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Karanja Seed Oil: A Potential Source of Biodiesel

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ABSTRACT: Usage of fossil fuel creates the frightening condition which whole universe has to face along with ecological misbalances. The rapid consumption of these reserves are unable to match the escalating demands of the globe and also swift price hikes are seen in the last few years. Current condition is intimidating and calls for a quick rush in discovering new alternatives so as to meet our demands by dipping dependence on diesel fuel and should be environmentally sustainable thereby increasing our exchange level across the globe. Biodiesel has potential and also very important area of research because of ecological misbalances and rising of petroleum prices. Biodiesel was prepared from the non-edible oil of Karanja by transesterification of the crude oil with methanol in the presence of NaOH as catalyst. A maximum conversion of 92% (oil to ester) was achieved at 6000C. Important fuel properties of methyl esters of biodiesel produced from karanja oil like viscosity, flash point, fire point, calorific value etc., was found out and compared to the properties of Indian standard biodiesel. As the acid values of this oil were more than 3, hence it can be converted to biodiesel by esterification followed by transesterification process. The methyl ester produced by these methods was analyzed to a certain their suitability as diesel fuels. Then the comparison of physicochemical properties was done karanja oil, karanja oil methyl ester and biodiesel. The various properties of methyl esters are found to be comparable with that of diesel fuel. However it requires further studies for considering the product as a suitable biodiesel.

KEYWORDS: Karanja oil, Extraction, Transesterification, Biodiesel

I. INTRODUCTION

The Energy comes in a variety of renewable forms like wood energy, wind energy, solar energy, ocean water power, geothermal energy. Bio energy generated by bio fuels is viewed as a strong source of energy in the coming years. The Energy is also available in the nonrenewable form of fossil fuels that is oil, natural gas and coal, which provide almost 80% of the world's supply of primary energy. Use of these fossil fuels is a major source to cause pollution of land, sea and the entire atmosphere. [1]. India is the world's largest importer edible oil followed by European Union and China. India is the world's third-largest consumer after China and the EU. A growing population, increasing rate of consumption and increasing per capita income are accelerating the demand for edible oil in India [2]. The various alternative fuel options tried in place of hydrocarbon oils are mainly biogas, producer gas, ethanol, methanol and vegetable oils. Out of all these, vegetable oil offers an advantage because of their comparable fuel properties with that of diesel [3]. The idea of using vegetable oil as fuel has been around from the birth of diesel engine. Rudolph diesel, the inventor of the engine that bears his name, experimented with fuels ranging from powdered coal to peanut oil [4]. Non-edible oils that can be used to produce bio-fuels are gaining worldwide acceptance as one of the comprehensive solutions for problems of environmental degradation, energy security, restricted imports, rural employment and agricultural economy. Bio-fuels are fuels produced by a number of chemical / biological processes from biological materials like plants, agricultural wastes etc. Being sourced from trees already existing and to be further propagated, bio-fuel is a source of renewable energy. Bio-diesel can be used as a pure fuel or blended with petroleum diesel depending on the economics and emissions [5]. Biodiesel is an alternative diesel fuel that can be produced from renewable feedstock such as edible and non-edible vegetable oils, wasted frying oils and animal fats. Biodiesel is

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 3, March 2016

oxygenated, sulphur free, non-toxic, bio gradable and renewable fuel [6]. Of the various alternate fuels under consideration, biodiesel, derived from vegetable oils, is the most promising alternative fuel to diesel due to the following reasons.

- Biodiesel can be used in the existing engine without any modifications.
- Biodiesel is made entirely from vegetable sources; it does not contain any sulfur, aromatic hydrocarbons, metals or crude oil residues.
- Biodiesel is an oxygenated fuel.
- Emissions of carbon monoxide and soot tend to reduce.
- The use of biodiesel can extend the life of diesel engines because it is more lubricating than petroleum diesel fuel.
- Biodiesel is produced from renewable vegetable oils/animal fats and hence improves the fuel or energy security and economy independence [7].

Biodiesels have low volatility and high viscosity due to long chain structure hence there is problem to use vegetable oil directly as bio diesel in CI engine applications. Again it creates the common problems such as excessive pumping power, poor atomization of fuel particles and improper combustion as lower in air-fuel mixing rate [8]. In this review paper we study alternative fuel that is Pongamia Pinnata (Karanja). This oil is blended with diesel fuel in various proportions like 10%, 20%, and 30% etc. The various researchers and engineers have been experimented the effects of vegetable oil on the performance and emission characteristic of constant speed CI engines [9]. Pongamia oil is non-edible oil extracted from seeds of Pongamia pinnata, commonly known as karanja in Assam [10]. It is estimated that by 2017, 20% of energy needs of India should be met by biodiesel. As on Sep 2011 Indian annual diesel consumption was 60 million MT and 20% of 60 million MT diesel amounts to 12 million MT. Pongamia pinnata is one of the promising tree species suitable for providing oil for biodiesel production, which conforms to international standards. This tree species is found to be well spread throughout India, excluding temperate regions. [11].

II. EXTRACTION OF CRUDE KARANJA OIL

Vegetable oils are produced from numerous oil seed crops. While all vegetable oils have high-energy content, most require some processing to assure safe use in internal combustion engines [12]. Karanja tree and seeds can be seen as shown (Fig. 1)



Fig. 1: Karanja Tree and seeds [13]

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

The extraction of oil from karanja seed was done by using different methods, i.e. mechanical expression, solvent extraction and cold percolation using n-hexane as solvent [14]. As a diesel fuel substitute, Honge falls under the category of bio-diesel. Extraction requires passing the seeds through a screw crusher, generally called expellers. The oil is then filtered to make it clean enough for processing [15]. It is found that the maximum yields were obtained by the Solvent extraction method (31%) as compared to mechanical expeller (24%) and cold percolation method (27%) [16]. The most common method to extract oil involves in collecting the pods. The pods are kept in water for 2 to 3 hours followed by drying in hot atmospheric condition. The dried pods are stuck with hammers and sticks to open them after which the seeds are winnowed out. Oil extraction is carried out in Ghanis and small expellers. The oil is dark in color with a disagreeable odor [17]. Characteristics of fatty acids in karanja oil are as given (Table 1).Karanja Seed Oil Cake is by-product after oil extraction, which otherwise goes waste or as fertilizers, is used as Precursor for Activated Carbon Preparations [18].

S. No.	Fatty acid	Value (%)
1	Palmitic	3.7-7.9
2	Stearic	2.4-8.9
3	Oleic	44.5-71.3
4	Linoleic	10.8-18.3
5	Lignoceric	1.1-3.5

Table 1: Characteristics of fatty acids in karanja oil [17]

III. PROPERTIES OF CRUDE KARANJA OIL

The large size of the vegetable oil molecules and the presence of oxygen in the molecules suggest that some fuel properties of the vegetable oils would differ markedly from those of hydrocarbon fuels [20]. As we know the fresh extracted crude oil is yellowish red/ brown and it get darkened during the storage. The oil is having disagreeable odor and bitter taste. The solvent extraction method gives good quality oil than ordinary extraction methods. The iodine value is a measurement of the unsaturation of fats and oils. Higher iodine value indicated that higher unsaturation of fats and oils. Table 3 shows Physico-chemical Properties of Pongamia pinnata -crude oil [21]. Physical-chemical Properties of Pongamia pinnata crude oil given (Table 2).

Property	Unit	Value
Color	-	Yellowish red
Odor	-	Characteristic odd odor
Density	gm/cc	0.924
Viscosity	mm ² /sec	40.2
Acid Value	mg/KOH	5.40
Iodine Value	-	87
Saponification Value	-	184
Calorific Value	Kcal/KG	8742
Specific Gravity	-	0.925
Unsaturation matter	-	2.9
Flash Point	°C	225
Fire Point	°C	230
Cloud Point	°C	3.5
Pour Point	°C	-3
Boiling Point	°C	316
Cetane Number	-	42
Copper strip Corrosion	-	No Corrosion observed
Ash Content	in %	0.07

Table 2: Physical-chemical Properties of Pongamia pinnata -crude oil [21]

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 5, Issue 3, March 2016

IV. BIODIESEL PRODUCTION FROM PONGAMIA PINNATA OIL

Vegetable oils are not suitable direct replacements for diesel fuel in engines, boilers or cogeneration systems, due to their inappropriate physical properties such as longer molecule chains, lower pour points, lower vapor pressures, higher viscosities and higher flash points. These features cause poor atomization, poor vapor–air mixing, low pressure, and incomplete combustion and engine deposits. However, it is possible to reduce the viscosity of vegetable oil, improve the physical features of vegetable oil through dilution, pyrolysis, micro emulsion and Esterification [22].

4.1 BLENDING: Vegetable oil can be directly mixed with diesel fuel and may be used for running an engine. The blending of vegetable oil with diesel fuel in different proportion were experimented successfully by various researchers. Blend of 20% oil and 80% diesel have shown same results as diesel and also properties of the blend is almost close to diesel [23].

4.2 MICRO –EMULSIFICATION: To solve the problem of high viscosity of vegetable oil, micro emulsions with solvents such as methanol, ethanol and butanol have been used. A micro emulsion is defined as the colloidal equilibrium dispersion of optically isotropic fluid microstructures with dimensions generally in the range of 1–150 nm formed spontaneously from two normally immiscible liquids and one or more ionic or non-ionic amphiphiles [23].

4.3 CRACKING: Cracking (Pyrolysis) is the process of conversion of one substance into another by means of heat or with the aid of catalyst. It involves heating in the absence of air or oxygen and cleavage of chemical bonds to yield small molecules [23].

4.4 TRANSESTERIFICATION: Transesterification is the process of using an alcohol (e.g. methanol, ethanol or butanol), 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 byproduct [23]. Due to the relatively high costs of edible oils, the cost of producing methyl or ethyl esters from edible oils is currently more expensive than hydrocarbon-based diesel fuels. The cost of biodiesel can be reduced if one can consider non-edible oils, spent vegetable oils and used frying oils instead of edible oils [24]. Chemical treatment namely Esterification was suggested by the researchers for conversion of the extracted vegetable oil in to combustible fuel inside the engine. Esterification process popularly used method of chemical treatment, which removes the unwanted fatty acid presented in the vegetable oil and reduced the viscosity. When the fatty acid presented above 4% (by volume) then two stage Esterification process suggested, otherwise single stage Esterification recommended [25].

V. PROCEDURE FOR PRODUCING KARANJA BIODIESEL

5.1 ESTERIFICATION: Bobade S.N et al. [26] explained the production of biodiesel using Esterification as follows. The methyl ester is produced by chemically reacting karanja oil with an alcohol (methyl), in the presence of catalyst. A two stage process is used for the transesterification of karanja oil. The first stage (acid catalyzed) of the process is to reduce the free fatty acids (FFA) content in karanja oil by Esterification with methanol (99% pure) and acid catalyst sulfuric acid (98% pure) in one hour time at 57oC in a closed reactor vessel. The karanja crude oil is first heated to 50oC and 0.5% (by wt) sulfuric acid is to be added to oil then methyl alcohol about 13% (by wt) added. Methyl alcohol is added in excess amount to speed up the reaction. This reaction is proceeding with stirring at 700 rpm and temperature was controlled at 55-57 oC for 90 min with regular analysis of FFA every after 25-30 min. When the FFA is reduced up to 1%, the reaction is stopped. The major obstacle to acid catalyzed Esterification for FFA is the water formation.

5.2 TRANSESTERIFICATION: Bobade S.N et al. [26] explained the production of biodiesel using trans- -esterification as follows. The catalyst used is typically sodium hydroxide (NaOH) with 1% of total quantity of oil mass. It is dissolved in the 13% of distilled methanol (CH₃OH) using a standard agitator at 700 rpm speed for 20 minutes.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

The alcohol - catalyst solution was prepared freshly in order to maintain the catalytic activity and prevent the moisture absorbance. After completion it is slowly charged into preheated esterified oil. When the methoxide was added to oil, the system was closed to prevent the loss of alcohol as well as to prevent the moisture. The temperature of reaction mix was maintained at 60 to 65°C (that is near to the boiling point of methyl alcohol) to speed up the reaction. The recommended reaction time is 70 min. The stirring speed is maintained at 560- 700rpm. Excess alcohol is normally used to ensure total conversion of the fat or oil to its esters. The reaction mixture was taken each after 20 min. for analysis of FFA. After the confirmation of completion of methyl ester formation, the heating was stopped and the products were cooled and transferred to separating funnel. Once the reaction is complete, it is allowed for settling for 8-10 hours in separating funnel. At this stage two major products obtained that are glycerin and biodiesel. Each has a substantial amount of the excess methanol that was used in the reaction. The glycerin phase is much denser than biodiesel phase and is settled down while biodiesel floated up. The two can be gravity separated with glycerin simply drawn off the bottom of the settling vessel. Once the glycerin and biodiesel phases were separated, the excess alcohol in each phase was removed by distillation. Once separated from the glycerin and alcohol removal, the crude biodiesel was purified by washing gently with warm water to remove residual catalyst or soaps. Transesterification process (Fig. 2) and methods of biodiesel production (Table 3) are shown below.

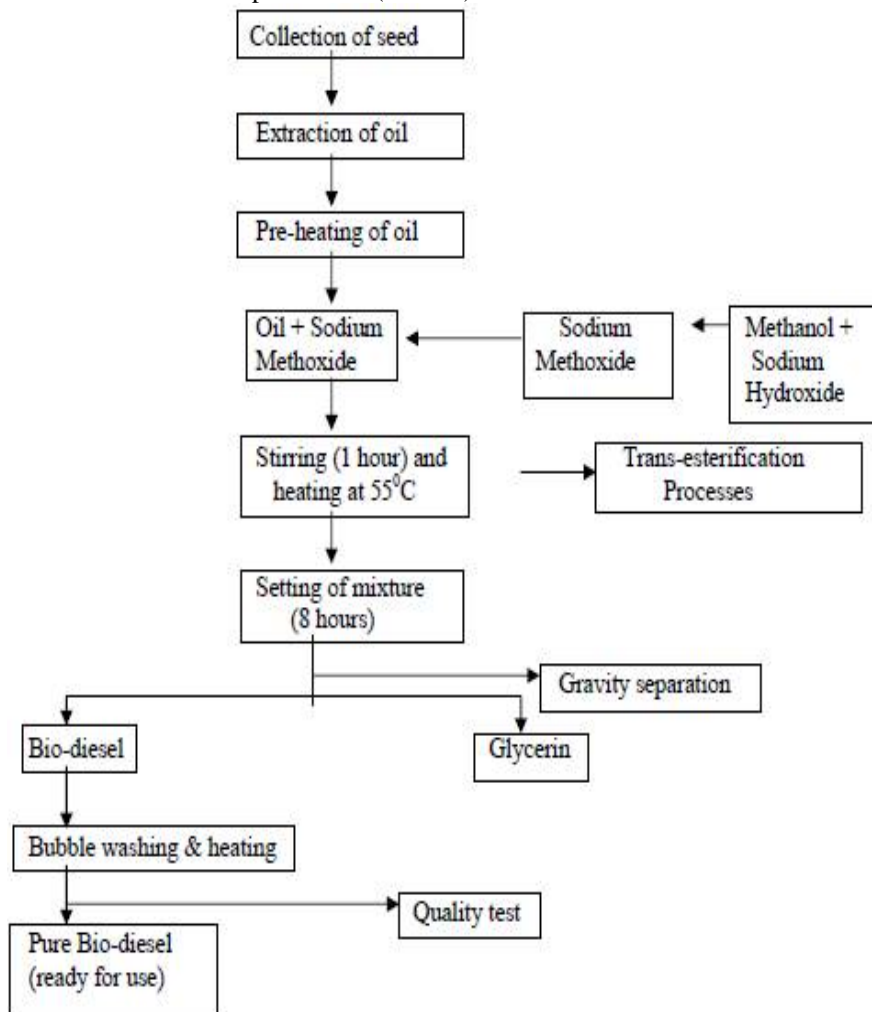


Fig. 2: Transesterification process [27]

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

Esterification Reaction			
Reaction time	Reaction temperature	chemicals	quantity
60- 80min.	60 -65°C	H ₂ SO ₄	0.5%
		Methanol	13%
Transesterification Reaction			
After esterification to check Fatty acid level (<1 % suitable for transesterification).			
60- 65 min.	60 -65°C	NaOH	1%
		Methanol	13%

Table 3: Observation table (Oil taken for reaction = 1 Lit. Karanja oil) [26]

Two of major properties that influence the production process of biodiesel are the FFA present in the oil and its water content. Transesterification will not occur if FFA > 3%. The FFA content of karanja oil can be as high as 15.62% (equivalent to 31.24 mg of KOH/g sample) and water content as 10.2% depending on the source [27]. Table 4 shows Properties of karanja oil methyl esters.

Property	CKO methyl ester	EN 14214/ASTM limits
Acid value, KOH, mg g ⁻¹	0.17	0.5 max
Water content,%	0.038	0.05% max
Kinematic viscosity (40 °C), mm ² /s	4.66 ± 0.02	3.50–5.00
Cloud point, °C	6	NS ^a
Pour point, °C	3	NS ^a
Flash point, °C	212	120 min
Density (15 °C), g cm ⁻³	0.883	0.860–0.900
Group 1 metals (Na + K), mg/kg		0.5
Refractive index (at 40 °C)	1.478	NS ^a
Free glycerin, wt.%	0.0064	0.02
Total glycerin, wt.%	0.082	0.240
Phosphorus, mg/kg	0.04	<4–10
Monoglyceride content, wt.%	2.63	<0.8
Diglyceride content, wt.%	0.78	<0.2
Triglyceride content, wt.%	0.06	<0.2

Table 4: Properties of karanja oil methyl esters [27]

VI. RESULT

Many researchers worked on the Pongamia Pinnata oil and they found some result. The Compression ratio (CR) varied for all valid CR Brake thermal efficiencies of Pongamia oil methyl ester blends are very close to diesel and 20% blend with diesel, B20 provided the maximum efficiency for biodiesel operation. When injection pressures varied from 180 bar to 200 bar emissions reduced and performance increased. For 200bar injection pressure HC emissions decreased by 12.8 % for B20 and 3 % for B40 at full load but the BSEC was slightly more for B20 and B40. NOx decreased by 39 % for B20 and 28 % for B40 at full load. When the load varied by keeping other parameters constant thermal efficiency, bsfc, mechanical efficiency, volumetric efficiency are well comparable with diesel for diesel engine. Smoke density, CO, HC and even NOx emissions are less in case of Karanja biodiesel. Engine performance & Thermal efficiency recorded same as that of diesel in many experiments. When ethanol and karanja oil blend was used in diesel engine 70% blend showed good performance & higher thermal efficiency but, less than that of diesel engine. That means instead of diesel we can use ethanol-karanja oil blends in CI engine without any major modification.

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Vol. 5, Issue 3, March 2016

VII. CONCLUSION

In this review study we have seen different methods to improve the performance of karanja oil methyl ester fuelled compression ignition (C.I.) engine. Many researchers used different techniques for investigation and results were compared with the diesel fuel. Many experiments were conducted with Pongamia methyl ester (PME) by various Injection pressures, Compression ratios, additives, load etc. Almost all the experiments were conducted at a constant speed of 1500 rpm. It can be seen that all experiments showed improved performance and reduced emission of harmful gases. Injection pressure of 200 bar and 16:1 compression ratio can be used as optimum values and CI engines can be run with karanja biodiesel. Hence it can be concluded that the blends of honge methyl ester with diesel up to 40% by volume could replace diesel for running the diesel engine for getting less emissions without sacrificing the power output and will thus help in controlling air pollution to a great extent. In this paper we study the properties of karanja oil, Biodiesel production process, properties and result of karanja Biodiesel as an alternative fuel for CI engine. Based on this study on karanja biodiesel, we can conclude that the karanja oil can be used as an alternative fuel for diesel engine without any modification.

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