadav *et al.*,(2012) [22], Amia and Ekka (2014) [37], Sinha *et al.*, (2017) [7]
Antioxidant activity	…….	As concentration of flower extract and ascorbic acid increases, the ferric reducing antioxidant power increases.	Indu and Annika (2014) [21]
Anticancer activity	…….	Cell viability was found to decrease as the concentration of the floral extract increases and cytotoxic effect was found to increase	Indu and Annika (2014) [21]

Useful parts of plant

Every part of this versatile tree species posses some medicinal properties, either in small of large proportion. Different parts of tree often contain a quit different active ingredients, so that one part may be toxic and another one quite harmless (Erik and Michael, 2004) [18]. The most useful parts of mahua consist of flowers, seeds, leaves etc (Table 4).

Table 4: Parts vise use of *Madhuca indica*

Parts of Plant	Medicinal Properties
Leaf	Enzyme, Wound Healing, Anti Burns, Bone Fracture Emollient, Skin Disease, Rheumatism, Headache
Oil	Laxative, Piles, Hemorrhoids, Emetics, Anti Earth worm
Fruit	Sweet, Refrigearnt, Aphrodisic, Tonic, Dipsica, Bronchitis, Astringent, Anti Ulcer, Acute and Chronic Tonsillitis, Pharyngitis
Bark	Gums, Tonsillitis, Diabetic, Stomach Ache, Anti Snake Poisoning, Astringent, Emolliant, Fracture, Itching
Flower	Refrigerant, Liquor, Jelly, Sweet Syrup, Expectorant, Increase the production of milk in women, Stimulant, Diuretics, Anthelmentic, Strangury, Verminosis, Hepatoprotective, Gastropathy

[***Source*:** Wealth of India, 2007 [27]; Seshagiri and Gaikwad, 2007 [28]]

Use of Mahua as food

Irrespective of being a versatile species having a rich source of nutrition and easy availability in close vicinity of rural areas, the flowers are not very much popular as food among local population. It is observed that only a small quantity of flowers is consumed raw, cooked or fried in different parts of country (Bhaumika *et al.*, 2014) [44].

Use of Mahua for processing of different food products

Sugar syrup: Abhyankar and Narayan (1942) [45] reported that the sugar syrup prepared from dry mahua flowers contains very high content of sugar (sucrose, glucose, fructose, arabinose, few amount of maltose and rhamnose), which can be further used as a sweetening agent in different preparations such as halwa, meethi puri, kheer etc. The water extract from dried flower is decolorized with help of different decolorizing agents such as slaked lime and activated charcoal before concentrating it to the desired concentration (Shriwastaea *et al.*, 1970 and Benerji *et al.*, 2010) [48, 49].

Jam, jelly, malmaade: mature but still unripe fruits are used for jam making with help of citric acid. Whereas, the pulp is converted to marmalade or syrup which is used as a food additive. Further, the pulp is also used in the manufacturing of jelly however; sometimes guava is also added to modify the astringent flavor (Reuther *et al.*, 1967) [46]. Similarly, Patel (2008) [3] prepared the mahua jam and jelly using the fresh flowers and the developed products were tested for their colour, flaour, taste, texture and overall acceptability using hedonic test which revealed that the products were highly acceptable. Bhaumik *et al.* (2014) [44] further reported that the majority of mahua flowers are used in preparation on distilled liquors.

Fermented products: Kumari *et al.* (2016) [50] reported that fermented products flowers are used as crude material for the production of alcohol and alcoholic beverages. Local population of North-West India used to collect and dry mahua flowers for the preparation of "mahua daaru" which contains approximately 20-40 per cent alcohol. Mahua flowers are mixed with water and kept aside for fermentation. During the fermentation *Navshar* (Ammonium choride) and jaggery are added. Sometime black pepper is also added to develop a strong hot flavor. After fermentation, the mixture is kept in a traditional container with distillation setup. Kumari *et al.* (2016) [50] estimated that one kilogram of dried flowers yield about 300-400 ml of mahua daaru.

Similarly, Behera *et al.* (2016) [10] reported that the tribal people of Orissa use mahua flowers to make country liquor known as "mahuli" using the same procedure. The only different found in distillation process and ingredients is that; that at the time of fermentation bakhar tablets {*Asparagus racemosus* (roots), *Cissampleos pareira* (roots), *Clerodendrum serrautum* (roots), *Dipteracanthus suffruticosus* (roots), *Elephantopus scaber* (roots), *Lygodium flexusoum* (roots), *Ochna obtisata* (roots), *Phoenix acaulis* (roots), *Holarrhena pubescens* (bark), *Homalium nepalense* (bark), *Woodfordia fruticose* (flower), *Xantolis tomentosa* (fruit), *Madhuca indica* (seeds)} is added. Chandar (2001) estimated that approximately 30-40 per cent mahuli is obtained from one kilogram mahua flower.

Miscellaneous uses of Mahua

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

Conclusion

Besides having multipurpose use mahua satisfies the basic need of the tribal population in the form of 3F i.e. fed, fodder and fuel due to its vital components and abundant ability around the tribal dominant areas. However, due to its limited availability for short span the versatile species is still untouched by the processors, researchers and consumers. It is worthwhile to cultivate mahua on large scale especially on unproductive and wasteland as it has a large potential for the production well established drugs. Generally *Madhuca indica* is known only for liquor making however; people should be made aware of its versatile uses. Yet due to lack of appropriate knowledge and processing practices this highly nutritious and useful tree is considered as underutilized. So there is a strong need of documentation and conservation of this versatile species for a source of food, medicine and sources of income for poor and tribal population at the time of scarcity.

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