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Medicinal and commercial potential of *madhuca indica*: A review

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Abstract
Madhuca indica and *Madhuca longifolia* are the two species of Genus Madhuca, belongs from Sapotacase family, which are found in the central and north Indian forests and plains of India. Both the species, which are present in India, are known as '*Mahua*' and it is widely pronounced local name also. '*Sweet butter tree*' is also well known name of these trees. These are considered as wild, cultivated tree and medicinal herb. M. longifolia is an ever green or semi ever green tree while B. latifolia is a deciduous tree, growing under dry tropical and sub-tropical climatic conditions. Generally these trees are 15-20 meter tall with a spreading, dense, round, shady canopy. After maturation (8 to 10 year old) these trees start bearing flowers and fruits, and give up to 60 years. Both the species can't be differentiated on the basis of their purpose, medicinal uses and commercial values. The whole tree is useful as food, fodder and fuel so that, it is categorized in multipurpose forest trees. The seed contains oil and protein in a great amount and the oil content in latifolia is 46% and in longifolia is 52% and protein is 16 mg/g.

Keywords: bassia latifolia, brassica longifolia, biodiesel, medicinal uses, flower, seed, bark

Introduction
The botanical introduction of Madhuca indica is as follows:
Kingdom: Plantae
Order: Ericales
Family: Sapotacase
Genus: Madhuca
Species: indica
Madhuca longifolia is the other one specie which found in india.
Mahua or Madhuca pronounced by various names according to the Nations and state wise, some of the names are as follows:
Botanical names: Bassia longifolia, Bassia latifolia, Madhuca indica, Madhuca latifolia, Illipe malabrorum, Illipe latifolia [4].
Indian Names: mahua, moha, mahwa, mohua, madhuca, kuligam, nattiluppai, tittinam, mowa, mavagam, moa, madurgam, mowrah, illuppai etc.
Sri Lankan Name: mee,mi,illuppai [4, 7].
These threes are pronounced in English as honey tree and butter tree; in French as illipe, arbre à beurre, bassie; in Sanskrit: madhuca;in Bengali as mohua and in Oriya as Mahula.
In indian states these trees are known as: in Oriya: mahwa, mahula, Mahula; in Bengal:Maul; in Maharashtra:mahwa and mohwro; in gujrat: mahuda; in Andhra Pradesh:ippa,puvvu; in Karnataka: ippe or hippe; in tamilnadu: illupei, elupa; in kerala: poonam and ilupa and in Orissa: mahula, moha and modgi.
The various parts of Madhuca indica such as flowers, leaves, bark, seeds, and seed oil has great medicinal value, are as follows:

1. Flower
The Flowers are white colored, sweet scented; 2 cm long, pointed and found in bunches at the end of the branches. Flowers are sweet in test so that it is used as sweetener to prepare the local disease in the tribal and rural areas and also used as exchanger. In the rural and tribal areas flowers are used as a substitution of food because they depends 25-50 percent on forests foods. Orissa, Bihar, Himachal Pradesh, Maharashtra and Madhya Pradesh are the states, their rural and tribal people depends on forest food when agricultural production is impracticable. They used Mushroom and Madhuca indica flowers as a substitute of grain. Outside the India; Nepal, Bhutan, Thailand, Maxico, Kenya, Zimbabwe etc. are the nations which used Madhuca species's flower as food. The nutritional contents of Madhuca flower are 54.24% total inverts, 50.62% Reducing sugar, 3.43% Cane sugar, 54.06% total sugar, 19.8% Moisture, 6.37% Protein, 0.5% Fat, 4.36% ash, 8% calcium and 2% phosphorous [5].
Medicinal uses: The extract of flowers is used as tonic, analgesic and diuretic and Heptoprotective activity. Flowers are also used for the treatment of helminths, acute and chronic tonsillitis, pharyngitis and bronchitis diseases. The traditional uses of flower are as tonic, cooling agent, aphrodisiac, astringent, demulcent [5].
Externally, the flowers extract is rubbed for oleation. It is also used as a nasya (nasal drops) in head deseases caused by pitta, like sinusitis and pitta disease. The flowers play an important role for increasing the lactation in new nurshing mothers and in boosting the quantity of seminal fluids also [5].

2. Seed and seed oil
Orange brown fleshy berry Fruits are ovoid (2-4cm) contains 1-4 seed. Seeds are elongate, brown shining colored (1-2cm). The seed is known as 'Tora' and seed oil as 'Mahua butter' which is semi solid pale yellow fat. After Drying and decertification each seed yields two kernels with size of 2.5 cm x 1.75 cm (70% by wt.)(1).The seed contains oil and protein in a great amount. The seed is used as vegetable and

seed oil for cooking. It is also used in the manufacture of vanaspati ghee, soaps, and laundry chips and used as illuminant and hair oil [5].

The properties of seed oil is as: Refractive index (1.452-1.462), Iodine value (55-70), Saponification value (187-197), Unsaponifiable matter (%) (1-3), Stearic Acid C 18:0 (%) (22.7), Oleic Acid C C18:0 (%) (37.0), Palmitic C 16:0 (%) (24.5), Linolic Acid C18:2 (%) (14.3) [5].

Medicinal uses: The seeds extract is anti-inflammatory, anti ulser, hypoglyuacemic and effective to alleviate pain. The seed oil has emuluscent property, used in skin disease, rheumatism, headache, laxative, piles and sometimes as galactogogue [5].

3. leaves

Leaves are elliptical(15-25 x 8-15cm) has pointed end, base angled, thick, hairy, nerves strong (12 pairs), tertiary nerves oblique, and margin entire or wavy [5].

Medicinal uses: Leaves extract is used for Wound healing activity, Nephro and hepato protective activity, Antioxidant activity, Antimicrobial activity, Astringent, Stimulant, Emollient, Demulcent, Rheumatism, Piles, Nutritive, Verminosis, gastropathy, Dipsia, bronchitis, consumption, dermatopathy, rheumatism, cephalgia, hemorrhoids, Antihyperglycemic activity,cytotoxic activity, chronic bronchitis and Cushings disease [5].

4. Stem and Bark

Stem is cylindrical, decumbent and branched, 10-15 meter long, which is covered with brown colored rough bark. Bark is slightly cracked and fissured, internally it is red in color and exudes white, which give white milky latex or gum on making a cut. Tree has 2-4 cm longed reddish stalk [5].

Medicinal uses: The stem extract is used for Antidiabetic activity, Antihyperglycemic, Wound healing activity, Antibacterial activity, Antimicrobial activity, Antioxidant activity, Astringent, Stimulant, Emollient, Demulcent, Rheumatism, Piles, Nutritive, bleeding and spongy gums, chronic ulcer, Itch, swelling, fractures, snake-bite poisoning, chronic bronchitis, diabetes mellitus, chronic tonsillitis and pharyngitis [5]. The bark powder with ghee and honey is used to improve the vitality and sexual vigor.

Ethanolic extract: (an anti-Cancer Drug)

The ethanolic extract of all parts of Madhuca indica plant shows in vitro cytotoxicity against different human cancer cell lines such as lung, neuroblastima, and colon. The activity was reported in respect of Tumor volume, Tumor weight, Mean Survival Time, Tumor cell count, Body weight, Haematological studies. There was no more activity reported in liver cancer cells, where as in case of colon cancer cells showed maximum activity [4, 9].

Preparation of Plant Extracts

The ethanolic plant extract is prepared by mixing the finely powdered dry parts of plant (at room temp.) with 95% ethanol under reduced pressure. This was filtered and stored. To prepare stock solution, stored extract was redissolved in Dimethylsulphoxide (DMSO), which were filter before testing on cell lines [4, 9].

Culture of human Cell Lines: The human cancer cell lines (such as lung, liver, colon and neuroblastima) were grown in RPMI-1640 with 2 mM L-glutamine medium at pH 7.2 followed by the dissolving the Penicillin. This was filtered and stored at 2-5ºC temperature. For cryopreservation 20 % FCS dissolved in 10 % DMSO in growth medium and complete growth medium contains 10% FCS. The cultured human cell lines were preserved in a 5% CO_2 atmosphere with 95% humidity at 37ºC temp [4 9].

In vitro Cytotoxic Activity: The cytotoxic potential is the unit to determine the anticancer activity. This is calculated using human cancer cell lines to allow growing on tissue culture plates with ethanolic extract. The cell growth was count by ELISA reader after staining with Sulforhodamine B dye (SRB) [9].

Cell treatment: When enough number of human cancer cell lines was grown by the method which is mentioned above. The dead cells and the cells at subconfluent stage were selected, which were harvested using Trypsin- ethylene diamine tetra acetic acid (EDTA) to make single cell suspension using pipetting method. A hemocytometer (using trypan blue) was used to count the viable cell [9].

The viability of Viable cell should be >97% and the density have to be 5,000 - 40,000 cells/100µl. 1:1 of cell suspension together with complete growth medium was mixed into each section and the plates were incubated at 5% CO_2 atmosphere with 95% humidity at 37ºC temp for 24 hours. After 24 hours, the ethanolic extract, DMSO (vehicle control) and positive control were added. The micro plate reader was used to measure the absorbance [9].

The % cell inhibition was calculated by using the following formula [8].

% Cell Inhibition = [100- Absorbance (sample)/Absorbance (control)] x100.

This was found that the ethanolic extract inhibit the human cancer cells from 58.04-64.61% (depending on the concentration of ethanolic extract used) [8].

In vitro antimicrobial activity

The extract of Madhuca indica was showed best inhibition against the growth of Gram (+) positive bacteria at 2mg/ml-10mg/ml test concentrations whereas Gram (-) negative bacteria didn't show any activity at 2.5mg/ml test concentration. The MI extract also showed good inhibiting activity against microorganisms (except for P. aeruginosa). The MI Extract also showed maximum inhibition against S. aureus (20.6 mm) and B. sublitis (18.3mm). In Gram negative bacteria, ethanolic extract of Madhuca indica showed maximum inhibition against E. coli (16.6mm) and P. aeruginosa (15.6mm) [10].

Seed oil: as Bio-diesel

Seed kernels contain 20-50% oil, which is extracted by Ghani or Expeller. The yield of Oil from kernels is depending on Ghani or Expeller. The quality of extracted oil is depending on the storage condition of kernels and their protection from fungus and insects. Fresh kernels has 1-2% fatty acid while poorly stored has 30%. Fresh extracted oil is yellow in color while commercial oil is greenish yellow due to addictive ingridiant to provide odor and taste [7].

Bio-diesel (Mahua Oil Methyl Ester) prepared from seed oil by transesterification process followed by esterification.

The Transesterification is a reducing process which involves the reduction of triglyceride and alcohol to glycerol and ester

in the presence of catalyst such as KOH, NaOH, HCl, H_2SO_4, Lipase, etc. The ester molecule has one third molecular weight in compare of seed oil molecule therefore it has low viscosity. Commercially alkali catalyzed tranestrification process is used because it is faster than acid catalyzed transesterification [3, 6, 7].

Process to convert seed oil to Bio-diesel: This process involves two steps

Esterification: In a three-necked round- bottomed flask seed Oil (free from water), H_2SO_4 and Methanol (in measured amount) were taken and Heat the resulting mixture for 1.5-2 hours to maintain a steady temperature with continuously stirring. During the reaction samples were collected at regular intervals and acid value was determined. At the point of acid value 0.1-0.5 heating was stopped and the products were cooled. Resulting product was further treated for transesterification step to obtain Mahua oil methyl esters (Bio-diesel) [6].

Transesterification: The resulting product obtained from esterification, solution of Sodium Methoxide ($NaOCH_3$) catalyst (in methanol) and Methanol (in proper amount) were taken in a three necked round bottom flask. After proper closing (airtight) of the flask it was heated to maintain the temperature around 70°C for 1-2 hours on mantle heater. If necessary, excess alcohol was used for total conversion of the oil to its esters. During the reaction completion the oil to Mahua oil methyl ester (Bio-diesel) is checked by using thin layer chromatography (TLC) technique (in various time intervals). After the confirmation of methyl ester formation, the heating was stopped and the products were cooled and Mahua oil methyl ester (Bio-diesel) was separated by using separating funnel. It was washed and dried under vacuum to remove moisture [6].

This is the Comparison of Fuel properties of Mahua oil methyl ester (Bio-diesel) and diesel: [7].

Table 1

Properties	Bio-diesel (Mahua oil methyl ester)	Diesel
Density (15^0C), kg/m^3	872	835
KinematicViscosity,40^0C, mm^2/s	4.0	2.4
Flash point,^{0}C	204	70
Fire point,^{0}C	230	76
Cloud point,^{0}C	6	-10 to -15
Pour point,^{0}C	1	-35 to -15
Acid value, mg of KOH/g oil	0.5	NA
Calorific value (MJ/Kg)	41	43
Saponification value	130	NA
Color	Slight greenish yellow	Light brown
Cetane number	50	47
Aniline point, ^{0}C	63	69
Iodine value	60	NA
Diesel index	145	150

The summary of some diseases which can be cured by using the madhura indica plant [5].

Bronchitis: The flowers of Mahua are used with milk for treating chronic bronchitis and cough.

Orchitis (Testis inflammation): Boiled extract of Madhuca leaves are used in relieving pain from orchitis.

Rheumatism: Boiled bark extract in water is used to get relief from rheumatism (by taking internally). The oil obtained from seeds can also be applied on the affected areas (By externally).

Diabetes: A mixture of bark power decoction is used to cure of diabetes.

Piles: Seed Oil has laxative properties, which is used to cure chronic constipation and piles.

Lactation: Madhuca flowers and Seed are used to increase the milk production in new nursing mothers.

Eczema: Madhuca leaves boiled with sesame oil and used for treatment of eczema (Externally).

Bleeding Gums: 8 ml of bark extract in 600 ml of water is used as a gargling agent for treatment of spongy and bleeding gums.

Burns or skin problems: The leaves ash mixed with ghee is used for cure of scalds and burns. For itching problems bark paste is applied locally.

Tonsillitis: The above gargling solution is also used for curing of chronic and acute tonsillitis and pharyngitis.

Conclusion

The Madhuca tree is a good friend of Tribal and Rural peoples because it gives them food, fodder and shelter. The all parts of Madhuca has medicinal importance so that they are used to cure various diseases such as Bronchitis, Tonsillitis, Bleeding Gums, Eczema, Rheumatism, Diabetes etc. We know that the energy sources are limited in this world and seed oil have appropriate properties like diesel that's by it can be used as energy producing oil (Bio-diesel) (renewable energy source). The seed oil is used as bio-diesel, anti-cancer drug and anti-microbial activity. The Madhuca tree is Beneficial for animals also. Leaves and cake formed after oil extraction is used as animal food as well as fertilizer. Ethanolic extract also used for wound healing activity in animals. Scientists have proved that Madhuca gives natural immune protection. Now a day's scientist regularly investigating the properties, medicinal uses (especially as anti-cancer drug), and on Bio-diesel production of Madhuca tree.

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