Identification of Non-Conventional Seeds Oil as a Potential Feedstock for Biodiesel Production

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Abstract: ***Energy is the critical input factor for the socioeconomic development and welfare of human being of any country. Fossil fuels are the major sources for the energy demand since their exploration. Due to limited reserves of fossil fuels, environmental degradation, and volatility in fuel prices, there is a growing need for energy security and protection of the environment. Country like India with an agricultural background has wasteland of about 55.27 million hectares, which can be utilized for growing plants/crops, which produce non-edible oil in appreciable quantity. Various non-convetional fruit seeds containing large amount of oil such as Soap nut, Hirda, Gulmohar, Hingot, Babool, Cotton, etc. can be used for biodiesel production. Thus indigenously produced biodiesel, which is defined as the mono-alkyl ester of vegetable oils or animal fats, obtained by transesterifying oil or fat with an alcohol, is considered one of the options to substitute the petroleum fuels.***

Keywords: Non- conventional Fruit seeds, transesterification, Biodiesel, Ethyl ester etc

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 non-edible), 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.

$$\text{Vegetable oil} + \text{Alcohol} \xrightleftharpoons{\text{acid}} \text{Triglyceride} + \text{water}$$

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^{0}C in the presence of alkali catalyst.

Both vegetable oil and alcohol are combined together at a temperature of 60-65^{0}C. 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. [2]

4. Various Fruit Seeds

1) Sapindus Mukrossi (Soapnut) oil seeds:

Free fatty acid composition in percentage []

Linoleic: 4.73
Oleic: 52.64
Stearic: 1.45
Palmitic: 4.67
Palmitoleic: 0.37
Arachidic: 7.02
Eicosenic: 23.85
Erucic: 1.09
Alpha or Gamma linolenic: 1.94
Behenic: 1.45
Lignoceric: 0.47

Physico chemical properties of Soapnut seed oil:-[3]

Oile Content: 30-35%
Calorific value (KJ/Kg): 38171
Kinematic viscosity mm^2/s (40^0 c): 3.5
Flash point (^{0}C): 236
Fire point (^{0}C): 238
Density (Kg/m^3): 902
Cetane number : 58

Physico chemical properties of Soapnut seeds Methyl ester:[4]

Calorific value (KJ/Kg): 40020
Kinematic viscosity mm^2/s (40^0 C): 4.630
Density at 15^{0}C in Kg/m^3: 874
Flashpoint (^{0}C): 165
Cloud point (^{0}C): -1
Pour point (^{0}C): -4
Cetane number: 56

2) Terminalia Chebula (Hirda) oil seeds:

Free fatty acid composition [5]

Linolenic: 1.1
Linoleic: - 23.3
Oleic: 54.8
Stearic: 9.6
Palmitic: 1.4
Myristic: 1.9

Physico chemical properties of Hirda seed oil: [5]

Oil content: 32.6 %
Density (Kg/m^3): 913.2
Refractive index: 1.47
Acid Value (mg KOH): 4.9
Saponification Value: 201.3
Iodine value: 107.3

Physico chemical properties of Hirda seeds Methyl ester: [5]

Calorific value (MJ/Kg): 38-40
Kinematic Viscosity (30^0 C): 5.6
Density (Kg/m^3): 910
Carbon Residue (%): 0.23

3) Delonix Regia (Gulmohar)

Free fatty acid composition in percentage [6]

Linolenic: 18.6
Linoleic: 41.2
Oleic: 21.3
Stearic 6.1
Palmitic: 9.1
Archidic: 17.5

Physico chemical properties of Delonix Regia seed oil: [7]

Oil content: 30.8%
Density (Kg/m^3): 933
Kinematic viscosity mm^2/s (40^0 C): 36.65
Refractive index: 1.42
Acid Value (mg KOH): 4.88
Saponification value: 198.23
Iodine value: 117.46

Peroxide Value (mg O/g oil): 3.82
Cloud Point (^{0}C) : 13

Physico chemical properties of Delonix Regia seed Ethyl ester: [8]

Density (Kg/m^3):859
Kinematic Viscosity (40^{0}C):4.0
Pour Point (^{0}C):-21
Cloud Point (^{0}C): 4.4
Flash Point (^{0}C):110
Calorific value (KJ/Kg): 37200
Acid Value (mg NaOH): 0.3

4) Balanites Roxburghii (Hingot):

Free fatty acid composition in percentage [10]

Palmitic: 16.07
Palmitoleic: 0.08
Stearic: 7.74
Oleic: 39.79
Linoleic: 34.95
Linolenic: 0.07

Physico chemical properties of Hingot seed oil: [10]

Oil Content : 45%
Acid Value (mg KOH): 0.43
Iodine Value (g/100g): 95.7
Saponification Value: 197.7
Density (Kg/m^3): 870
Kinematic viscosity mm^2/s (40^0 C): 22.3
Pour Point (^{0}C):-6
Cloud Point (^{0}C): -4

Physico chemical properties of Hingot seeds Methyl ester:[11]

Kinematic viscosity mm^2/s (40^0 C): 3.8
Density at 15^{0}C in Kg/m^3:836
Pour Point (^{0}C):3
Cloud Point (^{0}C): 4
Acid Value (mg KOH): 0.3
Iodine Value (g/100g): 96.7
Calorific value (KJ/Kg): 39650

5) Acacia Raddiana Seed:

Free fatty acid composition in percentage [13]

Linoleic: 21
Stearic: 6
Oleic: 34
Palmitic: 38.3
Others: 0.5

Physico chemical properties of Acacia Raddiana seed oil: [13]

Oil Content (%): 11%
Acid Value (mg KOH): 0.4
Iodine Value (g/100g): 63.32
Density (Kg/m^3): 912
Kinematic viscosity mm^2/s (40^0 C): 37.4

Physico chemical properties of Acacia Raddiana seed Ethyl ester: [13]

Refractive index: 1.3896
Kinematic viscosity mm^2/s (40^0 C): 4.1
Density (Kg/m^3): 876
Iodine value: 63.10
Calorific value (KJ/Kg): 32780

6) Gossypium (Cotton) Seed:

Free fatty acid composition in percentage:[14]

Linolenic: 1
Linoleic: 54
Oleic: 19
Myristic: 0.4
Stearic: 2
Palmitic: 20
Palmotoleic : 0.4

Physico chemical properties of Cotton seed oil: [14]

Oil Content (%): 18-25%
Iodine Value (g/100g):105
Density (Kg/m^3): 912
Flash Point (^{0}C): 207
Fire point (^{0}C): 230
Kinematic viscosity mm^2/s (40^0 C): 55.61
Cetane number: 52
Calorific Value (Kj/Kg): 38000

Physico chemical properties of Cotton seed Ethyl ester: [15]

Kinematic viscosity mm^2/s (40^0 C): 3.5
Density (Kg/m^3): 862.4
Flash point (^{0}C): 200
Fire Point (^{0}C): 56
Gross Caloric Value (Kj/Kg): 35660
Cetane number: 38

5. Conclusion

Various non-conventional 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 non-conventional fruit seeds unutilized and underutilized for biodiesel production which can be taken for the studies.

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