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STUDY ON FUEL PROPERTIES OF VARIOUS VEGETABLE OIL AVAILABLE IN BANGLADESH AND BIODIESEL PRODUCTION

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Abstract: The present review aims to study the prospects and opportunities of introducing vegetable oils and their derivatives as fuel in diesel engines. Some fuel properties are always available in vegetable oils. In this investigation Cottonseed oil, Mosna oil and Sesame oil are chosen for producing biodiesel as an alternative fuel for diesel engine. Fuel-related properties of these oils are reviewed and compared with those of conventional diesel fuel. Biodiesel is produced by transesterifying the oil with an alcohol such as methanol under mild conditions in the presence of a base catalyst. Satisfactory amount of biodiesel is produced from Cottonseed oil at 3:1M ratio of methanol and oil. Biodiesel from cottonseed oil has various fuel properties which are similar to diesel. The cost of biodiesel production is also analyzed. This paper discusses in a general a perspective of biodiesel.

Keywords: Vegetable oil, Biodiesel, Transesterification.

1 Introduction

The technological, socio-economical and industrial development of any country diametrically depends on energy input. Petroleum oil, natural gas, electricity and coal are the vital sources of energy through the world commercially. The current energy requirement in Bangladesh is fulfilled mostly by using natural gas, fossil-based fuels such as petroleum product, coal etc. More than 90% energy demand for transportation is largely depends on petroleum product such as petrol and diesel of them diesel requirement is enormously higher. Due to increasing energy demand for such a densely populated country, it is requisite to develop alternative fuels as supplement. Biodiesel, the non-toxic fuel, is biodegradable and environmentally benign fuel used in diesel engines. Biodiesel does not contain any sulphur or aromatic compounds and its combustion results in lower emission of carbon monoxides, hydrocarbons and particulates [1].

Biodiesel is defined as the mono-alkyl esters of vegetable oils or animal fats, produced by using bio-chemical method known as transesterification. Direct use of vegetable oils cause some problem like poor atomization of fuel, incomplete combustion with heavy smoke emission, carbon deposition, sticking of oil rings, injector chocking mainly due to the high viscosity of SVOs (straight vegetable oils) which are already investigated by various researchers. Another problem is low volatility of vegetable oil due to high flash point. To overcome these problems transesterification has been followed to produce biodiesel. It has been found that vegetable oils hold special promise in this regard, because they can be grown up easily from the plants in rural areas. Vegetable oils from crops such as soybean, peanut, sunflower, rape, coconut, karanja, neem, cotton, mustard, jatropha, linseed and caster have been evaluated in many parts of the world in comparison with other non-edible oils.

Use of bio-diesel is catching up all over the world especially in developed countries. In Malaysia, the tropical climate encourages production of bio-diesel from palm oil. The US is contributing 25% of the world green house gases: i.e., oil and coal. We also need to reorganize its 70% of oil consumption is in transportation. On the basis of a report in 2007, USA uses 50 million gallons and European countries use 350 million gallons of bio-diesel annually. It is mixed with 20% of bio-diesel in fossil diesel. France is the country which uses 50% of bio-diesel mixed with diesel fuel. In Zimbabwe, 4 million jatropha has been planted in 2000 ha by the end of 1997. In Nicaragua, one million Jatropha curcas has been planted in 1000ha. The harvest of pods reached 3, 33,000 tones in the 5th year with a seed of 5000 tones and the oil extracted was approximately 1600 tons per annum. In Nepal, 22.5 ha of area are planted with 40,000 rooted cuttings of Jatropha curcas. The rural women co-operative have been trained to extract oil, produce soap and use 30:70 mixes [oil/kerosene] of oil and kerosene in stove without smoke [2].

Bangladesh is heavily dependent on import of fossil fuel and coal. Such dependency makes economy of Bangladesh more vulnerable to external price shocks in the international energy market. Price of fuel in the international market has been showing rising trend since last few years. Bangladesh annually imports about 3.5 million tons of different fuel oils. Of them, some 1.3 million tons are crude oil, 1.45 million tons diesel, 380 tons kerosene, 215 tons jet fuel and 155,000 tons petrol and octane. The search for alternatives of fossil fuels is a major environmental and political challenge also [3]. In Bangladesh, alternative fuels should be used for saving the conventional fuels and better future. It is easy to produce biodiesel in Bangladesh because there are many vegetable oils in Bangladesh such as Soyabean, Sunflower, Neem, Jatropha, Mustard, Cotton seed, Coconut etc. If these oils are used for producing biodiesel then the pressure on conventional fuels would be reduced significantly.

Bio-diesel production is not something new. The first engine was run using groundnut oil as fuel in 19th century. Among the alternative energy sources, vegetable oil-based fuels were reconsidered, with biodiesel in form of esters of sunflower oil to be reported in 1980. Murugesan et al. [2] studied on Bio-diesel as an alternative fuel for diesel engines and found "B20" (20% bio-diesel + 80% diesel) is the best. But brake-specific energy consumption for B20 is reduced slightly. Sumathi [4] studied about Utilization of oil palm as a source of renewable energy in Malaysia and found that palm oil is one of the most productive bio-diesel sources. Panwar et al. [5] studied on performance evaluation of a diesel engine fueled with methyl ester of Castor seed oil. They found Castor methyl ester (CME) blends showed performance characteristics close to diesel. Asadullah Al Galib and Md Roknuzzaman [6] studied in their undergraduate thesis on Biodisel from Jatropha oil as an alternative fuel and found that Jatropha oil has potential as an alternative energy source. Sharma and Bhaskar Singh [7] studied on an ideal feedstock, kusum (Schleichera triguga) for preparation of biodiesel and reported that kusum oil can be a possible feedstock for a large scale production of biodiesel. Fatnassi Saloua et al. [8] studied on Methyl ester of [Maclura pomifera (Rafin.) Schneider] seed oil for biodiesel production and characterization. They reported methyl esters with a high degree of unsaturation are not suitable for biodiesel as the unsaturated molecules react with atmospheric oxygen and are converted to peroxides. And biodiesel must have a flash point higher than 120 ˚C. Farooq Anwar et al [9], Umer Rashid, Muhammad Ashraf, Muhammad Nadeem studied on Okra (Hibiscus esculentus) seed oil for biodiesel production. Simon Michael Gmu¨nder et al. [10] studied about Life cycle assessment of village electrification based on straight jatropha oil in Chhattisgarh, India. They found that rural electrification based on extensive jatropha cultivation is environmentally friendly compared to the usage of fossil diesel or to connection to the local grid. Md. Nurun Nabi et al. [12] works on Karanja (Pongamia pinnata) in Bangladesh. Silitonga et al. [13] works on J. Carcas in Indonesia. Many writers' [11, 14] works on several methods of biodiesel production and its importance. Significant studies are available in the literature to use local vegetable sources as biodiesel. Some of these sources were found feasible for commercial use, for example veranda, jatrapha, etc.

However, there are a lot of vegetable sources still available which are not investigated by other and have prospective to be used as biofuel, for example, Cotton seed, Sesame, Mosna, Royna seed etc. This paper will highlight, mainly, the feasible study and properties of these available local vegetable sources (Cottonseed oil, Mosna oil, Sasame oil) to use as prospective biodiesel source. It will also include the cost analysis of biodiesel production.

2 Methodologies

2.1 Input selection

Different types of raw materials and chemicals are used for producing biodiesel which are as follows.

Cottonseed oil

Cottonseed is primarily used to make Cottonseed oil, It contains high levels of saturated fat, and tends to have high levels of pesticide residue as well, hence it is not healthy for human consumption. The benefits of cottonseed oil are mainly viewable from a manufacturing standpoint. It has an incredibly long shelf life and also a very high smoke point (450 degrees). Cottonseeds have little use outside of producing cottonseed oil.

Sesame oil

Sesame is considered as one of the important oil seed in Bangladesh. It contains 42.5- 46.2 % edible oil. As an annual crop it is cultivated widely almost in all the districts of Bangladesh because the soil texture and climatic condition of Bangladesh are quite suitable for its cultivation. The commonly cultivated varieties in the country are black and white seeded.

Mosna oil

Bangladesh has huge number of vegetable oil. Most of them are used for cooking. Mosna is one of them. This is mainly cultivated in the southern part of Bangladesh. The cultivation starts in Kartik and ripe at Poush (Bengali calendar month). This is used for cooking mainly. Mosna oil is similar to mustard oil and sicam oil. Now a day the use of this oil is decreasing rapidly because people like soybean oil and mustard oil more than any other oil. But, Mosna require less fertile land and cultivation is cheaper than other kind of vegetable oil. For this we have chose this oil. If anyone can find out a suitable use of this oil then the cultivation will increase. It will help the farmer of our country by using their unused lands. This will bring the financial benefit to farmers.

Alcohol Selection

Price is the main factor in determining which alcohol to use in the production process. Ethanol and methanol are the two most common options. High quality methanol is cheaper than ethanol; therefore, methanol is used in nearly all biodiesel operations Methanol can be obtained in quantities of 5 gallons or more from many bulk fuel distributors and from distributors of racing fuel. The cost of methanol represents a relatively large component of total cost of producing biodiesel.

Catalyst Selection

A catalyst is required to facilitate the reaction between the oil and the alcohol. The most common catalysts used in small scale biodiesel production are sodium hydroxide and potassium hydroxide. Catalysts such as sodium methoxide and potassium methoxide are also used. Availability and compatibility with processing equipment are the two main determinants of catalyst selection, although price is also a contributing factor.

2.2 Procedure

At first the oil is extracted from seeds and the fuel properties of them such as viscosity, calorific value, boiling point, etc are measured. Viscosity is measured by Universal Saybolt Viscometer and calorific value is measured by Bomb Calorimeter. Then the properties are compared with the diesel. The fuel properties of the selected oils are given in table. Then the transesterification reaction is accomplished in a stirred reactor maintaining the temperature 55-60˚C which is below the boiling point of methanol (65˚C).

The ratio of methanol to vegetable oil is kept at different ratio. Some producers use 3:1 molar ratio which is more rapid. Although the reaction with 6:1 molar ratio is little slower but it gives complete conversion of the oil to biodiesel. So 100% excess methanol (6:1 molar ratio) is used usually. But for optimum solution different ratio of methanol and vegetable oil are used in this project. The ratio of methanol and vegetable oil is kept 7:1, 6:1, 5:1, 4:1, 3.5:1, 3:1, 2:1 and 1:1. And it is shown that different oil shows different results at several molar ratio of methanol to vegetable oil.

Another step of biodiesel production is mixing the catalyst with alcohol. Sodium hydroxide and methanol are used; the resulting mixture is referred to as sodium methoxide. For production of

biodiesel different amount of catalyst are used in several beakers for several ratios of methanol and vegetable oil.
At the end of transesterification process the Biodiesel is segregated from sediments such as glycerin, catalyst etc and is done by mixing oil with 75% to 90 % of the methanol and catalyst and this mixture is allowed to react to equilibrium. Then, the glycerin that has formed is separated by gravity separation and the remaining 10% to 25% of the methanol and catalyst is added for second reaction period.
The layer of glycerin and biodiesel is shown different for different ratio of methanol and vegetable oil. For cottonseed oil the better clear layer is found at the 3:1 ratio. And at this ratio the biodiesel is clearly separated from glycerin after the reaction. For Mosna oil the better layer is found at the 3.5:1 ratio. But at this ratio the biodiesel is not fully separated from glycerin. And for Sesame oil the better but very poor layer than cottonseed oil is found at the 3.5:1 ratio but a very small amount of biodiesel can be estranged from glycerin. The total procedure of biodiesel production is shown schematically in figure1.

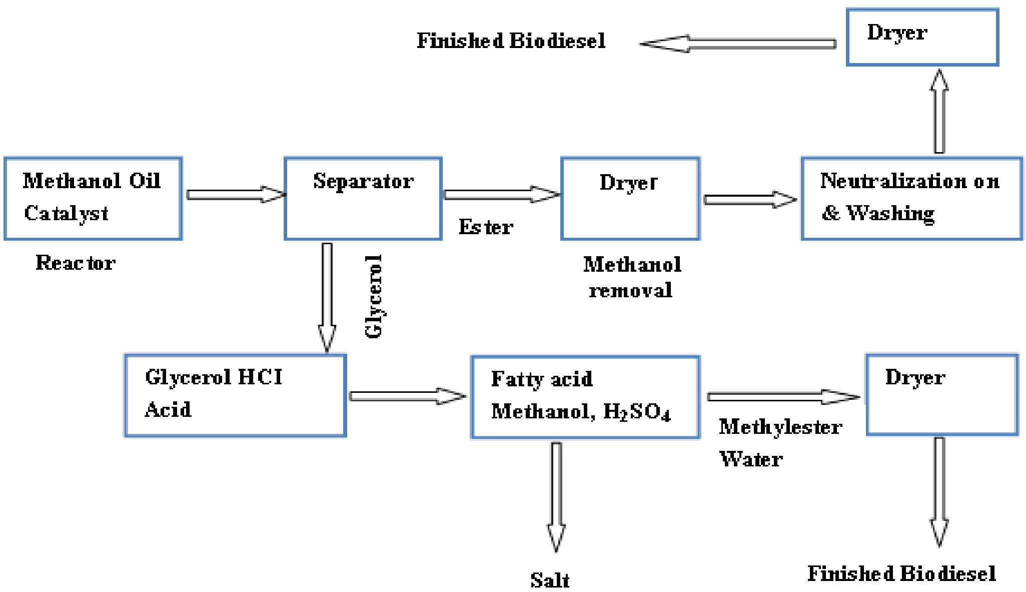

Fig 1: Schematic of Biodiesel Processing

The various phase of reaction while producing biodiesel by cottonseed oil are shown in the figure 2(a, b).

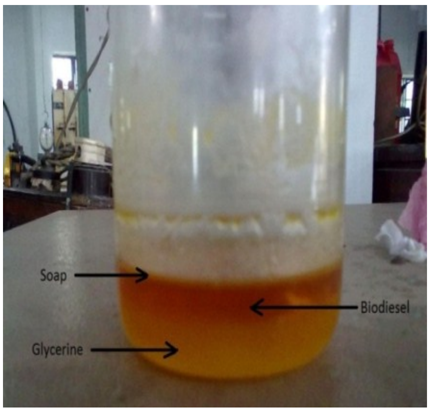

Figure 2(a): various layers found while reaction

Figure 2(b): Glycerin and soap after extraction of biodiesel

2.3 Final products
The transesterification process produces two products, biodiesel and glycerin.

Biodiesel: Biodiesel quality depends on the inputs and processing techniques used in its production. The American Society for Testing and Materials (ASTM) has developed quality standards for biodiesel. Unfortunately for small scale producers, the cost of testing a batch biodiesel is likely to exceed the value of the fuel produced. Fuel that has not been tested for ASTM standards generally cannot be marketed on a commercial basis. Most small scale producers will be limited to producing biodiesel for personal use. Lack of ASTM testing does not necessarily imply that fuel quality is poor, but small producers must focus on accurate processing procedures to ensure fuel quality. These steps may include proper filtering, accurate catalyst measurement and fuel washing procedures.

Glycerin: Glycerin produced during the biodiesel process is crude and unrefined. Numerous markets are available for refined glycerin, but these markets are not generally available to small producers because of the cost of glycerin refining. Crude glycerin produced in small scale biodiesel operations typically contains unreacted oil, catalyst, methanol (if not recovered during processing) and some biodiesel. Glycerin and biodiesel are generally considered as environmentally friendly, but the catalyst and methanol contained in crude glycerin are not. Thus, a producer's alternatives for disposing of crude glycerin may be limited. One option is to use the crude glycerin as fuel oil. Another is to compost it. Large volumes of liquid glycerin are produced in the biodiesel process (10% to 15% of biodiesel production) and adequate planning is required for successful composting. Some biodiesel producers also use glycerin as a dust suppressant or for soap making.

3 Cost analyses

Cottonseed:

Oil extraction from 2.5 kg of Cottonseed = 0.5 Liter, Oil extraction cost per liter = 50 Tk
Biodiesel production from 150 ml cottonseed oil = 130 ml
Biodiesel production from 1 liter cottonseed oil =867 ml
Cost of biodiesel per liter = 21077.69 Tk

Mosna:

Oil extraction from 3 kg of Mosna = 1.13Liter, Oil extraction cost per liter = 39.82 Tk
Biodiesel production from 180 ml cottonseed oil = 140ml
Biodiesel production from 1 liter cottonseed oil = 777.78 ml
Cost of biodiesel per liter = 2856.28 Tk

Sesame:
Oil extraction from 3 kg of Sesame =0 .975Liter, Oil extraction cost per liter = 46.15 Tk.

4 Result and discussion:

Table 4.1: Observed Properties of Cottonseed oil and Biodiesel

Properties	Cotton-seed oil	Bio-diesel	Diesel
Density (g/cc)	0.9	0.88	0.84
Boiling Point (° C)	319	262	248
Calorific Value(MJ/Kg)	41.95	38.51	45
Kinematic Viscosity at 34˚C(mm2/s)	29.215	7.2	3.0

Table 4.2: Properties of Mosna oil and Biodiesel

Properties	Mosna oil	Bio-diesel	Diesel
Density (g/cc)	0.903	0.875	0.84
Boiling Point (° C)	383	198	248
Calorific Value(MJ/Kg)	46.39	52.129	45
Kinematic Viscosity at 34˚C(mm2/s)	25.24	9.24	3.0

Table 4.3: Properties of Sesame oil and Biodiesel

Properties	Sesame oil	Diesel
Density (g/cc)	0.884	0.84
Boiling Point (° C)	380	248
Calorific Value(MJ/Kg)	43.54	45
Kinematic Viscosity at 34˚C(mm2/s)	32.73	3.0

Biodiesel is gradually gaining acceptance in the market as an environmentally friendly alternative diesel fuel. Biodiesel is a clean burning fuel that is renewable and biodegradable. There should a healthy debate about turning food crops or animal feed into fuel and the consequences of the switch to biofuels need to be carefully thought out. The focus of biodiesel production needs to be on sources like waste oil and grease, animal fats and non edible sources. For this purpose we tried to produce biodiesel from Cotton seed Oil, Mosna Oil and Sesame oil. From our current research it is also found that the fuel properties of produced biodiesel are almost same as diesel.

Here we measured the properties of biodiesel produced from cotton seed oil and mosna seed oil and compared with those properties of diesel as shown in table 4.1 and table 4.2. Density of biodiesel from cotton seed oil is almost same as diesel. The calorific value is quite lower than diesel, but when it will be mixed with diesel for running a diesel engine it will be perfect. Viscosity of biodiesel from cotton seed oil is quite higher than diesel. We have reduced the viscosity of cottonseed oil from 29.215mm^2/s to 7.2 mm^2/s at 34°C. Biodiesel from mosna also has density similar to diesel. Boiling point of this biodiesel is quite low than diesel. Its calorific value and kinematic viscosity is higher than diesel. Biodiesel produced from mosna oil has higher calorific value 7MJ/Kg than diesel. But, the production rate is very low. From several proportion of methanol and sesame oil reaction we did not get any

satisfactory result for producing biodiesel but in the table 4.3 result have shown that the properties of diesel is nearly same as sesame oil .
The cost of oil production from crops (sesame and mosna) is almost same except cotton seeds. The cost for biodiesel production per litter from cotton seed and mosna oil are quite high for small production. But, for large amount of biodiesel production the cost will be reduced significantly. For large scale of production the cost of raw vegetable oil will be very low and the use of chemical will be low. Beside this the valuable use of large amounts of byproduct like soap, glycerin, oilcake, etc will reduce the overall production cost of biodiesel.
Modern and efficient technique of separation of biodiesel from the production plant will reduce the amount of use of chemical. Reuse of methanol will also reduce the production cost. This will bring the biodiesel at the limit of general people for regular use.

5 Conclusions

The aim of this study was to evaluate best oil as a potential raw material for biodiesel production. Three types of oil (cottonsed oil, mosna oil, sesame oil) are extracted from the seeds and chemically converted via an alkaline transesterification reaction to fatty acid methyl ester. The significant change of fuel properties of these oils is observed. The cost of the biodiesel production is also analyzed.
The optimum conditions established for the methanolysis of crude Cotton seed oil in the present investigation were recorded to be: 3:1 M ratio of methanol to oil and 1.00% (w/w) catalyst. And biodiesel from Cottonseed oil showed different fuel properties which are close to diesel For Mosna oil the optimum conditions were recorded to be 3. 5:1 M ratio of methanol to oil and 1.00% (w/w) catalyst. But small amount of biodiesel was found from this oil and production cost is higher than cottonseed oil. And for Sesame oil the optimum conditions were recorded to be 3.5:1 M ratio of methanol to oil and 1.00% (w/w) catalyst. But separation of oil and glycerin was not possible.
As the environment and soil in Bangladesh is very suitable for Cottonseed cultivation so this crop should be cultivated on large scale production yielding non-conventional oil that can be usefully converted into biodiesel.

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