Available on line www.jocpr.com

Journal of Chemical and Pharmaceutical Research

ISSN No: 0975-7384
CODEN(USA): JCPRC5

J. Chem. Pharm. Res., 2011, 3(2):39-49

Non-edible oils as the potential source for the production of biodiesel in India: A review

Saroj K. Padhi and R. K. Singh

Chemical Engineering Department, National Institute of Technology, Rourkela, Orissa, India

ABSTRACT

As the stock of fossil fuels diminishing throughout the world and demands for energy based comforts and mobility ever increasing, so there is a need to increase biodiesel production. Bio diesel is an alternative diesel fuel prepared from renewable resources and is most popular as an alternative energy sources because it is non toxic and biodegradable . India has great potential for production of biodiesel from non-edible oil seeds. From about 100 varieties of oil seeds, only 10-12 varieties have been tapped so far. The promising non-edible sources in India are Madhuca Indica (Mahua) ,Jatropha curcas(Ratan Jyot), Pongamia pinnata (Karanja) and Melia azadirachta (Neem). This review paper assesses and integrates the biological, chemical and genetic attributes of the plant and describes about the different tree borne oilseeds in India, Extraction of oil from tree borne oilseeds , properties ,composition and future potential of bio diesel If the developed process is scaled up to commercial levels then excellent business opportunity will be offered by the biodiesel and it could be a major step towards the creation of an eco-friendly transportation fuel that is relatively clean on combustion and provides farmers with substantial income.

Keywords : Tree borne oil seeds, Non edible oils, transesterification, Bio diesel.

INTRODUCTION

Biofuels are being given serious consideration as potential sources of energy in the future, particularly in developing countries like India. Due to recent petroleum crisis**[1-2]** and unavailability of petroleum diesel the demand for petroleum diesel is increasing day by day hence there is a need to find out an appropriate solution. Biodiesel is a clean burning alternate fuel, produced from renewable resources like virgin or used vegetable oils, both edible and non-edible. It can be used in compression-ignition (diesel) engines with little or no modifications. Bio diesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. It can be stored just like petroleum diesel fuel and hence does not require a separate infrastructure. The use of biodiesel in conventional diesel engines results in substantial reduction of unburned hydrocarbons, carbon monoxide and particulate matters. Its higher cetane number improves the ignition quality even when blended in petroleum diesel. The use of edible oil to produce bio diesel in India is not feasible in view of big gap in demand and supply of such oil. Indian plants like Jatropha (Jatropha curcas), Mahua (Madhuca Indica), Karanja (Pongamia pinnata) and Neem (Mellia azadirachta) contain 30% or more oil in their seed, fruit or nut. Better environmental performance, greening of wastelands and creation of new employment opportunities are the main advantages of biofuels. In India, as edible oils are in short supply, non-edible tree borne oilseeds (TBOs) of karanja, Jatropha , Mahua and Neem are being considered as the source of straight vegetable oil (SVO) and biodiesel. Plant species, which have 30% or more fixed oil in their seeds or kernel, have been identified **[3]**. Traditionally the collection and selling of tree-based oilseeds was generally carried out by poor people for use as fuel for lighting. Presently there is an extended use of these oils in soaps, varnishes, lubricants, candles, cosmetics, etc. However, the current utilization of non-edible oilseeds is very low. There are many ways and procedures to convert vegetable oil into a Diesel like fuel, the trans-esterification process was found to be the most viable process **[4]**.Trans-esterification is the process of using an alcohol (e.g. methanol, ethanol or propanol), in the presence of a catalyst, such as sodium hydroxide or potassium hydroxide, to break the molecule of the raw renewable oil chemically into methyl or ethyl esters of the renewable oil, with glycerol as a by product. Trans-esterified oils have proven to be a viable alternative diesel engine fuel with characteristics similar to those of Diesel fuel. Its physical and chemical properties required for operation of diesel engine are similar to petroleum based diesel fuel. **[5]** Just like petroleum diesel, biodiesel operates in compression-ignition engines. Transesterification is a chemical reaction that aims at substituting the glycerol of the glycerides with three molecules of monoalcohols such as methanol thus leading to three molecules of methyl ester of vegetable oil. **[6].** The molecular weight of ester molecule is $1/3^{rd}$ of oil and low viscosity. Methanol and ethanol is widely used in the transesterification .Methanol is used because of low cost, and physicochemical advantages with triglycerides and sodium hydroxide**[7]**. The alkali hydrolysis of the oil must have acid value <1 and moisture content of $<0.5\%$. The acid catalyst is the choice for transesterification when low-grade vegetable oil used as raw material because it contains high free fatty acid (FFA) and moisture. Acid catalyst as sulphuric acid (H_2SO_4) is used for esterification process.

2. Major non-edible tree borne oilseeds (TBOs)

2.1 .Mahua (Madhuca Indica)

Bio diesel from mahua seed is important because most of the states of India are tribal where it is found abundantly. The annual production of mahua is nearly 181 Kt. Mahua is a non traditional, non edible oil also known as Indian butter tree. Mahua seed contain 30-40 percent fatty oil called mahua oil**[8-13]**. Mahua is a medium to larger tree. In India the mahua plant is found in most of the state e.g. Orissa, Chatishgada, Jharkhand, Bihar,Madhya Pradesh ,Tamil nadu. It can be sucessesfully grown in waste land & dry land. The tree is a strong light demander and gets readily suppressed under shade. The tree has potential of enhancing rural income. The tree may attain a height of upto 20 meters and is well adapted to varied weather conditions it has wide spreading branches and circular crown which presents a visually appealing structure. The tree has a large spreading root system, though many of them are superficial. The fruit is a kind of berry, egg shaped. Mature seeds can be obtained during June to July. The mahua tree starts bearing seeds from seventh years of planning. Commercial harvesting of seeds can be done only from the tenth year. Seed yield ranges from 20 -200 kg per tree every year, depending on its growth and development. As a plantation tree, Mahua is an important plant having vital socio-economic value. This species can be planted on roadside, canal banks etc on commercial scale and in social forestry program's, particularly in tribal areas. Wood can be used as timber, making pulp and paper. Mahua flowers are rich in sugar, minerals, vitamins and calcium. The fatty acid composition of mahua oil oil has been reported in **Table – 1[14]**.

2.2 Jatropha (Jatropha curcas)

Jatropha curcus is a drought-resistant perennial, growing well in marginal/poor soil. Jatropha the wonder plant produces seeds with an oil content of around 37%. The oil can be combusted as fuel without being refined. It burns with clear smoke-free flame, tested successfully as fuel for simple diesel engine. The by-products are press cake a good organic fertilizer, oil contains also insecticide. It is found to be growing in many parts of the country, rugged in nature and can survive with minimum inputs and easy to propagate .Medically it is used for diseases like cancer, piles, snakebite, paralysis, dropsy etc. Depending on soil quality and rainfall, oil can be extracted from the jatropha nuts after two to five years. It grows on well-drained soils with good aeration and is well adapted to marginal soils with low nutrient content. Jatropha curcas grows almost anywhere, even on gravelly, sandy and saline soils. It can thrive on the poorest stony soil. The leaves shed during the winter months form mulch around the base of the plant. Its water requirement is extremely low and it can stand long periods of drought by shedding most of its leaves to reduce transpiration loss. Jatropha is also suitable for preventing soil erosion and shifting of sand dunes. The fatty acid composition of jatropha oil has been reported in **Table – 2[14]**.

2.3. Karanja (Pongamia pinnata)

Karanja is a medium sized tree is found almost throughout India. Karanja tree is wonderful tree almost like neem tree. The common name of the oil is Karanja Seed Oil and the botanical name is Pongamia glabra of Leguminaceae family. Pongamia is widely distributed in tropical Asia and it is nonedible oil of Indian origin . It is found mainly in the Western Ghats in India, northern Australia, Fiji and in some regions of Eastern Asia. **.**The plant is also said to be highly tolerant to salinity and can be grown in various soil textures viz. stony, sandy and clayey. Karanja can grow in humid as well as subtropical environments with annual rainfall ranging between 500 and 2500 mm. This is one of the reasons for wide availability of this plant species. The tree bears green pods which after some 10 months change to a tan colour. The pods are flat to elliptic, 5-7 cm long and contain 1 or 2 kidney shaped brownish red kernels. The yield of kernels per tree is reported between 8 and 24 kg. .The kernels are white and covered by a thin reddish skin. The composition of typical air dried kernels is: Moisture 19%, Oil 27.5%, and Protein 17.4%. The present production of karanja oil approximately is 200 million tons per annum. The time needed by the tree to mature ranges from 4 to 7 years and depending on the size of the tree the yield of kernels per tree is between 8 and 24 kg. The oil content extracted by various authors ranges between 30.0 to 33% **[3]**. The oil is used by common people due to its low cost and easy availability. The fatty acid composition of karanja oil has been reported in **Table – 3[14]**.

2.4 Neem

Neem (Mellia azadirachta) is of Meliaceae family. The other names of neem are Margosa, Veppam, Vepun, Nimba and Vepa (Telugu) etc**[15-17]**.It is one of the two species in the genus Azadirachta, and is native to India and Burma, growing in tropical and semi tropical regions. Neem is a fast growing tree and can reach upto a height of 15 – 20 merrily to 35 – 40 m. It bears an ovoid fruit, 2cm by 1cm and each seed contains one kernel. The seed kernels, which weigh 0.2g, constitute some 50-60% of the seed weight and 25% of the fruit. The fat content of the kernels ranges from 33-45%. The fruit yield per tree is 37-55 kg.. Neem oil can be used as Soaps, medicinal and insecticide . Neem oil is usually opaque and bitter but it has recently been shown that it can be processed into non bitter edible oil with 50% oleic acid and 15% linoleum acid. The bitter cake after extraction of oil has no value for animal feeds although it has been reported that after solvent extraction with alcohol and hexane a meal suitable for animals is produced. Neem seeds are usually crushed prior to extraction in ghanis. Whole dried fruits may be directly passed to expellers. Good quality kernels (50% oil) yield 40% oil in ghanis. In expellers whole dried fruits, depulped seeds and kernels, yield 4-6%, 12-16% and 30-40% oil respectively (Bring)). The cakes, which contain 7-12% oil are sold for solvent extraction. Major fatty acid composition of oil are Palmitic acid 19.4%,Stearic acid 21.2%,Oleic acid 42.1%,Linoleic acid 14.9%,Arachidic acid 1.4%.Neem oil is unusual in containing non-lipid associates often loosely termed as "bitters" and organic sulphur compounds that impart a pungent, disagreeable odour.

3. Oil processing technology of oil seeds

3.1 Oil extraction and Purification of Oil

Although oil extraction can be done with or without seed coat, for jatropha, utilization of a mechanical de hulling system (to remove the seed coat) can increase oil yield by 10%.Choosing efficient extraction methods can increase the yield by more than 5%. While in cold pressing (<60°C), around 86 – 88% efficiency is achieved, hot pressing (110 – 120°C) can increase it to around 90%.The solvent extraction method enhances the efficiency up to 99%. A disadvantage with the solvent extraction is that the quantity of phospholipids in solvent extracted oil is twice as high as compared to pressed oil. This necessitates a further step of oil de gumming before trans-esterification. Oil extraction methods are also being developed based on fermentation hydrolysis. In this process, cell walls of the oil plant seeds are destroyed followed by the release of the oil present within the cells **[18]**. This new method not only produces higher quality of oil and cake but also requires much less energy and results in lower levels of environmental pollution. The efficiency so far obtained is 86% and more research is needed to develop an effective enzyme system. The extracted oil can be purified by Sedimentation prosesss.This is the easiest way to get clear oil, but it takes about a week until the sediment is reduced to 20 - 25 % of the raw oil volume. The purification process can be accelerated tremendously by boiling the oil with about 20 % of water.

3.2 Detoxification of seed cake

After extraction of oil from seed the detoxification of the seed cake is necessary so that the seed cake can be used as cattle feed. The type of toxic component present in the seedcake varies from seed to seed, but for jatropha seed cake detoxification is highly essential. From Several investigations it is found that de-acidification and bleaching could reduce the content of toxic phorbol esters to 55% **[19]**. Efficiency of the treatment also depends upon the type of toxic component present in the seedcake and the effective detoxification techniques.

4. Biodiesel processing

There are four ways in which oils and fats can be converted into biodiesel, namely, transesterification, micro emulsions and pyrolysis. Pyrolysis refers to a chemical change caused by application of thermal energy in absence of air or nitrogen. The liquid fractions of the thermally decomposed vegetable oil are likely to approach diesel fuels. The pyrolyzate has lower viscosity, flash & pour points than diesel fuel but equivalent calorific values. The cetane number of the pyrolyzate is lower. The pyrolysed vegetable oils contain acceptable amounts of sulphur, water and sediment with acceptable copper corrosion values but unacceptable ash, carbon residue and pour point. The formation of micro-emulsions (co-solvency) is a potential solution for reducing the viscosity of vegetable oil. Micro-emulsions are defined as transparent, thermodynamically stable colloidal dispersions. A micro-emulsion can be made of vegetable oils with an ester and dispersant (co-solvent), or of vegetable oils, an alcohol and a surfactant and a cetane improver, with or without diesel fuels. The process of converting the raw vegetable oil into biodiesel, which is fatty acid alkyl ester, is termed as transesterification. There are three basic routes to biodiesel production from oil are such as base catalyzed transesterification of the oil , direct acid catalyzed transesterification of the biolipid and Conversion of the biolipid to its fatty acids and then to biodiesel.Trans-esterification being the most commonly used method. Conversion is complicated if oil contains higher amounts of FFA (>1% w/w) that will form soap with alkaline catalyst. The soap can prevent separation of the biodiesel from the glycerin fraction. Crude oil contains about more than 25 % FFA, which is far beyond the 1% level. Few researchers have worked with feedstock having higher FFA levels using alternative processes. Pretreatment step to reduce the free fatty acids of these feedstocks to less than 1% before transesterification reaction was completed to produce biodiesel. The reduction of FFA <1% is best if esterification followed by Trans-esterification.

4.1. Esterification

Normally most of the oils are converted into biodiesel esters using the base catalysed trans-esterification method. But there are certain exceptional cases wherein direct trans-esterification cannot be performed. Such cases appear in raw vegetables oils(Non edible oil) like karanja oil, mahua oil, Nim,Jatropha and sal oil, etc because these raw vegetable oils posses high free fatty acid (FFA). For determining whether the raw vegetable oils can be trans-esterified directly the acid value is the most important property that must be known. If the acid value <3 then the raw vegetable oil can be directly trans-esterified. If the acid value >3 then there is slight change in the production process. At first the oil undergoes esterification and then followed by trans-esterification. In the esterification process the excess of the free acid gets reacted. The remaining acid content in the oil undergoes trans-esterification. So this method is effective for oils that contain high free fatty acid (FFA) content. So the selection of acid catalyst is very important. The aim of esterification reaction is to remove water during processing otherwise seriously hurt the reaction conversions.

4.2. Transesterification

Transesterification also called alcoholysis is the displacement of alcohol from an ester by another alcohol in a process similar to hydrolysis, except that an alcohol is employed instead of water.

Suitable alcohols include:methanol, ethanol, propanol, butanol, and amyl alcohol. Methanol and ethanol are utilized most frequently. This process is widely used to reduce the viscosity of triglycerides, there by enhancing the physical properties of fuel and improve engine performance. Thus fatty acid methyl ester (also known as biodiesel) is obtained by transesterification.

4.3. Effect of different parameters on production of biodiesel

Process Variables

The most important variables which influence the transesterification reaction are: reaction temperature, ratio of alcohol to vegetable oil, catalyst mixing intensity and purity of reactants.

i. Reaction Temperature

The literature has revealed that the rate of reaction is strongly influenced by the reaction temperature. However the reaction is conducted close to the boiling point of methanol (60 – 70 ^{0}C) at atmospheric pressure for a given time. Such mild reaction conditions require the removal of free fatty acids from the oil by refining or pre-esterification. Therefore degummed and deacidified oil is used as feedstock **[20].** Pretreatment is not required if the reaction is carried out under high pressure (9000 kPa) and high temperature (240 ^{0}C), where simultaneous esterification and transesterification take place with maximum yield obtained at temperatures ranging from 60 – 80 ^{0}C at a molar ratio of 6:1 **[20-22]**.

ii. Ratio of Alcohol to Oil

Another important variable is molar ratio of alcohol to vegetable oil. As indicated earlier, the transesterification reaction requires 3 mol of alcohol per mole of triglyceride to give 3 mol of fatty esters and 1 mol of glycerol. In order to shift the reaction to the right, it is necessary to either use excess alcohol or remove one of the products from the reaction mixture. The second option is usually preferred for the reaction to proceed to completion. The reaction rate was found to be highest when 100% excess methanol was used. A molar ratio of 6:1 is normally used in industrial processes to obtain methyl ester yields higher that 98% (w/w) **[20]**.

iii. Catalysts

Alkali metal alkoxides are found to be more effective transesterification catalysts compared to acidic catalysts. Sodium alkoxides are the most efficient catalysts, although KOH and NaOH can also be used. Transmethylation occurs in the presence of both alkaline and acidic catalysts **[23]**. As they are less corrosive to industrial equipment, alkaline catalysts are preferred in industrial processes. A concentrateon in the range of 0.5 – 1% (w/w) has been found to yield 94 – 99% conversion to vegetable oil esters **[21]**, and further increase in catalyst concentration does not affect the conversion but adds extra cost, as the catalyst needs to be removed from the reaction mixture after completion of the reaction.

iv. Mixing Intensity

It has been observed that during the transesterification reaction, the reactants initially form a two-phase liquid system. The mixing effect has been found to play a significant role in the slow rate of reaction. As phase separation ceases, mixing becomes insignificant. The effect of mixing on kinetics of the transesterification process forms the basis for process scale-up and design.

v.Purity of Reactants

Impurities in the oil affect the conversion level considerably. It is reported that about 65 – 84% conversion into esters using crude vegetable oils has been obtained as compared to 94 – 97% yields refined oil under the same reaction conditions **[20]**. The free fatty acids in the crude oils have been found to interfere with the catalyst. This problem can be solved if the reaction is carried out under high temperature and pressure conditions.

vi. Effect of moisture and water content on the yield of biodiesel

Water could pose a greater negative effect than presence of free fatty acids and hence the feedstock should be free from water[24]. Even a small amount of water (0.1%) in the transesterification reaction would decrease the ester conversion from vegetable oil [25-26]. The yield of the alkyl ester decreases due to presence of water and FFA as they cause soap formation, consume catalyst and reduce the effectiveness of catalyst[27]. Moisture content from the vegetable oil is removed by heating in oven for 1 h at 383 K[28]. Meher et al.[29] too reported a precautionary step to prevent moisture absorbance and maintenance of catalytic activity by preparing the fresh solution of potassium hydroxide and methanol. It is found that even a small amount of water in the feedstock or from esterification reaction producing water from FFA might cause reduction in conversion of fatty acid methyl ester and formation of soap instead [30]. At the same time the presence of water had a positive effect in the yield of methyl esters when methanol at room temperature was substituted by supercritical methanol. However, no explanation for this has been provided [27]. The presence of water had negligible effect on the conversion while using lipase as a catalyst [31-32].

vii.. E**ffect of free fatty acids**

Free fatty acids (FFAs) content after acid esterification should be minimal or otherwise less than 2% FFAs. These FFAs react with the alkaline catalyst to produce soaps instead of esters. There is a significant drop in the ester conversion when the free fatty acids are beyond 2% [33].

viii. Effect of stirring

Stirring can play an important role in the yield of biodiesel production. Transesteri-fication reaction was carried out with 180, 360 and 600 revolutions per minute (rpm) and reported incomplete reaction with 180 rpm. The yield of methyl ester was same with 360 and 600 rpm[29]. Mode of stirring too plays a vital role in the transesterification reaction[34].The yield of biodiesel increased from 85% to 89.5% when magnetic stirrer (1000 rpm) was replaced with mechanical stirrer (1100 rpm). A plausible explanation may be a thorough mixing of the reactants by mechanical stirrer.

ix. Effect of specific gravity

Lower value of the specific gravity of the final product is an indication of completion of reaction and removal of heavy glycerine. The influence of molar ratio, temperature and catalyst quantity on the specific gravity of the biodiesel was studied by Miao and Wu [35]. The specific gravity of the product decreased sharply up to 2 h of reaction time using 30:1 molar ratio and up to 4 h of reaction time using 45:1 and 56:1 molar ratio after which it was almost constant.The best process combination reduced the product specific gravity from 0.912 to 0.864 with 100% catalyst,56:1 molar ratio at 303 K in 4 h of reaction time.

Table 1. Fatty acid profile of mahua oil [8]

Fatty Acid	Formula	Structure	Wt%
Palmitic	$C_{16}H_{32}O_2$	16:0	16.0–28.2
Stearic	$C_{18}H_{36}O_2$	18:0	20.0–25.1
Arachidic	$C_{20}H_{40}O_2$	20:0	0.0–3.3
Oleic	$C_{18}H_{34}O_2$	18:1	41.0–51.0
Linoleic	$C_{18}H_{32}O_2$	18:2	8.9–13.7

Table 2. Fatty acid profile of jatropha oil [14]

Fatty Acid	Formula	structure	Wt%
Myristic	$C_{12}H_{28}O_2$	14:0	0.5-1.4
Palmitic	$C_{16}H_{32}O_2$	16:0	12–7.0
Stearic	$C_{18}H_{36}O_2$	18:0	5.0–9.7
Oleic	$C_{18}H_{34}O_2$	18:1	37-63
Linoleic	$C_{18}H_{32}O_2$	18:2	19-41

Table 3. Fatty acid profile of Karanja oil [14]

Fatty Acid	Formula	structure	Wt%
Palmitic	$C_{16}H_{32}O_2$	16:0	3.7–7.9
Stearic	$C_{18}H_{36}O_2$	18:0	2.4–8.9
Lignoceric	$C_{20}H_{40}O_2$	24:0	1.1–3.5
Oleic	$C_{18}H_{34}O_2$	18:1	44.5–71.3
Linoleic	$C_{18}H_{32}O_2$	18:2	10.8–18.3

Table-4 : Annual Production of Non-edible Oil Seeds in India[44]

Type	Production (MT)	Oil %
Neem	500	30
Karanja	200	27-39
Kusum	80	34
Pilu	50	33
Ratanjot	-	30-40
Jaoba	-	50
Bhikal	-	37
Wild Walnut	-	60-70
Undi	04	50-73
Thumba	100	21

5. Biodegradability of biodiesel

Biodiesel is highly biodegradable in freshwater as well as soil environments. 90–98% of biodiesel is mineralized in 21–28 days under aerobic as well as anaerobic conditions [36-38]. Biodiesel has been reported to remove twice the amount of crude oil from sand as conventional shoreline cleaners [39]. Biodiesel increases the biodegradability of crude oil by means of co metabolism. More than 98% degradation of pure biodiesel after 28 days is reported by Pasqualino et al. [36] in comparison to 50% and 56% by diesel fuel and gasoline respectively. Also,the time taken to reach 50% biodegradation reduced from 28 to 22 days in 5% biodiesel mixture and from 28 to 16 days in case of 20% biodiesel mixture at room temperature. The biodegradability of the mixture was reported to increase with addition of biodiesel. And is depicts the biodegradability of fossil diesel under different conditions [40-43].

6. Storage, Handling and Use

Bio-diesel does not need any special precaution in storage and handling and the same conditions, which are used for petroleum diesel, are sufficient.It is preferable to store the fuel in clean, dry and dark environment. However the stability can be increased by doping with anti-oxidants. Biodiesel has poor oxidation stability. Use of oxidation stability additives is necessary to address this problem. Biodiesel may gel at low temperatures and care needs to be taken to avoid temperature extremes .Hence,insulation/jacketing of storage tanks and pipelines would need to be done at the low temperature zones. To avoid oxidation and sedimentation of tanks with biodiesel, storage tanks made of aluminum, steel etc. are recommended for usage. Biodiesel has a solvent effect, which releases the deposits accumulated on tanks and pipes, which previously have been used for diesel. These deposits can be expected to clog filters initially and precautions should be taken for this. Like normal diesel, prolonged storage, say over six months, of Bio-diesel in tanks is normally not recommended.

7. Future of Biodiesel in India

India has great potential for production of biodiesel from non-edible oil seeds. From about 100 varieties of oil seeds, only 10-12 varieties have been tapped so far. The annual estimated potential is about 20 million tones per annum. Wild crops cultivated in the westland also form a source of biodiesel production in India and according to the Economic Survey of Government of India, out of the cultivated land area, about 175 million hectares are classified as waste and degraded land. Thus, given a demand-based market, India can easily tap its potential and produce biodiesel in a large scale. Table- 4 depicts the annual production of non-edible oil seeds in India.**G**overnment agencies like Ministry of Rural Development, Environment and Forestry, Petroleum and Natural Gas, Agriculture, and Non-Conventional Energy Source can all play leading roles in this program.. Industry and research institutes have also the vital role for the success and a clear supply chain mechanism with utilization plan is necessary in national level like elsewhere across the globe. research organizations should be encouraged to undertake Life Cycle Analysis exercise for bio diesel produced from varied feedstock being used India and need to quickly develop high-yielding varieties of plants for various regions .Both scientific and agricultural research bodies should be involved directly and on a regular basis to regularly enhance the efficiency levels of both production and processing of bio diesel..It is required to select and evolve quick growing and high-yield varieties and improved methods of propagation to produce better quality oil and to provide farmer’s with a choice of Tree Borne Oil (TBO) species that are most appropriate to local agro-climatic conditions The seed collection and the processing of raw oil could also be taken up as a cooperative movement, which has led to several success stories in India. Small and medium scale industrial sector are required to take initiative for the downstream processing of raw oil and its supply to petroleum marketing companies .At the national level it is required to set up a very effictive task force for the coordination of plantation, production, distribution and marketing activities.The Government of India through its Planning Commission has initiated a national program to cultivate vast areas of waste lands by plantation of oil-bearing trees and as a result of this, substantial quantities of biodiesel can be available in the near future.

CONCLUSION

Edible oils are in use in developed nations such as USA and European nations but in developing countries the production of edible oils are not sufficient . In a country like India, there are many plant species whose seeds remain unutilized and underutilized have been tried for biodiesel production. Non-edible oil seeds are the potential feedstock for production of biodiesel in India. These species have shown promises and fulfills various biodiesel standards. India, with its huge waste/non-fertile lands, has taken a well noted lead in the area and commercial production. Proper processing of non-edible oil seeds and transesterification can ascertain the quality of biodiesel and can be fulfill the large commercial application .The future success of these non edible – oil as a sustainable source of feedstock for the biofuels industry is reliant on an extensive knowledge of the genetics, physiology,and propagation of theses species. In particular, research should be targeted to maximizing plant growth as it relates to oil biosynthesis.

REFERENCES

[1]N.S.Venkataraman, *Chemical Industry Digest*,April,p.77**(2004)**
[2] Based Biodiesel-Opportunities and contents in developing countries like India, Chemical Industries News, **(2004)** April,p.79
[3] Azam A. M., and Nahar N. M., **2005.** *Biomass and Bioenergy*. 2005 Article in Press.
[4] Ma F, Hanna MA. *Biores Technol* **1999**;70: 1–15.
[5] Srivastava, A and Prasad, R, *Oil Energy* **2000**; Rev.4:111-133
[6] Sihna S, Bhardwaj D, Gupta PK, *Biomass and Bio energy*. **2004** ; 13:501-505.
[7]Pramanik K, Srivani K, Chandra V, *Indian chemical engineering congress*. **2000;** Dec:18-21.
[8] Altin R, Cetinkaya S, Yucesu HS. *Energy Convers Manage* **2001;4**2: 529–38.
[9] Agarwal AK, Das LM, *Journal of engineering for For Turbines and power*. **2001**; 123:440-447.
[10] Ram BVB, Ramanathan V, Phuan S, Vedaraman N, *Indian chemical Engg. Journal*. **2004**; 14(2):12-15.
[11] Phuan S, Vedaraman N, Sankaranarayanan G, Ram BVB, *Renewable energy*. **2005**; 30:1269-1278.
[12] Azam MM, Waris A, Nahar NM. *Biomass and Bioenergy*. **2005;** 29: 293-302.
[13] Carraretto C, Macor A, Mirandola A, Stoppato A, Tonon S, *Energy*. **2004;** 29:2195-2211.
[14] Katwal RPS, Soni PL. *Indian Forester* **2003;**129(8):939–49.[15]
[16] Eckey, E.W. Vegetable Fats and Oils, Reinhold Publishing Corp, **1954.** p 559
[17] Rumkini, C., *Food Chemistry*, Vol 26, No.:2, p.119-124
[18] Janulis, P. *Renewable energy*, **2004;** 29: 861 – 871.
[19]Haas, W., Mittelbach, M. *Industrial crops and products*, **2000;**12 (2): 111- 118.
[20] Freedman B, Pryde EH, Mounts TL; *J. Am Oil Chem Soc*; **1984**; 61 (10): 1638 – 43
[21]Feuge RO, Gros AT; *J. Am Oil Chem Soc*; **1949;** 26(3), 97
[22] Hui YH; Industrial Oil and Fats: Industrial and Consumer Non-edible Products from Oils and Fats; Edited by Baily, New York, Wiley; **1996**, P 5
[23] Formo MW; *J. Am Oil Chem Soc*; **1954,** 31 (11):548–59
[24] Kusdiana D, Saka S. *Bioresour Technol* **2004**;91:289–95.

[25]Romano S. Vegetable oils-a new alternative. In: Vegetable oils fuels—proceedings of the international conference on plant and vegetable oils as fuels. ASAE Publication 4-82. Fargo, ND, USA, **1982**. p. 101–16.
[26]Canakci M, Gerpan JV. *Trans Am Soc Agric Eng* **1999**;42(5):1203–10.
[27] Demirbas A. *Energy Conservat Manage* **2006;**47:2271–82
[28] Srivastava PK, Verma M. *Fuel* 2007. doi:10.1016/j.fuel.**2007**.08.018.
[29] Meher LC, Dharmagadda VSS, Naik SN. *Bioresour Technol* **2006;**97:1392–7.
[30] Ellis N, Guan F, Chen T, Poon C. *Chem Eng J* **2007**.doi:10.1016/j.cej.**2007**.06.034.
[31] Madras G, Kolluru C, Kumar R. *Fuel* **2004**;83:2029–33.
[32] Demirbas A. *Int J Green Energy* **2007**;4:15–26.
[33] Naik M, Meher LC, Naik SN, Das LM. *Biomass Bioenergy* **2007.** doi:10.1016/j.biombioe.**2007**.10.006.
[34] Sharma YC, Singh B. *Fuel* **2007**. doi:10.1016/j.fuel.2007.08.001.
[35] Miao X, Wu Q. *Bioresour Technol* **2006**;97:841–6.
[36] Pasqualino JC, Montane D, Salvado J. *Biomass Bioenergy* **2006;**30:874–9.
[37] Zhang X, Peterson C, Reece D, Moller G, Haws R. *Trans Am Soc Agric Eng* **1998;**41:1423–30.
[38] Makareviciene V, Janulis P. *Renew Energy* **2003;**28(15):2395–403.
[39] Pereira G, Mudge SM. *Chemosphere* **2004;**54(3):297–304.
[40]Molina-Barehona L, Rodrı´guez-Va´zquez R, Herna´ndez-Velasco M,Vega-Jarquı´n C, Zapata-Pe´rez O, Mendoza-Cantu´ A, et al. *Appl Soil Ecol* **2004**;27(2):165–75.
[41] Boopathy R. *Bioresour Technol* **2004**;94:143–51.
[42] Mohn WW, Radziminski CZ, Fortin MC, Reimer KJ. *Appl Microbiol Biotechnol* **2001;**57:242–7.
[43]Mukherji S, Jagadevan S, Mohopatra G, Vijay A. *Bioresour Technol* **2004;**95(3):281–6.[44] Interim Report of " Auto Fuel Policy".