The Biodiesel Characteristic Of Kepayang Oil (*Pangium edule Reinw.*)

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Abstract **-** The research was conducted in the Pilot Plant Laboratory, Faculty of Agriculture Technology, Andalas University, Padang, West Sumatra, Indonesia in October 2008 to February 2009. The research objective was to know biodiesel characteristic *o*f kepayang seed oil. The biodiesel was made in two steps i.e., esterification process and transesterification. Physicochemical characteristic of the biodiesel were yield, viscosity, density, acid number, Iod number, saponification number, gliserol number, and ester content. Biodiesel from kepayang oil toward to viscosity, density, acid number, iod number, soup number, gliserol number, and ester content was full fill ASTM biodiesel quality. The result shown that kepayang biodiesel can be used for diesel engine to substitute the petro diesel.

Keywords: *kepayang, biodiesel, esterification, transesterification*

1 Introduction

Energy needs continue to grow in line with industry developments and also population growth in the world. The main energy resources that are used today mainly come from fossils energy include petroleum, natural gas and coal [1]. As a result, crude oil prices increase at 78 dollars/barrel. It is difficult case for industrialized countries that based on fossil energy [8]. They need alternative fuels as an energy resource that is more environmental friendly and can be renewed.

One of these biofuels is biodiesel; it can replace diesel fuel as engine fuels through transesterification process of vegetable oil and fat [4]. [9] biodiesel can be produced by esterification of fatty acid that it contained in vegetable oil. Bio-diesel raw materials can be derived from a variety of vegetable resources, namely oil and fat groups, such as palm oil, coconut oil, soybean oil, peanut, rapeseed, jatropha, and also from the oil that has been used for frying and will be reused (*jelantah*) [13]. In addition, beside the plants that mentioned above, there are many other plants that have not been developed but have great potential to be cultivated as a forest plants that produce a vegetable oil, such as kepayang (*Pangium edule Reinw*.). That is numerous in West Sumatra tropical forests - Indonesia. Kepayang oil visualization is brownish yellow, slightly viscous liquid with specific odor of kepayang seed. The other characteristics are density of 0.902 g/ml, 4.9% water content, acid number 22.5 mg/g oil, saponification number 200 mg/g oil, 80% fat content, and pH 3-5. Kepayang oil can be used as an electrolyte to makes the resistor [15]. In addition, kepayang oil can be used as alternative raw materials to make cooking oil [14]. Therefore, the immense possibility of kepayang oil can be used as biodiesel, so this research aim is to determine biodiesel characteristic of kepayang seed oil.

2 Problem Formulation

The research was conducted in the Pilot Plant Laboratory, Faculty of Agriculture Technology, Andalas University, Padang, West Sumatra - Indonesia in October 2008 to February 2009. Raw materials that are used kepayang seed oil that obtained from Harau village, Sub-district Harau, Lima Puluh Kota Regency. Edible palm oil is as comparison material obtained from traditional market in Padang, West Sumatra.

Chemicals that are used 98% methanol, 98% Potassium Hydroxide, 98% Sodium Hydroxide, concentrated Sulphuric Acid, Cyclohexane, 0.1 N Sodium Thiosulfat, 0.5 N Hydrochloric Acid, PerIodat Acid, Hexane, 0.1 N Potassium Hydroxide solution in 95% Ethanol, Phenolphtalein indicator solution, Wijs reagent, Acetic Acid, 1% Urea solution, Potassium Iodides solution, and aquades. Tools that are used distillation equipment, titration equipment/burette, magnetic stirrer, separating funnel, vertical cooler, absorb pipettes, thermometers, glass cup, measuring cup, Whatman filter paper, pycnometer, erlenmeyer, bulb filler pipette, laboratory flask, blender, and analytical scales.

2.1 Procedure of biodiesel production [13]

100 ml of kepayang oil puts into 300 ml Erlenmeyer grindstones. Then, conduct to mix 15 ml methanol with 1 ml H_2SO_4 as acid catalyst as much as 2% (v/v). The mixture solution is placed in the Erlenmeyer that containing kepayang oil that has been attached to distillation equipment unit, then heated it at 60^{o}C for 90 minutes.

The stirring have done with magnetic stirrer that is set at 150-200 rpm. After that, the mixture was inserted into the separator funnel to separate the methyl esters (biodiesel) that were still mixed with kepayang oil and glycerol with calming the mixture for 24 hours. Biodiesel result that it mixed with kepayang oil is washed 2 times with 50 ml of warm distilled water. Washing result is followed by transesterification process. For comparison purposes is used esterification of palm oil which then also followed by transesterification process.

The next process is transesterification using the KOH as base catalyst as much as 0.32% (v/v) for the reaction tends to be faster than using acid catalyst. Reagents that are used were technical methanol with a concentration of 15%.

Esterification solution puts into the Erlenmeyer that it has been fitted to the distillation unit. The mixture was reacted by heating it at temperature of 60^{o}C for 90 minutes. Stirring have done with magnetic stirrer that it set at the speed of 150-200 rpm. After that, biodiesel mixture was inserted into a separator funnel to separate it from glycerol by calming it for 24 hours.

The biodiesel was washed 2 times with 50 ml of 0.05% acetic acid solution and followed by washing it using the warm distilled water at 55^{o}C temperature to obtain the biodiesel pH is 6.8 to 7.2. Then warming it for 10 minutes at a temperature of 110 - 120^{0}C, to remove water molecule, then filter it using filter paper that has been sprinkled with anhydrous sodium sulfate. For comparison purposes used the palm oil.

2.2 The biodiesel physical chemical testing

The Physicochemical testing of Biodiesel were yield, viscosity at a temperature of 27^{0}C by the stokes method, density by pycnometer method, acid number by titrimetric method, iodine number by wijs method, saponification number by titrimetric method, the total of glycerol content by titrimetric method, and ester content that obtained from analyze the total of saponification number with glycerol content. Tests were conducted on the results of biodiesel on the process of esterification and transesterification.

3 Problem Solution

3.1 Biodiesel yield

Yield of kepayang oil biodiesel obtained by 99.5% while palm oil biodiesel was obtained by 98%. These results indicate that all of kepayang oil reacted perfectly into biodiesel. So there is no blocking reaction between triglycerides and methanol reaction with soaps formation which can reduce biodiesel yield. Blocking reaction also led to increase methanol needs for ester and transester reaction. According to [12] blocking reaction causes methanol consumption increased 2 levels and biodiesel yield decreased 20 - 30%. According to [5], [2] the soap resulting will also inhibit the transesterification reaction that decreases biodiesel yield.

Transesterification reaction can be influenced by several physical factors; one of them is transesterification temperature. The using of suitable temperature in biodiesel production will accelerate transesterification reaction. This is caused by the using suitable temperature that can supply energy to activate the reagent and collision between reactants to produce the reaction will also increase, so that the resulting products become more numerous, but if using inappropriate temperature, transesterification reaction will be not perfect so that other compounds than the main product, methyl ester, increased and effect on decreasing the biodiesel yield [7].

3.2 Viscosity

Table-1 shows that the viscosity value of kepayang biodiesel is full fill ASTM standard that requires viscosity range from 1.9 to 6.0 mm^2/s. Viscosity values of kepayang oil biodiesel is also not much different from the value of palm oil biodiesel viscosity as comparison standard. In palm oil esterification, reaction occurs to increase the viscosity value, while on kepayang oil occurs to decrease the viscosity values. Increasing viscosity occurs due to saponification reactions. While [1] said that, transestrification reduces vegetable oil viscosity until 85%.

Table-1, The viscosity value of kepayang oil biodiesel and palm oil biodiesel

Biodiesel	Esterification (mm^2/s)	Transesterificatin (mm^2/s)
Kepayang oil	2,1207	2,0233
Palm oil	1,9657	2,5199

Viscosity that is incompatible with the standards cannot be used as biodiesel because it can cause various problems in the engine. According to [3] deriving triglyceride into three fatty acid ester would be lower one third of the atomic weight. It also will reduce viscosity about 5-10%. [6] said that increasing the chain length and saturation degree, so viscosity will increase. The viscosity will be lower with the double bond remaining in the biodiesel raw material composition.

In its use at the engine, fuel viscosity has an influence on injection and combustion process in engine fuel. High viscosity will cause a high resistance to the injection pump so that causing high pressure and volume injection. This tends to increase NOx emissions and fuel room temperature [11]. Atomization of the fuel is highly depends on viscosity, injection pressure and size of injector hole. Greater viscosity can cause fuel atomization will produce larger droplet with high momentum and have a tendency to collide with the relatively cool cylinder walls that causing flame extinction and increasing deposit, spray penetration and fuel engine emission. Conversely, low viscosity would produce a very fine spray and cannot enter further into the combustion cylinder so that the fuel rich zone formed which causes soot formation [12].

3.3 Density

Table-2 shows that the density of kepayang oil biodiesel is full fill ASTM standard which requires density value of 0.850 to 0.890 g/cm^3. At palm oil biodiesel as comparison standard at esterification stage, its density values has full fill the standard, while in transesterification step has not full fill ASTM standard.

Table-2. Density value of kepayang oil biodiesel and palm oil biodiesel

Biodiesel	**Esterification** ($gram/cm^3$)	**Transesterification** ($gram/cm^3$)
Kepayang oil	0, 8889	0, 8891
Palm oil	0, 8858	0, 8943

Density influences on the heat and power generated by the volume unity of engine fuel. Density also affected on viscosity. However, if the density exceeds the provisions, so incomplete reaction will occur in the oil conversion [12]. The using biodiesel as fuel engine, biodiesel density affects to calorific value, engine power production, emissions and causing damage to the motor. Biodiesel density is affected by length of carbon chain and double bond number (unsaturated fatty acid composition) [11].

3.4 Acid number

Table-3 shows that the value of acid number of kepayang oil biodiesel is full fill ASTM standard that requires maximum value of 0.8. Acid number of palm oil biodiesel as comparison standard obtained higher than acid number of kepayang oil. This will greatly affect to the engine, because the high acid content in the biodiesel will cause corrosive at the engine.

Table-3. The acid value of kepayang oil biodiesel and palm oil biodiesel.

Biodiesel	**Esterification** (mg KOH/gram)	**Transesterification** (mg KOH/gram)
Kepayang oil	0, 6732	0, 3927
Palm oil	0, 8415	1, 1220

Esterification and transesterification reaction decrease value of acid number where acid number on the transesterification was obtained much lower than esterification stage. Decreasing acid number indicates the least of free fatty acid content. According to [12] the high of acid numbers are indicators that biodiesel still contains free fatty acids, which means that biodiesel is corrosive and can cause soot or crust on diesel engine injector.

The high of free fatty acid levels on biodiesel will give a negative effect on its using in engine. That it will cause corrosive properties and deposit on the engine [11].

3.5 Iodine number

Table-4 shows that kepayang oil biodiesel has a lower value than ASTM standard that requires the maximum value is 115. While on palm oil biodiesel obtained a smaller amount than kepayang oil biodiesel. Where is in the transesterification stage obtained a lower value than the esterification stage. This decreasing is due to double bond number that reduces biodiesel saturation level.

Table-4. Iodine value of kepayang biodiesel and palm oil biodiesel

Biodiesel	Esterification (mg/g)	Transesterification (mg/g)
Kepayang oil	97, 6154	71, 5969
Palm oil	54, 6646	56, 6169

High or low the iodine numbers indicated double bond number in the biodiesel of fatty acid constituent. Where, the double bond is the unsaturated fatty acid indicator [12].

In the engine performance, bio-diesel with a high iodine number value will occur to polymerization reaction and form deposits at fuel injection pipe, piston ring and piston ring groove [11]. When a diesel engine operated with biodiesel which has iodine number greater than 115, deposit will be formed at injection hole piping, piston ring and piston ring canal. This situation is caused by fat double bond which becomes unstable due to hot temperature; it was resulting polymerization reactions and accumulates carbonation form or deposit formation [12].

3.6 Saponification number

Value of the saponification number of kepayang oil biodiesel has a greater value than palm oil biodiesel as a comparison (Table 5). Generally, the materials of un-saponifiable fraction still contained 1-2%. The large number of the un-saponifiable fraction was also indicated as the least amount of methyl esters in biodiesel [11].

Table-5. The value of saponification numbers of kepayang oil biodiesel and palm oil biodiesel

Biodiesel	Esterification (mg KOH/gram)	Transesterification (mg KOH/gram)
Kepayang oil	109, 3950	103, 3175
Palm oil	105, 1875	102, 3825

3.7 Glycerol content

Table-6 shows that the number of glycerol content was lower than ASTM standard that requires the maximum number is 0.24. Total of glycerol content of the palm oil biodiesel has a smaller amount than kepayang oil biodiesel.

Table-6. The glycerol content of kepayang oil biodiesel and palm oil biodiesel.

Biodiesel	Esterification (%-b)	Transesterification (%-b)
Kepayang oil	0, 2009	0, 2009
Palm oil	0, 1507	0, 1632

Esterification and transesterification reaction caused a decreasing in total of glycerol content, although not giving a different value in each process. The total of glycerol content that do not full fill the standard will damage engine. According to [12] glycerol remaining can damage engine due to the OH groups which are chemically aggressive towards the non iron metal and chromium mixture, otherwise it will form a deposit in the burning hole.

The increasing levels of glycerol can be caused by partial hydrolysis of the glycerin remaining in biodiesel. The high of total glycerol levels could affect deposit formations on the needle injector and piston engine on the engine so that the power generated reduced [11].

3.8 Ester content

Results analysis of Ester content shows in the Table-7 that has full fill the standard of Indonesian Biodiesel which requires value ≥ 96.5% [11].

Table-7. Ester content of kepayang oil biodiesel and palm oil biodiesel.

Biodiesel	Esterification (%-b)	Transesterification (%-b)
Kepayang oil	98, 4759	98, 7046
Palm oil	98, 5454	98, 1755

4 CONCLUSIONS

Biodiesel from kepayang oil toward viscosity, density, acid number, iod number, saponification number, gliserol number, and ester content was full fill ASTM biodiesel quality. The result shows that kepayang biodiesel can be used for diesel engine to substitute the petro diesel.

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