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Suitability of Some Fruit Seeds Oil for Use as Biodiesel Fuel

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Abstract: ***Due to recent petroleum crisis 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. Bio fuels are being given serious consideration as potential sources of energy in the future. Biodiesel is a clean burning alternate fuel, produced from both edible and non-edible oil seeds. It can be used in compression-ignition engines with little or no modifications. Biodiesel is simple to use, biodegradable, nontoxic, and essentially free of sulfur and aromatics. It can be stored just like petroleum diesel fuel. The use of biodiesel in conventional diesel engines results in substantial reduction of unburnt hydrocarbons, carbon monoxide and particulate matters. Its higher cetane number improves the ignition quality even when blended in petroleum diesel. Various fruit contain large amount of oil in their seeds. Studies have been undertaken to compare free fatty acid composition and physico chemical properties of seeds oil & biodiesel produced from various fruit seeds such as Chikku, Awala, Jamun, Tamarindus Indicus, Orange, Moringa Oleifera etc.***

Keywords: Fruit seeds, transesterification, Biodiesel, Ethyl ester

1. Introduction

Biofuels have become one of the major solutions to issues of sustainable development, energy security and a reduction of greenhouse gas emissions. Biodiesel, an environmental friendly diesel fuel similar to petro-diesel in combustion properties, has received considerable attention in the recent past worldwide, Biodiesel is a methyl or ethyl ester made from renewable biological resources such as vegetable oils (both edible and nonedible), recycled waste vegetable oil and animal fats. The use of vegetable oils as alternative fuels has been in existence long ago but was set aside due to the availability of petroleum products which appears to be cheaper.[1]

Biodiesel is now recognized as an alternative because it has several advantages over conventional diesel. It is safe, renewable and non-toxic. It contains less sulphur compounds and has a high flash point (>130°C). It is almost neutral with regards to carbon dioxide emissions, and emits 80% fewer hydrocarbons and ~50% less particles. It enjoys a positive social impact, by enhancing rural revitalization. It is the only alternative fuel currently available that has an overall positive lifecycle energy balance.

2. Oil Extraction Process

Various techniques such as mechanical extraction, solvent extraction, traditional extraction and super critical fluid extraction are used to obtain the oil from the seeds. The solvent extraction has become the most popular method of extraction of oil because of its high percentage of oil recovery from seeds. Solvent extraction bridges the gap between mechanical extraction which produces oil with high turbidity metal and water content and supercritical fluid extraction which is very expensive to build and maintain its facilities. Temperature is increased for oilseeds after pre-treatments such as cracking, dehulling and milling by heating, roasting and steaming of oilseeds prior to extraction and is termed thermal treatment of oilseeds. Better extraction is achieved by heating, which reduces the oil viscosity and released oil from intact cells, and also reduces moisture in the cells. Temperature plays an active role in the seed treatment for mechanical extraction and ensures an effective solvent process by heating the solvent which hastens the extraction process. At the right temperature and moisture content, the individual oil droplets unite to form a continuous phase and flow out maximizing oil yield. Solvent extraction is the use of chemicals as solvents in the extraction of oil from oilseeds. Solvent extraction is known for its high yielding oil output, ease and swiftness to carry out: relatively cost effective, high overhead cost, and hazardous effects during and after operations. The use of this method requires a complete refining process to ensure traces of the solvents to be removed totally. Solvent extraction of cleaned, cracked, dehulled and conditioned flakes with hexane is commercially practiced to extract oil. [2]

3. Biodiesel Production

Generally two stage transesterification process is used for the production of biodiesel. This process consists of a sequence of three consecutive reversible reaction i.e. conversion of triglycerides to diglycerides followed by diglycerides to monoglyceride. The glycerides were converted into glycerol and one ester molecule at each step. If the oil contains more than 4% free fatty acids (FFA), then a two step transesterification is applicable to convert the high FFA oils to its mono esters. The first step, the acid catalyzed esterification reduces the free fatty acid content of the oil.

$$\text{Vegetable oil} + \text{Alcohol} \underset{}{\overset{\text{acid}}{\rightleftharpoons}} \text{Triglyceride} + \text{water}$$

The second step, alkaline transesterification process converts the products of the first step to its mono-esters and glycerol. In this process vegetable oils are heated to temperature of 80-85^{0}C by placing in water bath. Similarly alcohol is heated to

65^0C in the presence of alkali catalyst. Both vegetable oil and alcohol are combined together at a temperature of 60-65^0C. The reaction results in the formation of esters and glyceride. If water is mixed to the mixture, soap will be formed which reduces the formation of biodiesel. The chemical reaction is

$$\text{Triglyceride} + \text{alcohol} \xrightleftharpoons{\text{alkali}} \text{Glycerol+alkyl esters}$$

Simple alcohols are used for transesterification and this process is usually carried out with a basic catalyst (NaOH, KOH) in the complete absence of water. The bonding of alcohol and organic acid produces ester. An excess of alcohol is needed to accelerate the reaction. With methyl alcohol glycerol separation occurs readily. In the transesterification process alcohol combines with triglyceride molecule from acid to form glycerol and ester. The glycerol is then removed by density separation. Transesterification decreases the viscosity of oil, making it closer to diesel fuel in characteristics. [3]

4. Various Fruit Seeds

1) Chikku seeds (Manilkara Zapota):

Free fatty acid composition in percentage [4]
Linoleic: 17.92
Linolenic: 1.86
Oleic: 64.15
Stearic : 2.80
Palmitic: 13.27

Physico chemical properties of Chikku seed oil: [4]
Percentage oil content in kernel (%): 23-30%
Kinematic viscosity mm^2/s (40^0 C): 34.75
Density (Kg/m^3): 887
Acid value (mg KOH/g): 3.79
Iodine value (g Iodine/100g):65.02
Peroxide value (g/kg O_2): 269.54

Physico chemical properties of Chikku seed Ethyl ester:
Density (Kg/m^3): 875
Kinematic viscosity (mm^2/s): 4.67
Flash point (^{0}C): 174
Pour Point (^{0}C): -6
Iodine value (g Iodine/100g):65.28
Acid value (mg KOH/g): 0.15
Calorific value (KJ/kg): 37200
Cetane number: 52

2) Awala seeds (Phyllanthus emblica):

Free fatty acid composition in percentage [5]
Linolenic: 8.8
Linoleic: 44.0
Oleic: 28.4
Stearic : 2.1
Palmitic: 3.0

Physico chemical properties of Awala seed oil: [5]
Oil content in seeds oil %by wt.:16.7
Density (Kg/m^3): 922.1
Refractive index: 1.4870
Acid Value (mg KOH): 2.3
Saponification value: 192.8
Iodine value: 139.5

Physico chemical properties of Awala seed Ethyl ester: [5]
Viscosity (30^0C): 4.1
Carbaon Residue (%): 0.11
Calorific value (KJ/Kg): 44000-47000
Density (Kg/m^3): 920

3) Jamun seed (Syzygium cumini):

Free fatty acid composition in percentage [7]
Lauric: 2.8
Myristic: 31.7
Palmitic: 4.7
Stearic: 6.5
Oleic: 32.2
Linoleic: 16.1
Malvalic:1.2
Sterculic:1.8
Vernolic:3

Physico chemical properties of Jamun seed oil: [6]
Oil Content: 10%
Acid Value (mg KOH): 1.711
Iodine Value (g/100g): 97.12

Saponification Value: 180
Refractive Index: 1.481
Density (Kg/m^3): 943.2

Physico chemical properties of Jamun seeds Methyl ester:[8]
Calorific value (KJ/Kg): 40700
Kinematic viscosity mm^2/s (40^0 C): 4.72
Density at 15^0C in Kg/m^3:872
Flashpoint (^0C): 76
Fire point (^0C): 92
Cetane number: 58

4) Tamarindus Indicus Seed:

Free fatty acid composition in percentage [9]
Oleic: 0.19
Linoleic: 0.41
Myristic: 1
Luric:0.32
Octanoic: 0.3
Stearic: 0.4
Palmitic: 0.13
Lignoceric:0.14
Arachidic : 0.06
Behenic: 0.02

Physico chemical properties of Tamarindus Indicus seed Ethyl ester: [9]
Kinematic viscosity mm^2/s (40^0 C): 38.00$\pm$0.10
Density (Kg/m^3): 911
Flash point (^0C): 110
Pour point (^0C): -4
Iodine value: 95.00$\pm$0.40
Saponification Value (mg KOH/g): 186.10$\pm$0.30
Cloud point (^0C): 2
Acid Value: 0.5$\pm$0.02

5) Orange seeds (Citrus reticulate):

Free fatty acid composition in percentage [11]
Linoleic: 37.65
Linolenic: 3.80
Oleic: 25.55
Stearic : 4.62
Palmitic: 26.90
Asclepic: 1.20

Physico chemical properties of Orange seed oil:[10]
Oil Content: 84%
Calorific value (KJ/Kg): 34650
Kinematic viscosity mm^2/s (40^0 C): 3.52
Acid Value (mg KOH): 51.40
Density (Kg/m^3): 816.9
Cetane number: 47
Fire point (^0C): 82
Flash point (^0C): 74
Saponification Value: 194.25

Physico chemical properties of Orange seed Ethyl ester: [11]
Calorific value (KJ/Kg): 34650
Kinematic viscosity mm^2/s (40^0 C): 4.17$\pm$0.18
Flash point (^0C): 1.64$\pm$3.2
Acid Value (mg KOH): 0.34$\pm$0.03
Density (Kg/m^3): 882$\pm$13
Cetane number: 57.6$\pm$2.26
Cloud Point (^0C): 10.00$\pm$0.13
Pour point (^0C): 8.00$\pm$0.12

6) Moringa Oleifera seeds:

Free fatty acid composition in percentage [12]
Linolenic: 17.1
Linoleic: 19.5
Oleic:56.2
Stearic: 4.6

Physico chemical properties of Moringa Oleifera seed oil: [12]
Oil Content: 38.9%
Density (Kg/m^3):1000
Saponification Value: 252
Iodine Value (g/100g): 140
Refractive Index: 1.462

Physico chemical properties of Moringa Oleifera seed Ethyl ester: [13]
Calorific value (KJ/Kg):18841.5

Kinematic viscosity mm^2/s (40^0 C): 4.83
Cloud point (^{0}C): 18
Pour point (^{0}C): 17
Cetane Number: 67.07

5. Conclusion

Various fruit seeds are found to be very good and viable feed stock for biodiesel production. The major limitations of all the oils were mostly high free fatty acid values. These high values make them more suitable for two stage process of transesterification in order to obtain reasonable yields of the methyl ester. The various properties were compared with diesel and found to be quite closer and hence can be used in existing diesel engines without any modification.

6. Future Scope

In addition to the above there are so many fruit seeds unutilized and underutilized for biodiesel production which can be taken for the studies.

References

[1] Siddalingappa R. Hotti and Omprakash D. Hebbal, "Biodiesel Production Process Optimization from Sugar Apple Seed Oil (Annona Squamosa) and Its Characterization", Journal of Renewable Energy, ID-148587, (2015)
[2] M. O. Aremu, H. Ibrahim and T. O. Bamidele, "Physicochemical Characteristics of the Oils Extracted from some Nigerian Plant Foods- A Review", Chemical and Process Engineering Research, 2225-0913, pp 36-42 (2015).
[3] Visnusarathy Dhakshinamurthy Gobichettipalayam, Bala Murugan R., "Experimental Investigation of Performance and Emission Characteristics of Jamun Seed Oil Methyl Ester (JOME) in Single Cylinder Compression Ignition Engine", International Journal of Science, Engineering and Technology Research, 2278-7798, pp 3203-3212, (Dec. 2014)
[4] R. Satish Kumar, K. Sureshkumar, & R. Velraj "Optimization of biodiesel production from Manilkara zapota(L.) seed oil using Taguchi method", ELSEVIER Fuel 140, pp 90-96(2015)
[5] Dr. Prashant B. Shingwekar, "Green Chemical from Awala (Phyllanthus emblica) and Hirda (Terminalia Chebula) seeds oil of Vidarbha Region of Maharashtra", IOSR Journal of Applied Chemistry, 2278-5736, pp 73-76(2014).
[6] Mr. K. Vignesh, Mr. C. V. Durai Arasan & Mr. K. Veeramanikandan, "Analysis on performance and emission using Jamun Methyl ester blended fuel in VCR engine, International Journal of Technology & Engineering Research, 0980-9589, (2016).
[7] Shrikant Baslingappa Swami, Nayan Singh J. Thakor, Meghatai M. Patil & Parag M. Haldankar, "Jamun (Syzygium cumini (L.)): A review of its food and Medicinal uses", Food & Nutrition Sciences, 38146, pp1100-1117 (2012).
[8] Dr. Akleshwar Mathur, "Extraction and characterization of Syzygium cumini (Jamun) seed oil", IJAREST, 2393-9877 volume 2 (2015).
[9] Balaji Panchal, Sanjay Deshmukh & Munish Sharma, "Optimization of oil extraction and characterization from tamarindus indica Linn seed oil", International Journal of Oil, Gas & Coal Engineering, pp1-6, doi: 10.11648/j.ogce. 20140201.11 (2014).
[10] K. Dinesh Kumar & Dr. G. Prasanthi, "Experimental investigation on a Diesel engine fuelled with Orange oil Diesel blends using E. G. R. system, Transactions on Engineering and Sciences, 2347-1964, Vol. 2, pp 32-36, (2014)
[11] Umer Rashid, Muhammad Ibrahim, Shahid Yasin, Robiah Yunus, Y. H. Taufic-Yap & Gerhard Knothe, " Biodiesel from Citrus reticulate (mandarin orange) seed oil, a potential non-food feedstock", ELSEVIER Industrial Crop and Products, pp 355-359, (2013).
[12] Akleshwar Mathur Ph. D., " Renewable energy sources from Moringa Oleifers seed oil: A Rich source of oil for Biodiesel, International Journal of Computer Applications, 0975-8887, pp5-7, (2014).
[13] Umer Rashid, Farooq Anwar, Brayan R. Moser & Gerhard Knothe, " Moringa oleifera oil: A possible source of biodiesel", ELSEVIER Bioresource Technology, 0960-8524, PP 8175-8179, (2008)