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## Mahua seed- a Multipurpose Tree-borne oilseeds (TBOs) of India

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### ABSTRACT

*Madhuca longifolia* belonging to the family Sapotaceae, is also known as Mahua and Indian Butter nut tree. Mahua seed, is an important tree-based oilseed valued for its high content (33-61%) of pale yellow semi - solid fat. Mahua seed oil is edible and contains 65.9% total unsaturated fatty acid. It is used by tribal as vegetable butter in addition it is used in skin care products, soaps, detergents, etc. Mahua butter can be used as a substitute to cocoa butter. India has the vast potential of more than 0.6 million tons of tree borne oil (TBO). But near about only 80,000 tons of oil is being extracted. It is, therefore, necessary to exploit domestic resources to maximize production and ensure the oil security for the country. Seeds are the rich source of minerals and can be used as nutraceuticals . Biodiesel obtained from the mahua oil has potential for alternative fuel options for diesel oil in India.

**Keywords:** Biodiesel, Mahua butter, Nutraceutical, Seeds, Tree borne oil

### INTRODUCTION

India is one of the major oilseeds grower and importer of edible oils. India's vegetable oil economy is world's fourth largest after USA, China & Brazil. The oilseed accounts for 13% of the Gross Cropped Area, 3% of the Gross National Product and 10% value of all agricultural commodities. This sector has recorded annual growth rate of area, production and yield @ 2.44%, 5.47% and 2.96% respectively during last decade (1999-

2009) Tree Borne Oilseeds (TBOs), like sal, mahua, simarouba, kokum, olive, karanja, jatropha, neem, jojoba, cheura, wild apricot, walnut, tung etc. are cultivated/grown in the country under different agro-climatic conditions in a scattered form in forest and non-forest areas as well as in waste land /deserts/hilly areas. These TBOs are also good source of vegetable oil and therefore need to be supported for cultivation (Kureel, *et al.*, 2009).

Mahua (*Madhuca longifolia*) a tree of Indian origin, has been known from prehistoric times and belonging to family *Sapotaceae* is also known as the Indian butter tree (Singh *et al.*, 2000). The name *Madhuca* emanate from Sanskrit language (*Madhu* means Honey) due to its flower which is sweet in taste. It is an important seasonal flowering tree having vital socio-economic value to the tribals all over India because of its religious importance and contribution to their economy and life style (Hegde and Daniel (1993). The tree is widely grown throughout the tropical and subtropical region of Indian subcontinent and found up to the elevation of 1200 m (Hiwale, 2016). Being a prominent tree in tropical mixed deciduous forests in India, it is adapted to arid environments and majorly grown in Chota-Nagpur plateau area covering the states of Jharkhand, Chhattisgarh, Odisha and further west towards Madhya Pradesh, Maharashtra, and Gujarat (Panda *et al.*, 2010). Mahua is a medium size, shady deciduous tree, having height up to 16-20 m, usually with a spreading, dense, shady canopy and possess semi-evergreen foliage. The tree matures at an age of 8-15 years and fruits up to 60 years. The leaves are thick, leathery, woolly at lower face and oblong shaped with pointed at tip and exude a milky sap when cut. Young leaves are pinkish to reddish brown. This most attractive tree with its rounded crown is found everywhere along farm bunds and habitation as well as in the natural forest in India's tribal heartland. Very rarely mahua is planted manually and mostly flourished through natural regeneration. Due to the economic importance of the mahua tree, British forest administrators historically spared it from felling, a policy still observed today. As a consequence, mahua trees are some of the largest, oldest, and most common in the fields and forests (Anon, 1976).

## TAXONOMY

Botanical Name: *Madhuca longifolia*

Kindom : *Plantae*-Plants

Superdivision: *Spermatophyta* - Seed plants

Division : *Magnoliophyta* - Flowering plants

Class : *Magnoliopsida* – Dicotyledons

Order : *Ericaleae*

Family : *Sapotaceae*

Genus : *Madhuca*

Species : *longifolia*

(Source: <https://plants.usda.gov/home/plantProfile?symbol=MAL05>)

Though mahua is accepted as a local name of *Madhuca longifolia*, the regional names in some of the potential states of India are:

Language	Regional name
English	Indian butter tree
Gujarati	Mahuda
Hindi	Mahua
Marathi	Mohwra
Malayalam	Illupa
Odia	Mahula
Sanskrit	<i>Madhuka</i>



Figure. 1 A Ten year old Mahua tree at NAU, Navsari Campus

### Commercially useful components of mahua tree

Mahua is one of those multipurpose tree species that is mainly cultivated or harvested for three major Fs *i.e.* food, fodder and fuel (Patel *et al.*, 2011). The tree yields a number of products of daily utilities. It is valued in India because of widespread use of its flowers, fruits, and seed (Ramadan *et. al.*, 2006) as depicted in Figure 2.

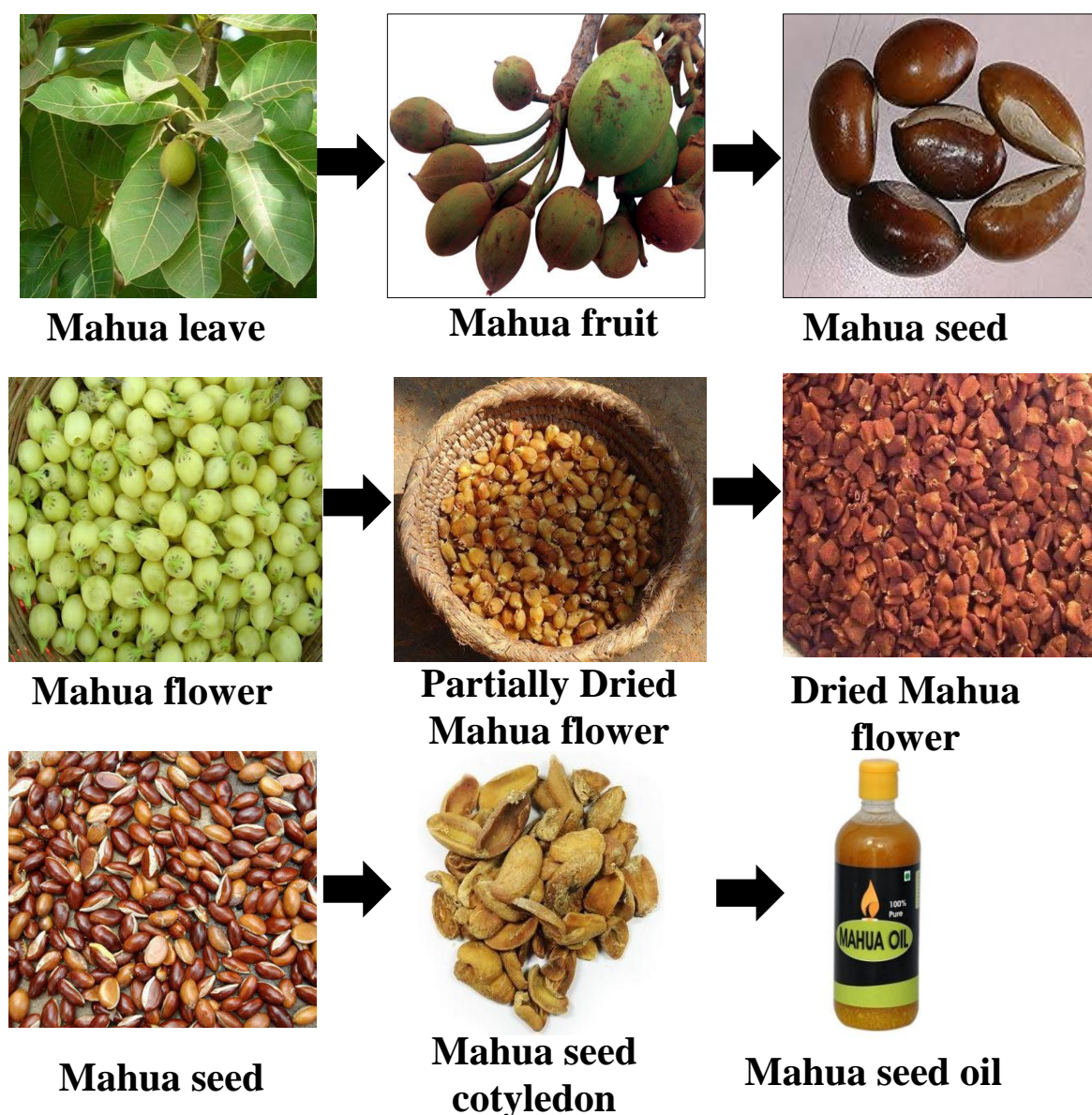


Figure 2. Useful components from a mahua tree

Mahua flowering season extend from mid- February to April and usually blooming depend upon environmental conditions. Mahua flowers are small, fleshy, pale yellow in colour and borne in cluster and don't remain for too long, blooming at night and falls off before dawn. The yellow flower spreads around the Mahua tree like a carpet. Mahua flowers are good source of carbohydrate particularly rich in sugar (40-60% on dry weight basis). Mahua flowers can serve as an important raw material for varieties of alcoholic and non-alcoholic beverage production (Anon. 1976). The sweet, fleshy flowers, available in early summer, are eaten fresh or dried, ground and stored as flour and used as sweetener for the preparation of different kinds of Indian sweet dishes and sometimes fermented to make alcohol (Hegde and Daniel, 1993; Fern, 2014). Very often, this is the only food available in summer. Mahua fruits are green at maturity and turn reddish-yellow when ripe. Fruits are 2.5-5.0 cm long, ovoid, fleshy and having 1-4 elongated seeds (2.0-3.5 cm) of brown colour with shiny appearance. The green-fleshy



outer coat of the fruit is edible and called as “Tola/Tora” is eaten as vegetable in the state of many states such as Odisha, Chhatisgarh and Uttar Pradesh. The seed contains two kernels and is highly sensitive to desiccation and freezing, indicating recalcitrant nature of the seed. Fruits open after 45-60 days of flowering period and seeds get matured by the month of June and available up to mid of July. The mature fruits fall on the ground on ripening. Tribal people generally collect the fruits once it falls off the tree soon after ripening and separate the seed by pressing the fruit wall manually (Patel *et al.*, 2011; Gupta *et al.*, 2012). However, they are commercially harvested during June and July in rainy season. Harvested matured fruits from tree can also be kept for ripening and seeds extracted by depulping the fruit. (Hegde *et al.*, 2018).

Mahua seed, is an important tree-borne oilseed valued for its high content (33-61%) of pale yellow semi-solid fat (Singh, 1998; Ghadge and Raheman, 2005). Mahua seeds are largest source of natural hard fat commercially known as mahua butter or mowrah butter, therefore Mahua tree is also called as Indian butter nut tree. Fresh Mahua oil from properly stored seeds is yellow in colour with a not unpleasant taste. The oil is used as cooking oil by tribal peoples of Chhattisgarh, Gujarat, Maharashtra and Odisha etc. The seeds are collected/harvested with the beginning of rainy season in month of June to July with an annual production of 1.81 Million metric tonnes of fruit in India. This makes it one of the most important tree seed oil source in tribal area of India (Jha and Vaibhav, 2013). In Odisha, about 30,000 tonnes of mahua flowers and 6,000 tonnes of mahua seed is collected annually which is about about 40% of its potential (Anon., 2012). Though the potential is high, lower collection is because of the fact that the season is very short and some of the trees are inaccessible in forest areas (Bakhara *et al.*, 2016). The oil is edible and consumed in various rural areas and also beneficial for curing of skin diseases and smoothening of skin. Mahua seed oil has several medicinal and non-food applications (Gupta *et al.*, 2012). Kernel is about 70% by weight of seeds. Thus, mahua seed play an important contributor of rural agricultural economy because of its constituents having unique chemical properties suitable for industrial application for producing soap, biofuels and may augment the supply of nutritional and functional products. In view of its many uses, seeds of Mahua is an important activity in the annual calendar of tribal families (Ramadan and Moersel, 2006; Ramadan *et al.*, 2016).

### **Seed collection and storage practice**

Seeds are available from May to July. The fruits drop off after ripening or sometimes the fruit is eaten by birds and the seeds are dropped off. Present practice followed in seed collection is by picking of ripened fruit falling on ground. Typically, it is the women and children who collect mahua seeds. Collection is done by the cowherds when they take cattle for grazing. Generally, about 5.0 kg of seed is collected by a person per day. If there is stiff competition, the collection may be only 2-3 kg/day. The pulp of collected fruit is removed manually by separating the seed by pressing fruit wall and seeds are dried in sunlight for 5-8 days. Seeds are then stored in a jute bag or in a bamboo basket before decorticating the seed. Poorer households generally collect about 100 kg of seeds in a season compared to 40 kg by better-off household. Out of the total mahua

seed collected, tribal people decorticate 70% for home use and the remaining 30% is sold to oil crushing units existing in their nearby area (Hegde and Daniel, 1993). For oil crushing, farmers have to carry the seeds to distant villages/towns ranging from 8-30 kilometers away. Oil crushing units generally operates in batch of 10 kg and therefore, during mahua season, there is a heavy rush for crushing and the tribal families have to wait in a queue day and night to get their batch crushed.

### Storage behavior in mahua seed

Varghese *et al.*, (2002) studied the desiccation and storage of mahua (*Madhuca indica* J.F. Gmel.) seeds to determine their storage behaviour. It was found that the mature seeds, which were shed at relatively high moisture content (53%), exhibited 100% viability initially. Drying of seeds to 39.4% moisture content under natural drying condition had no adverse effect on germination but further drying to 37.7% moisture content (silica gel drying) reduced germination by 11%. Thus, freshly mature seeds are desiccation-sensitive (recalcitrant). Almost 90% loss in germinability was registered when dehydrated below 16.8% and 14.8% moisture content after 29 (natural drying) and 10 days (silica gel drying). Seeds became non-viable when desiccated below 9.4% moisture content in both the drying conditions (natural drying and silica gel drying). There was a strong positive correlation obtained between decline of viability and rate of dehydration. Seeds are also chilling sensitive, damage may occur even at 15°C. The physico-chemical attributes of mahua seed is presented in table. 1

**Table 1. Physico-chemical attributes of mahua seed**

Properties	Mean Value
Fresh Moisture Content (% wet basis)	53
Kernel (%)	73.9 – 83.6
Husk (%)	16.4 – 26.1
Oil (%)	33 – 61
Protein (%)	16.9
Fibre (%)	3.2
Carbohydrate (%)	22
Ash (%)	3.4
Saponins (%)	2.5
Tannins (%)	0.5

Source: Singh and Singh, (1991)

### Commercial uses of mahua seed oil

The kernel of the mahua seed constitutes the seeds of commerce. The seed kernel yields 20–30% oil when crushed in a primitive crusher, 34–37% in an expeller, and 40–43% when extracted with solvents. Fresh mahua oil from properly stored seeds is yellow in color without any unpleasant taste. Commercial oils are generally greenish-yellow in color with an offensive odor and disagreeable taste. The oil is fluid, often throwing out a

deposit of stearine in cold weather when the oil solidifies to a buttery consistency. The crude oil has a deep color with a high acidity and an unpleasant odor. Refining and hydrogenation yield a product similar to mutton tallow or cacao butter. Oils having an acid value below 13 may be refined by treating with caustic soda; those with higher acid values are extracted with alcohol and further treated with alkali. India has the vast potential of more than 0.6 million tons of tree borne oil (TBO). But near about only 80,000 tons of oil is being extracted. It is, therefore, necessary to exploit domestic resources to maximize production and ensure the oil security for the country. Physico-chemical properties of mahua seed oil is presented in table 2.

**Table 2. Properties of Seed oil**

Properties	Value
<i>Physico-chemical</i>	
Refractive index	1.452
Saponification value	187-197
Iodine value	55-70
Peroxidase value (meq/kg)	0.24
Unsaponifiable matter (%)	1-3
Specific gravity	0.915
<i>Fatty acids composition (%)</i>	
Palmitic C 16:0 (%)	24.5
Stearic Acid C 18:0 (%)	22.7
Oleic Acid C18:0 (%)	37.0
Linoleic Acid C18:2 (%)	14.3
Total Unsaturated	65.9
Total Saturated	32.7

Source: Mishra et al., (2013); Ramadan et al., (2016)

### Composition and uses of mahua seed cake

The deoiled seed cake contains 30 % protein, 1 % oil, 8.6 % fiber, 42.8 % carbohydrates, 6 % ash, 9.8 % saponins, and 1 % tannins (Table 3). Defatted Mahua flour is toxic due to the presence higher percentages of saponins, however the levels of saponins could be reduced by treatment with isopropanol. Singh and Singh (1981) also reported that the defatted flour showed good oil absorption and emulsification properties.

**Table 3 Proximate Composition (%) of Mahua Seed and Defatted Seed Flour**

Constituent	Whole seed	Defatted flour
Protein (N × 6.25)	16.9	29.4
Oil	51.5	1.1
Fibre	3.2	8.6
Carbohydrates	22.0	42.8
Ash	3.4	6.0
Saponins	2.5	9.8
Tannins	0.5	1.0

Source : Singh and Singh (1991) Ramadan *et al.*, (2016)

The solubility of protein was high at both acidic and alkaline pH with a minimum at 4.0. The in-vitro digestibility of mahua seed flour after treatment with isopropanol was found to be 81%. Polyacrylamide gel electrophoresis showed five bands with different relative mobilities and they contained both high and low molecular weight protein fractions. Detoxified mahua seed flour appears to be a good source of protein for food and feed products. Another researcher at CFTRI, Mysore reported that Alcohol, 20-5%, was used to remove the saponins and it was found that two stage 60% ethanol extraction removed 90% of the saponins present in the flour.

#### Food and non-food application of mahua seed oil

The crude fat content of mowrah fruit-seeds was about 58%, is really high, which together with the large seed mass, makes the seeds a rich source of fat. In fatty acid profile of mowrah butter, thirteen fatty acids were identified, wherein the analysis of Fatty Acid Methyl Ester (FAME) gave the proportion of oleic, stearic, palmitic and linoleic as the major fatty acids, which comprising together more than 98.5% of total identified FAME (Table 4). Oleic acid was the main fatty acid (37.3%) followed by stearic acid (25.9%). The results show that in mowrah butter about 46% of the fatty acids present are saturated, 37.4% monounsaturated and 16.5% polyunsaturated. On the other side, mowrah fat relatively resembles palm oil, shea fat and cocoa butter in the fatty acid profile (Table 3). Thus, the characteristic pattern of fatty acids seems to explain the fat's suitability to the formulation of cocoa butter substitutes and also underlies its uses in some cosmetic and pharmaceutical preparations. Biodiesel derived from non-edible Mahua oil seems to be a better alternative to diesel oil in India. Properties of the Mahua biodiesel were found to be within the biodiesel limits of the European Union (Table 5).

**Table 4 Mahua (Mowrah) butter compared to selected natural semi-solid oils and fats: average levels of major fatty acids (%)**

Fatty acids	Mowrah fat	Shea fat	Cocoa butter	Palm oil
C16:0, Palmitic acid	20	4	25	44
C18:0, Stearic acid	26	45	35	4
C18:1, Oleic acid	38	43	35	39



C18:2, Linoleic acid	16	6	3	10
Total Saturated FA	46	49	60	48
Total monounsaturated	37.5	43	35	39
Total PUFA	16.5	6	3	10
S/U	0.85	1.00	1.57	0.97

Source: Ramadan and Moersel (2006)

**Table 5. Mahua oil and Biodiesel characteristics**

Sl. No.	Properties of fuel	Unit	Diesel	Biodiesel from Mahua seed	EN 14214 (limits)
1.	Kinematic viscosity at 40°C	cSt	4.57	4.85	3.5-5.0
2.	Specific gravity at 15°C	-	0.8668	0.8712	0.86-0.9
3.	Flash point	°C	42	157	>120
4.	Fire point	°C	68	183	-
5.	Pour point	°C	-18	2	-
6.	Cloud point	°C	-3	16	-
7.	Cetane number	-	50.6	51.2	>51
8.	Calorific value	kJ/kgK	42850	36914	-

Source: Mishra *et al.*, (2013)

### Engineering properties of mahua seed

The knowledge of engineering properties of mahua seed (Table 6) such as physical (Shape and size, test weight of thousand seed mass, bulk density, true density, porosity etc.), frictional (Angle of repose and coefficient of friction) and mechanical (hardness) are necessary for design and development of the processing technology and post-harvest process equipment for cleaning, grading, sorting and decortication/deshelling (Patel *et al.*, 2011; Shashikumaret *al.*, 2016).

**Table 6. Physical, mechanical and frictional Properties of Mahua seed at 9.4 % (wet basis) moisture content**

Properties	N1	Mean (Standard deviation)
Major dimensions (L) (cm)	100	3.04±0.24
Intermediate dimensions (B) (cm)	100	1.60±0.12
Minor dimensions (T) (cm)	100	1.30±0.17
Arithmetic mean diameter (cm)	100	2.01±0.12
Geometric mean diameter (cm)	100	1.81±0.03
Sphericity	100	0.60 (±0.03)
Aspect ratio (%)	100	53.11 (5.85)

Surface area (cm <sup>2</sup> )	100	10.40 (±0.42)
1000 seed mass (g)	10	1,697.5 (±145.38)
Bulk density (kg/m <sup>3</sup> )	10	381 (±23.78)
True density (kg/m <sup>3</sup> )	10	1,481.54 (±169.06)
Porosity (%)	10	73.96 (±3.37)
Hardness (N/mm)	10	40.55 (±1.73)
Angle of repose (°)	10	38.70 (±2.14)
Coefficient of friction		
Galvanised iron sheet	10	0.47 (±0.03)
Ply wood	10	0.44 (±0.01)
Glass sheet	10	0.40 (±0.03)
Plastic sheet	10	0.52 (±0.02)

N1 = Number of sample; Source: Shashikumar et al., (2016)

### Post- harvest management and processing

Mahua seeds are decorticated within a week after extracted from ripe fruits, otherwise it will germinate. Once seed are germinated, they become unfit for oil extraction. Kernels obtained after decortication/shelling should be dried up to moisture content of 8%, as higher moisture content is liable to fungal attack. Dried kernels can be utilized for oil extraction. The kernel can be packed in polythene lined gunny bag and stored for a year. Decortication process is an important unit operation prior to milling and extracting oil from the kernel of mahuseed to maximize oil yield. Decortication or dehulling of mahua seed is the process of detaching or dissociating the kernel from its enclosure or seed coat namely hull or husk. Thus decortication means breaking and complete removal of seed coat without damaged to its kernel. Traditionally, tribal peoples and farmers use manual method of decortivating the seed by applying impact force on the seed with help of a wooden mallet. The manual decortication process is tedious and time consuming and labour intensive process involving a relatively high expenditure of human energy and thus it indulges drudgery in the process. Quantity and quality of kernel out-turn fully depends upon the skill of the person. Furthermore, these methods result in bruising and serious injury to human fingers, coupled with low output rates of kernel (Figure 3).

This limits the availability of *M. longifolia* seed kernel and seed oil in the market. Thus, the quest for a satisfactory, effective and economical means such as mechanized decortication technique is the requirement of the time, for small and marginal farmers in rural and tribal area of India to reduce the excessive drudgery in mahua seed decortications. Manual decortication is costly due to labour intensive processes and low capacity. A mechanical mahua seed decorticator can be used for removal of the kernels from seeds.



Figure.3 Stages of breaking of the seed

### Marketing of mahua seed

About 70% of the farmers sell their mahua seed to village merchants in weekly market and wholesalers. Industries like soap maker etc. are collecting the seed/fruit directly from village weekly market or from wholesalers. Average wholesale price of mahua seed in current season of 2022 ranges from Rs. 1800 – 2200 per quintal indifferent parts of India.

### CONCLUSION

From the foregoing discussion and review of research work it can be concluded that mahua tree is a boon for the tribal economy due to multipurpose use its flower, fruit and seed, thus satisfying the basic need of tribal people in the form of 3F i.e. feed, fodder and fuel. Mahua tree gives significantly high quantity of oil. The oil is rich in polyunsaturated fatty acid (PUFA) and has desirable level of oleic and stearic acid to be used as cocoa substitute in confectionary products and production of margarines, cosmetic and pharmaceutical industries. Two stage 60% ethanol extractions removed 90% of the saponins present in the mahua seed flour. Mahua seed oil is edible and contains 65.9% total unsaturated fatty acid. Mahua butter can be used as a substitute to cocoa butter. Biodiesel obtained from the mahua oil has potential for alternative fuel options for diesel oil in India. With proper post harvest storage, decortication through mahua seed decorticator and marketing practice, farmers in India can earn better return from multipurpose tree-borne oilseed mahua seed.

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