Feasibility of Using Various Fruit Seeds Oil As A Source of Biodiesel

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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 nonedible oil in appreciable quantity. 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. Various fruit seeds containing large amount of oil in their seeds such as Mango, Custard Apple, Papaya, Cucurbita Pepo, Luffa Cylindrica, Cucumis Melo can be used for biodiesel production.

Keywords - Fruit seeds, transesterification, Biodiesel, Ethyl ester.

I. 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.[10]

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.

II. 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.[2] 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.

III. 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.

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

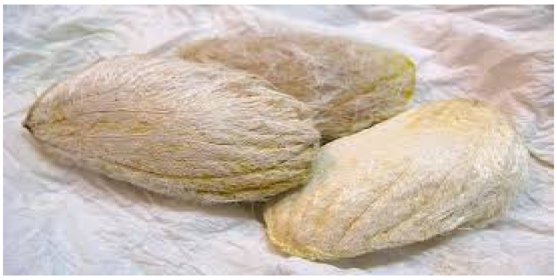
The second step, alkaline transesterification process converts the products of the first step to its mono-esters and glycerol. In this process vegetable oils are heated to temperature of 80-85^{0}C by placing in water bath. Similarly alcohol is heated to 65^{0}C in the presence of alkali catalyst. Both 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

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

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.[20]

IV. VARIOUS FRUIT SEEDS

1) Mango seeds (Mangifera Indica):



Free fatty acid composition in Methyl ester [4]

Linoleic: 32.15

Oleic: 37.29

Stearic : 4.07

Palmitic: 24.73

Lauric: < 0.01

Palmitoleic: <0.01

Archidic: 0.42

Myristic: 0.49

Margaric: <0.01

Physico chemical properties of Mango seed oil: [3]

Calorific value (MJ/Kg): 41.803

Kinematic viscosity mm^2/s (40^0 C): 20.97

Flash point (^{0}C): 298

Fire point (^{0}C): 315

Pour Point (^{0}C): 6

Density (Kg/m^3): 917

Cetane number: 50.6

Physico chemical properties of Mango seed Ethyl ester: [5]

Calorific value (MJ/Kg): 41.924

Kinematic viscosity mm^2/s (40^{0}C): 5.18

Flash point (^{0}C):166

Pour point (^{0}C): 7

Cloud point (^{0}C): 0

Fire point (^{0}C): 179

Density (Kg/m^3): 894.3

Cetane number: 51.6

2) Custard Apple seeds (Annona Squamosa):

Free fatty acid composition in Methyl ester Custard Apple seed oil [7]

Linoleic: 29.13

Oleic: 39.72

Stearic : 4.29

Palmitic: 17.79

Lauric: 0.08

Arachidonic: 1.06

Behenic: 2.01

Linolenic: 1.37

Physico chemical properties of Custard Apple seed oil: [6]

Kinematic viscosity mm^2/s (40^0 C): 27

Acid Value (mg KOH): 11

Saponification value: 117

Refractive index: 1.469

Iodine value: 145

Density (Kg/m^3): 740

Physico chemical properties of Custard Apple seed Ethyl ester:[8]

Calorific value (MJ/Kg): 37.51

Kinematic viscosity mm^2/s (40^0 c): 5.7

Flash point (^{0}C): 150

Cloud point (^{0}C): 2

Pour point (^{0}C): 5

Density (Kg/m^3): 865

3) **Cucumis Melo seeds:**

Free fatty acid composition in Methyl ester [16]

Linoleic: 50.34$\pm$0.53

Oleic: 21.12$\pm$0.71

Stearic: 10.84$\pm$0.18

Palmitic:17.68$\pm$0.47

Physico chemical properties of Cucumis Melo seed oil: [1]

Kinematic viscosity mm^2/s (40^0 c): 0.81

Flash point (^{0}C): 298

Acid Value (mg KOH): 5.40

Iodine Value (g/100g): 135.36

Saponification Value: 112.19

Refractive Index: 0.71

Physico chemical properties of Cucumis Melo seed Ethyl ester: [16]

Calorific value (MJ/Kg): 45.02$\pm$0.98
Kinematic viscosity mm^2/s (40^0 C): 4.75$\pm$0.04
Cloud point(^{0}C): 1.00$\pm$0.12
Pour point(^{0}C): -3.00$\pm$0.14
Flash point (^{0}C): 148$\pm$3.00
Acid Value (mg KOH): 0.45$\pm$0.03
Density (Kg/m^3): 892$\pm$15.7
Cetane Number: 58.0$\pm$1.52

4) **Pumpkin seed (Cucurbita Pepo):**

Free fatty acid composition in Pumpkin seed oil [15]

Linolenic: 0.68$\pm$0.14

Linoleic: 35.6-60.8

Oleic: 21-46.9

Stearic: 3.1-7.4

Palmitic: 9.5-14.5

Palmitoleic: 0.58$\pm$0.14

Gadoleic: 1.14$\pm$0.00

Physico chemical properties of Pumpkin seed oil: [1]

Kinematic viscosity mm^2/s (40^0 C): 0.7

Flash point (^{0}C): 312

Acid Value (mg KOH): 36.47

Iodine Value (g/100g): 150.37

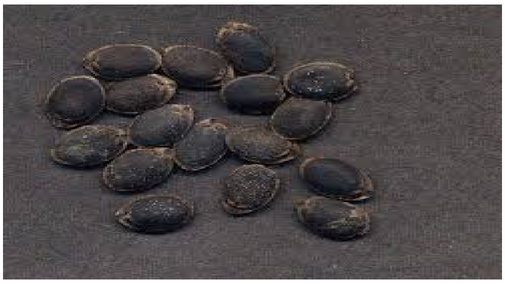
Saponification Value: 162.69

Refractive Index: 0.73

Physico chemical properties of Pumpkin seeds Methyl ester: [14]

Calorific value (MJ/Kg): 40.84
Kinematic viscosity mm^2/s (40^0 C): 2.20
Cloud point (^{0}C): 5
Iodine value: 104.36
Acid Value(mg KOH): 0.39
Saponification value: 190.69
Cetane number: 60.01

5) Luffa Cylindrica seeds:



Free fatty acid composition in Luffa Cylindrica seed oil [12]

Linoleic: 31.47

Oleic: 2.57

Stearic: 15.17

Palmitic: 12.86

Arachidic : 5.04

Myristic: 0.2

Palmitoleic: 0.1

Linolenic: 0.1

Behenic: 0.1

Arachidonic: 2.2

Physico chemical properties of Luffa Cylindrica seed oil: [1]

Calorific value (MJ/Kg): 30.20

Kinematic viscosity mm^2/s (40^0 C): 0.92

Flash point (^{0}C): 338

Acid Value (mg KOH): 2.47

Iodine Value (g/100g): 153

Saponification Value: 202

Refractive Index: 1.46

Density (Kg/m^3): 930

Cloud point (^{0}C): 8

Pour point (^{0}C): 3

Physico chemical properties of Luffa Cylindrica seed Ethyl ester: [11][13]

Calorific value (MJ/Kg): 28.75
Kinematic viscosity mm^2/s (40^0 C): 25
Flash point (^{0}C): 86
Pour point (^{0}C): 4
Refractive index: 1.46
Iodine value: 0.3
Saponification Value(mg KOH/g): .01
Cloud point(^{0}C): 7
Density (Kg/m^3): 880
Acid Value: 2.47

6) Papaya seeds (Carica Papaya):

Free fatty acid composition in Papaya seed oil [19]

Linoleic: 3

Linolenic: 0.2

Oleic: 76.8

Stearic : 4.9

Palmitic: 13.9

Palmitoleic: 0.2

Archidic: 0.4

Myristic: 0.2

Ecosonic: 0.3

Physico chemical properties of Papaya seed oil:[17]

Kinematic viscosity mm^2/s (40^0 C): 38.4

Acid Value (mg KOH): 0.72

Density (Kg/m^3): 910

Iodine Value (g/100g): 112.62

Cetane number: 63.75

Refractive Index: 1.469

Saponification Value: 195.8

Physico chemical properties of Papaya seeds Ethyl ester: [18]

Calorific value (MJ/Kg): 36.4
Kinematic viscosity mm^2/s (40^0 C): 3.57
Flash point (^{0}C): 198
Acid Value (mg KOH): 0.72
Density (Kg/m^3): 900
Iodine value: 112.62
Cetane number: 63.75
Cloud Point(^{0}C): 275
Pour point (^{0}C): 274

V. CONCLUSION

Various fruit seeds are found to be very good and viable food stock for biodiesel production. The major limitations of all the oils were mostly high free fatty acids 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.

VI. 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.

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