Improving biodiesel properties by mixing jatropha oil and soybean oil

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Abstract. The need for biodiesel as an alternative fuel will increase along with the increasing energy consumption and the depletion of fossil fuel reserves. Jatropha oil and soybean oil are potential raw materials for biodiesel. Each raw material gives different properties to biodiesel. Mixing the two types of oil makes it possible to improve the quality of biodiesel. The aim of this study was to determine the effect of variations in the composition of the oil mixture on the biodiesel properties. Jatropha oil was mixed with soybean oil in various compositions. The mixture was heated and stirred for 60 min at 90°C. The more the percentage of soybean oil biodiesel, the viscosity of the biodiesel mixture decreased. Mixing with 20% soybean oil has a significant reduction in viscosity. The increasing percentage of soybean oil also influences the higher heating value of the biodiesel mixture.

Keywords: heating value; viscosity; jatropha oil; soybean oil

1. Introduction
Energy needs will increase over time. So far, these energy needs have been supplied from fossil fuels. As a non-renewable fuel, fossil fuels will diminish over time (1). Biodiesel is an alternative fuel as a substitute for diesel fuels. The need for using biodiesel will increase. Biodiesel has many advantages, including renewable, non-toxic and biodegradable (2).

The main raw material for biodiesel is vegetable oil. Many vegetable oils, both edible and non-edible ingredients, can be processed into biodiesel. Biodiesel produced from edible feedstocks will compete with food needs. Among the potential non-edible raw materials is jatropha oil (3).

Vegetable oil is a triglyceride composed of glycerin and fatty acids. Each vegetable raw material has different fatty acids. The properties of fatty acids are influenced by the length of the chain and the number of double bonds in these fatty acids (4). The properties of fatty acids affect the properties of biodiesel such as viscosity, density, calorific value and flash point (5).

Jatropha oil has a relatively high viscosity and a relatively low calorific value. The use of jatropha oil biodiesel still requires a high percentage of diesel oil mixture. Efforts are needed to improve the properties of jatropha biodiesel, especially its viscosity and calorific value. One effort to improve the properties of jatropha oil is by mixing other vegetable oils such as coconut oil (6) and used cooking oil (7). Because each vegetable oils has a different fatty acid composition (5), research needs to be done for other feedstocks. One of the vegetable oils that are widely used as biodiesel feedstocks is soybean oil (8). Soybean oil has medium chain fatty acids, so this oil has the potential to be used in biodiesel mixtures with jatropha oil. Mixing jatropha oil and soybean oil was expected to improve the properties of the mixture as a biodiesel feedstock. The purpose of this study was to improve the biodiesel properties from jatropha oil by mixing the jatropha oil with soybean oil.

2. Material and methods
2.1. Materials
The raw materials used in this study were jatropha oil and soybean oil. Some properties of jatropha oil and soybean oil are presented in Table 1.

| Properties          | Jatropha Oil | Soybean Oil |
|---------------------|--------------|-------------|
|                     |              |             |

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The fatty acid content in raw materials is presented in Table 2 below.

| No | Fatty Acid                        | Abbreviation | Jatropha Oil | Soybean Oil |
|----|-----------------------------------|--------------|--------------|-------------|
| 1  | Methyl Butyrate                   | C4:0         | -            | 9.37        |
| 2  | Methyl Palmitate                  | C16:0        | 1.2          | 10.09       |
| 3  | Methyl Octadecanoate              | C18:0        | -            | 2.7         |
| 4  | Cis-9-Oleic Methyl ester          | C18:1        | 9.82         | 20.66       |
| 5  | Lenolelaidic Acid Methyl Ester    | C18:2        | 1.42         | -           |
| 6  | Methyl Lenoleate                  | C18:2        | -            | 50.82       |
| 7  | Methyl Lenolenate                 | C18:3        | -            | 0.21        |
| 8  | Gamma-linolenic Acid Methyl Ester | C18:3        | -            | 0.26        |
| 9  | Methyl Arachidate                 | C20:0        | -            | 0.15        |
| 10 | Methyl Cis-11-eicocenoate         | C20:1        | -            | 5.38        |
| 11 | Cis-4-7-10-13-16-19-decasaheoanoate| C21:6        | -            | -           |
| 12 | Methyl Docosanoate                | C22:0        | -            | 0.36        |
| 13 | cis-11 14 17-eicosatrienoic acid methyl ester | C22:3        | 87.19        | -           |

2.2. Experimental procedure

In the first method, mixing between pure jatropha oil and pure soybean oil was carried out on various compositions. The percentage of jatropha oil ranged from 0% and 100% with a 10% increase. Jatropha oil and soybean oil were mixed according to the ratio of the mixture that had been determined at a temperature of 90°C to be stirred for 60 minutes.

Then the esterification process was carried out on the mixture. The esterification process was done for 60 minutes at 60°C, using a base catalyst (H₂SO₄) which had been dissolved with methanol.

The transesterification process was conducted at 60°C within 60 minutes. The oil mixture was reacted with Methanol (15% of oil volume) using (KOH) as a catalyst. The settling process was carried out for 8 hours, then the separation between biodiesel and glycerol was carried out. Methyl esters which have been separated from glycerol are washed 3 times with water.

In the second method, each oil was processed into biodiesel by transesterification. The process of transesterification, separation and washing of this method was the same as the first method. Then mixing between the two types of biodiesel was carried out. Mixing was conducted at 90 °C and stirred for 60 minutes. The percentage of the mixture began from 0% to 100% with 10% increment. Then the density, viscosity, calorific value and flash point of each mixture were tested.

3. Results and discussion
From Table 2 it can be seen that jatropha oil was dominated by cis-11 14 17-eicosatrienoic acid methyl ester while soybean oil had a content of cis-9-Oleic Methyl ester as much as 20.66%, and Methyl Lenoleate as much as 50.82%.

Jatropha oil has many fatty acids that have double bonds. The structure of fatty acids has an effect on the oil properties, including viscosity, density and calorific value. Because jatropha has a longer carbon chain, its density, viscosity and flash point are relatively higher than that of soybean oil (5). Table 3 shows the properties of biodiesel from jatropha oil and biodiesel from soybean oil.

Table 3. Properties of biodiesel from jatropha oil and soybean oil

| Properties               | Jatropha Oil | Soybean Oil |
|--------------------------|-------------|-------------|
| Density, at 40 °C (kg/m³) | 907         | 862         |
| Viscosity, at 40 °C (cSt) | 19.8        | 7.7         |
| Calorific Value (MJ/kg)  | 36.79       | 39.45       |
| Flash Point (°C)         | 215         | 186         |

3.1. Density

Fuel is injected into the combustion chamber by volume, so the amount of mass of fuel injected depends on the density of the fuel. Fuel density affects the air fuel ratio.

Figure 1. Density of biodiesel from a mixture of jatropha and soybean oil

Figure 1 shows the density change in a mixture of jatropha oil and soybean oil. The more volume fraction of soybean oil in the mixture, the density decreases. The density of biodiesel blends ranges from 850 to 900 kg/m³. Density is influenced by the number of double bonds in fatty acids (9). Jatropha oil has more fatty acids with double bonds, so the density is relatively higher than soybean oil. It also affects the density of the mixture of both. Both types of mixing methods showed the same density results.

3.2. Viscosity
Viscosity is an important characteristic of liquid fuels, because it affects the quality of atomization when it is injected into the combustion chamber. High viscosity causes poor fuel atomization and incomplete combustion (10).

Figure 2 shows the change in viscosity of various compositions of a mixture of jatropha oil and soybean oil biodiesel. The higher the percentage of soybean oil biodiesel, the lower the viscosity of the biodiesel mixture. The length of the fatty acid carbon chain affects the viscosity. The longer the carbon chain of the fatty acid, the higher the viscosity (5). Jatropha oil has a relatively long fatty acid with a carbon chain. This causes the viscosity of jatropha oil biodiesel to be relatively higher than soybean oil biodiesel.

The decrease in viscosity from the mixture showed a non-linear relationship with the percentage of volume. Thus, mixing with 20% soybean oil has a significant reduction in viscosity. In the next volume fraction up to 100% soybean oil mixture, the biodiesel viscosity was relatively constant.

3.3. Flash point

The flash point is the properties of biodiesel which is related to the flammability properties (11). Mixing jatropha oil with soybean oil produces flash points in the range between 200 - 250°C. Figure 4 shows changes in flash point biodiesel from a mixture of jatropha oil and soybean oil.

The flash point value met the standard. The flash point decreased with increasing volume fraction of soybean oil in the mixture. This shows that the flash point is also influenced by the structure of fatty acids.
3.4. Calorific value

Calorific value indicates the energy content of a fuel. Because of the presence of oxygen atoms in biodiesel, the calorific value is relatively lower than fossil fuels (2).

Figure 4 shows changes in the calorific value of various compositions of a mixture of jatropha oil and soybean oil biodiesel. Jatropha oil has more unsaturated fatty acids than soybean oil. The number of double bonds in fatty acids affects the calorific value of a fuel. The more fatty acid content that has a double bond in the carbon chain (C = C) in biodiesel, the lower the calorific value (5). The increasing percentage of soybean oil also influenced the higher heating value of the biodiesel mixture.

4. Conclusion

Mixing jatropha oil with soybean oil caused a change in the properties of the biodiesel produced. The density of biodiesel from mixing jatropha oil and soybean oil decreased with increasing volume fraction of soybean oil. This also affects the heating value of biodiesel from the mixture.
The viscosity of the mixed biodiesel decreased with the increasing amount of soybean oil mixture. The more the percentage of soybean oil biodiesel, the viscosity of the biodiesel mixture decreased. Mixing with 20% soybean oil has a significant reduction in viscosity.

Flash points are also influenced by changes in the structure of fatty acids. Flash points for all variations of the mixture above 100°C meet ASTM standards. The increasing percentage of soybean oil also influenced the higher heating value of the biodiesel mixture.

Mixing jatropha oil with soybean oil provided a change in the composition of fatty acids which gives a positive change in the form of a decrease in viscosity and an increase in calorific value.

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