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*Review Article*

# Non-edible oil seeds: Potential Source for Biodiesel Production

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## Abstract

The rapid industrialization and increase in the size of the population has led to the great energy demand in recent years. Due to this, an alternative source of energy has been explored by various researchers. India is a vast agro-forestry country, fuels of biological origin from non-edible agricultural products is an ideal alternative source of renewable energy. More than 300 feedstock have been identified which can be used for production biodiesel. The conventional and non-conventional feedstock, used for the production of biodiesel includes edible oils, non-edible oils, algal oils, wild oils, used cooking oils, and animal fats. The dry and waste land can be reforested by planting trees which can yield non-edible oil for increased production of its seeds for commercial production of biodiesel. Thus this review summarized the various non-edible oil seeds and their importance for biodiesel production.

**Keywords:** Renewable energy; Non-edible oil seeds; Biooil; Biodiesel.

## Introduction

Energy is of great demand in today's world and the utilization of non-renewable sources has posed a threat towards energy consumption. The ever increasing oil prices, depleting oil reserves and fossil fuels hurdles the development of countries like India which makes the world looks for alternatives. Extensive research has been carried out and alternative fuels like biodiesel, bio-alcohol and other biomass sources prove positive results [1]. The transportation sector consumes 30 % of the world's total energy and is the reason for almost 60 % of the world's oil demand. It has been marked as the largest energy-consuming sector after the industrial sector and in the future will turn out to be the most-energy demanding sector of the world. Usage of renewable biological sources for biooil production as an alternative to pollution causing fossil fuels like coal, petroleum, diesel etc., proved to be successful. There are different potential feedstocks used for biodiesel production. The use of edible vegetable oils or the first generation feedstock has been of great concern recently; this is because they raise many concerns such as food versus fuel debate that might cause starvation especially in the developing countries and other environmental problems caused by utilizing much of the available arable land. This problem can create serious ecological imbalances as countries around the world began cutting down forests for plantation purposes. Hence, use of this feedstock could cause deforestation and damage to the wildlife. Therefore, non-edible vegetable oils or the second generation feedstock have become more attractive for biodiesel production. This feedstock is very promising for the sustainable production of biodiesel [2].

The major drawback of choosing renewable biological sources like plant, microbial cells, biomass, edible and non-edible seeds, is its availability and cultivation on agricultural lands that requires time and sustainable physiological conditions. However production of biooil from renewable sources decreases cost of production by 60-90% compared to the energy production from fossil sources [3]. Biooils with little upgrading treatments are already suitable for turbine fuel and home heating oil uses, and therefore receiving much attention [4].

Biodiesel is one of these promising alternative resources for diesel engines. It is defined as the mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats and alcohol with or without a catalyst. It is renewable, biodegradable, environmentally friendly, non-toxic, portable, readily available and eco-friendly fuel [5-8].

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## Non-edible oil resources

Non-edible vegetable oils are not suitable for human food due to the presence of some toxic components in the oils [6]. Recent comprehensive reviews on biodiesel production from various feed-stocks show the advantages of non-edible oils over edible oils. Production of biodiesel from non-edible oils feedstock can overcome the problems of food verse fuel, environmental and economic issues related to edible vegetable [9]. Non-edible oil based biodiesel production could become a major poverty alleviation program for the rural poor apart from providing energy security in general and to rural areas in particular and upgrading the rural non-farm sector, hence considered as sustainable and alternative fuels [6,10,11].

Non-edible oil plants are well adapted to arid, semi-arid conditions and require low fertility and moisture demand to grow. Moreover they are commonly propagated through seed or cuttings. Since these plants do not compete with food, seed cake after oil expelling may be used as fertilizer for soil enrichment [12]. Several potential tree borne oil seeds (TBOs) and non-edible crop source have been identified as suitable feedstock for biodiesel. Non-availability of quality planting materials or seeds, limited period of availability, unreliable and improper marketing channels, lack of post-harvest technologies and their processing, non-remunerative prices, wide gap between potential and actual production, absence of state incentives promoting biodiesel as fuel, and economics and cost–benefit ratio are the major issues in utilizing the non-edibles oil resources for biodiesel production [11,13].

Development of non-edible oilseed as alternative biodiesel feedstock in the transportation sector is critical towards achieving higher self-reliance energy security. This situation offers a challenge as well as an opportunity to look for replacement of fossil fuels for both economic and environmental benefits. Hence the choice has to shifter from using edible to non-edible sources for oil extraction. Thus there arises the need to rely and depend on non-edible seeds for production of biofuel [14,15]. Some of the most prominent non edible seeds that show enriched oil content are listed in the table 1.

## *Jatropha curcas L.*

*Jatropha curcas* L. is a small tree or large shrub, up to 5–7 m tall, belonging to the Euphorbiaceae family [11]. It is a drought-resistant plant capable of surviving in abandoned and fallowed agricultural lands [16]. It is a tropical plant that is able to thrive in a number of climatic zones with rainfall of 250–1200 mm. The plant is native to Mexico, Central America, Africa, India, Brazil, Bolivia, Peru, Argentina and Paraguay [12]. It is well adapted in arid and semi-arid conditions and has low fertility and moisture demand. It can also grow on moderately soda and saline, degraded and eroded soils. The ideal density of plants per hectare is 2500. It produces seeds after 12 months and reaches its maximum productivity by 5 years and can live 30–50 years. Depending on variety, the decorticated seed of Jatropha contain 43–59% of oil [17].

Table 1. Oil content present in non-edible seed sources

| Sl. No. | Non-edible seed sources | Oil content, % (w/w) |
|---|---|---|
| 1 | *Simmondsia chinesis* (Jojoba) | 50% |
| 2 | *Jatropha curcas* (Ratanjyot) | 46% |
| 3 | *Schlichera cleosa* (Kusum) | 51 -52% |
| 4 | *Azadirachta indica* (Neem) | 25-45% |
| 5 | *Pongamia pinnata* (Karanja) | 27-39% |
| 6 | *Sapindus mukorossi* (Soapnut) | 52% |
| 7 | *Moringa oleifera* (Drum Stick) | 38-40% |
| 8 | *Cleome viscose* (Wild Mustard) | 29% |
| 9 | Brassica juncea (Wild Mustard) | 47% |
| 10 | *Balanites roxburghii* (Dessert Date) | 31-35% |
| 11 | *Aegle marmelos* (Bael Tree) | 43% |
| 12 | *Raphanus sativus* (Turnip oil) | 35% |
| 13 | *Gossypium hirsutum* (Cottonseed) | 51-54% |
| 14 | *Thlaspi arvense* (Pennycress) | 15-30% |
| 15 | *Madhuca indica* (Mahua) | 35-45% |

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### *Pongamia pinnata L.*

*Pongamia pinnata L.* Pierre (karanja or honge), an arboreal legume is a medium sized evergreen tree belonging to the family (Legumnosae; Pappilonaceae), more specifically the Millettieae tribe, which grows in Indian subcontinent and south-east Asia and has been successfully introduced to humid tropical regions of the world as well as parts of Australia, New Zealand, China and the USA . A single tree is said to yield 9–90 kg seeds, indicating a yield potential of 900–9000 kg seed/ha (assuming 100 trees/ha) [18]. It is one of the few nitrogen fixing trees that produce seeds with a significant oil content [9]. The plant is fast growing, drought resistant, moderately frost hardy and highly tolerant of salinity. It can be regenerated through direct sowing, transplanting and root or shoot cutting. Its maturity comes after 4–7 years. Historically, this plant has been used in Indian and neighboring regions as a source of traditional medicines, animal fodder, green manure, timber, water-paint binder, pesticide, fish poison and fuel. Recently, *Pongamia pinnata* has been recognized as a viable source of oil for the burgeoning biofuel industry. The seed oil content ranges between 30 and 40 wt% [19]. The oil is reddish brown and rich in unsaponifiable matter and oleic acid [20].

### *Aleurites moluccana*

*Aleurites moluccana* is another member of the Euphorbiaceae family. It is generically known as the candle nut tree and Hawaiian tree. It thrives in wet or dry subtropical and tropical forest zones. *Aleurites moluccana* grows optimally between the altitudes of 0 and 1200 m; a temperature of 18–28º C, a rainfall of 650–4300 mm and a soil pH of 5–8. The tree produces spherical fruits, 5 cm or more in diameter, with a thick, rough, and hard nut shell making up to 64–68% of fruit, and the nut shell is difficult to separate from its oil-rich kernel. Each tree producing 30–80 kg of nuts. Oil production varies from 15% to 20% of nut weight. The oil is rich in polyunsaturated oils: linolenic, oleic and various linoleic acids [16].

### *Pachira glabra*

*Pachira glabra* belongs to the Malvaceae family, in the Bombacaceae subfamily. It is also known as French peanut, Guinea peanut or money. The tree is originally a Brazilian native tree, now grown throughout the tropics and subtropics. It produces green fruits which upon reaching maturity split open releasing seeds. Trees begin to fruit at about 4–5 years, producing fruits containing 10–25 rounded seeds of average 2.5 cm diameter, with 40–50% oil content [16].

### *Ricinus communis*

*Ricinus communis* belongs to the Eurphorbiaceae family and also called castor beans. It is non-edible oilseed crop that is easily grown and resistant to drought [20]. The tree is grown in many countries such as United States, India, China, Central Africa, Brazil and Australia with different cultivation cultures [21]. Its oil is viscous, slightly odor, pale yellow, non-volatile and non-drying oil with a bland taste and is sometimes used as a purgative. On the average, the seeds contain about 46–55% oil [22].

### *Calophyllum inophyllum L.*

*Calophyllum inophyllum L.* commonly known as polanga, is a non-edible oilseed belongs to the Clusiaceae family. It is a large and medium sized, evergreen sub-maritime tree which grows best in deep soil or on exposed sea sands. The rainfall requirement is 750–5000 mm/yr. This plant has multiple origins including East Africa, India, South-East Asia and Australia [23]. Fruits are spherical drupes and arranged in clusters. The fruit is at first pinkish-green later turning bright green and when ripe, it turns dark gray-brown and wrinkled. The tree yields 100–200 fruits/kg. In each fruit, one large brown seed 2–4 cm (0.8–1.6 in.) in diameter is found. The single, large seed is surrounded by a shell (endocarp) and a thin, 3–5 mm layer of pulp. Oil yield per unit land area has been reported at 2000 kg/ha. The oil is tinted green, thick, and woodsy or nutty smelling (Sahoo et al., 2007, Hathurusingha et al., 2011). The seed oil has very high oil content (65–75%) [24].

### *Madhuca indica*

*Madhuca indica* (Mahua) tree is native to dry region of India. The Mahua trees seed are found enormously in India especially in tribal and forest regions. It is also found in the forests of western India from Konkan southward to Kerala. Mahua trees are grows upto 1200 m height. Mahua tree starts producing seeds after 5 years and continues up to 60-80 years. The yield of Mahua seeds varies from 5-200 kg/tree,

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depending upon size and age of the tree and the total oil yield /ha is 2.7 tons/year [25]**.** The orange brown ripe flesh berries of Mahua (2.5-5.0 cm long) contains 1-4 shining seeds. The kernel constitutes about 70% of the seed and contains 50% oil. The kernels of Mahua seed were estimated to produce nearly 35 to 45 % of oil depending upon the growth and geographical factors which is highly viscous at room temperature [26]. Mahua oil is the non-edible with large production potential of about 60 million tons per annum in India. Fresh oil from properly stored seeds is yellow, while commercial oils are generally greenish yellow with disagreeable odor and taste. Mahua oil is an underutilized non-edible vegetable oil, which can be produced in large quantity in India.

## Advantages of biooil from non-edible seeds

Non-edible vegetable oils are most promising feedstock for the biodiesel production since they are renewable in nature and can be produced in large scale. The biofuels produced by transesterification of biooil from non-edible seeds are biodegradable and non-toxic in nature. They have huge potential to restore degraded lands, create rural employment generation and fixing of up to 10 tons/hectare/year $CO_2$ emissions.

## Conclusions

Non-edible vegetable oils are suitable for biodiesel production. The use of non-edible oils helps to overcome food security problems. They will play a significant role in converting dry and waste areas into cultivable lands. The good biofuels properties, engine performance and their emission characteristics proved the use non-edible oils for biodiesel production near future and long run. Thus the use of non-edible oils as feedstock for biodiesel production will help to overcome the dependency of the world from fossil fuels.

## Conflicts of Interest

Authors declare no conflict of interest.

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