Biodiesel Production from Chicken Fat Using Diethyl Ether as Co-Solvent

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ABSTRACT

Biodiesel can be produced from either vegetable oil or animal fats through transesterfication process. Problem that usually appears in transesterification process is long reaction time because oil and alcohol are not mutually dissolved. The addition of co-solvent can help mixing the reactants. In this study chicken fat was used as feedstock for biodiesel production through transesterification reaction. The reaction of chicken fat using diethyl ether as co-solvent, NaOH as catalyst, and methanol as reactant at a ratio molar of methanol/ oil 6 : 1. Variables studied were temperature, reaction time, ratio of co-solvent to methanol, and the amount of catalyst on biodiesel characteristics. Products were analyzed by gas chromatography to obtain the composition of biodiesel. The biodiesel properties like methyl-ester content, density, and viscosity was evaluated and was found to compare well with Indonesian Standard (SNI). The results of this work showed that the use of chicken fat is very suitable as low cost feedstock for biodiesel production. The best result was obtained in a ratio of co-solvent/ methanol 0,5 : 1 (v/v), a temperature of 35°C, 20 minutes of reaction time, and 0,8 % (w/w) of catalyst amount.

Keyword: biodiesel, co-solvent, chicken fat, transesterification

1. INTRODUCTION

Currently, the fuel requirement of the world is covered by the use of fossil fuels. Fossil fuels such as gasoline and diesel fuel are scarce toward fulfilling the future energy demand and against green environment so an alternative fuel is needed [1]. Biodiesel as alternative fuel can be produced from vegetables oil or animal fat. Biodiesel is bio-degradable and non toxic, so it is eco-friendly [2].

Vegetables oil and animal fat are two types of biological lipid material, made up mainly of triacylglicerols (TAGs) and less of diacylglicerols (DAGs) and monoacylglicerols (MAGs). Since many animal meat processing industry and large food processing facilities create large amount of animal fat so it is possible for biodiesel production from cheap raw materials [3]. Broiler chicken has a high fat content which is about 10,9% weight [4]. Broiler chicken fat is one of waste animal fat that can be used as feedstock for biodiesel, it can cope with environmental pollution, and is economical [5].

Biodiesel production through transesterification process involves the reaction between oil and alcohol (mostly methanol) in the presence of catalyst to form mono alkyl ester [6]. Methanol is monohidrik alcohol that ist used more frequently because of its low cost and high reactivity. Methanol is the shortest chain alcohol. It can quickly react with trigliceride and NaOH is easily dissolved in it [2].

Biodiesel production through transesterification process usually uses strong base homogen catalyst [7]. Acid catalyst such as sulphuric acid can be used in transesterification reaction but it is slower. Alkaline hydroxide (KOH and NaOH) is more desireable as base catalyst [8]. However, potassium based catalyst allow the formation of more soap than sodium based catalyst [9]. Moreover, NaOH is prefered in industry because of its low cost and good reaction kinetics [10].

Transesterification reaction is reversibe and a slight excess of alcohol is used to change the direction of reaction towards ester formation [11]. This process is associated with many problems, such as the reactants (oil and alcohol) are not readily miscible. Oil is hard to disperse in the methanol medium, so the rate of collisions of the glyceride and the methoxide (the mixture of methanol and the alkaline catalyst) molecules becomes slower. This lowers the rate of collision of the molecules and also the rate of reaction causing longer reaction times [6]. This problem can be solved by using a solvent (co-solvent) to mix the reactants in one phase [12].

The selected co-solvent should have boiling point close to the boiling point of the alcohol used, so that, after reaction, both methanol and co-solvent is recycled in a single step to be used again. The primary concerns with co-solvent transesterification are the additional complexity of recovering and recycling the co-solvent, although this can be simplified by choosing a co-solvent with a boiling point near that of the alcohol being used. Another concerns have been raised about the hazard level associated with the co-solvents [6]. The chosen co-solvent should dissolved well in alcohol and oil. It should have a boiling point below 120^{o}C to help solvent separation after perfect reaction. The preferred co-solvent is derived from the cyclic ether class such as tetrahidrofuran (THF), diethyl ether (DEE), and 1,4-dioxane. The co-solvent used should be anhydrous [12].

Many researches have been done to investigate the effect of various co-solvent in biodiesel production from vegetables oil in any conditions to get the best result. However, the use of animal fat especially chicken fat as biodiesel production feedstock is still very little. Therefore, this study aims to investigate the effect of co-solvent addition especially diethyl ether (DEE) in biodiesel production from chicken fat to various transesterification variables and biodiesel parameters.

2. MATERIAL AND METHODS

Material

The chicken fat is obtained from chicken abattoir at Pasar Padang Bulan, Medan. Diethyl ether (DEE), methanol, ethanol, phenolphalein indicator, and NaOH were purchased from CV Multi Kreasi Bersama, Medan.

Procedure

Oil Characterization

The oil was characterized for physical and chemical properties such as viscosity, free fatty acid content, and density. For the fatty acid content in oil is analyzed by GC-MS.

Fatty Acid Methyl Ester (FAME) Determination

The compositions of each methyl ester were determined in duplicate using a gas chromatographer equipped with a flame ionisation detector and an auto injector.

Other Analysis

The density, kinematic viscocity, and flash point of each methyl ester were determined in duplicate according to the procedure of SNI [13].

Oil Transesterification

Oil was introduced in a three-neck flask and was maintained at various reaction temperature (25, 30, and 35^{o}C) while stirred. Co-solvent diethyl ether was added in the mixture of methanol and catalyst and then the mixture was added in the three-neck flask. Transesterification reaction was carried out with various reaction time (10, 15, and 20 minutes). After the reaction was complete, residual mixture of co-solvent and methanol was separated by distillation. The process residue was a 2 phases liquid, upper phase was methyl ester (biodiesel), and lower phase was glycerol. The distillation residue was cooled to achieve phase equilibrium, and then it was separated by upper phase and lower phase. The methyl ester was washed with water by the temperature of 50^{o}C and dried.

3. RESULTS AND DISCUSSION

The variables tested were the ratio of co-solvent to methanol, reaction temperature, reaction time, and amount of catalyst. Oil type (chicken fat), catalyst type (NaOH), co-solvent type (diethyl eter/ DEE), alcohol type (methanol), and the metanol/ oil molar ratio (6:1) were fixed as common parameter in all experiments.

Characterization of Chicken Fat

Table 1 and 2 respectively present the composition analysis and properties of chicken fat.

Table 1. Fatty Acid Composition from Chicken fat

Peak Number	Oil Components	Composition (%w)
1	Lauric Acid (C12:0)	0,91
2	Myristic Acid (C14:0)	1,40
3	Miristoleinic Acid (C14:1)	0,22
4	Palmitic Acid (C16:0)	23,93
5	Palmitoleinic Acid (C16:1)	5,88
6	Stearic Acid (C18:0)	7,27
7	Oleic Acid (C18:1)	38,92
8	Linoleic Acid (C18:2)	19,81
9	Linolenic Acid (C18:3)	1,13
10	Arakidic Acid (C20:0)	0,07
11	Eikosenoic Acid (C20:1)	0,45

Based on the fatty acid composition data of chicken fat, it can be determined the molecular weight of chicken fat (in trigliceride form) is 854,984 gr/mol whereas the free fatty acid molecular weight of chicken fat is 272,329 gr/mol. The properties of chicken fat such as density, viscosity, and free fatty acid content were also determined. It was shown in table 2.

Table 2. The Properties of Chicken fat

Properties	Amount
Density	894,1 kg/m^3
Viscosity	14,45 mm^2/s
FFA	0,3948 %

Influence of The Ratio of Co-Solvent to Methanol

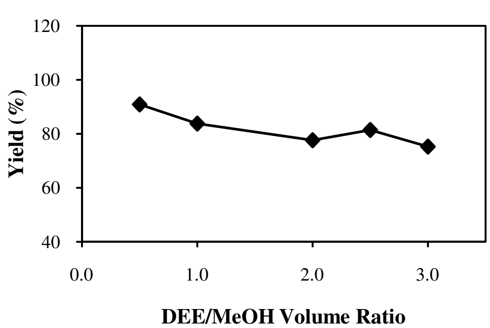

Fig. 1. Effect of Diethyl Eter/Methanol Volume Ratio in Biodiesel Yield at NaOH concentration of 0,8 wt%, reaction time of 20 minutes, and reaction temperature of 30^{o}C

Oil and methanol were two substances that were not readily miscible thus lowering the reaction rate and causing long reaction time. In this study various experiments were done to investigate the effect of diethyl eter:methanol volume ratio to biodiesel yield. Figure 1 shows that the more diethyl eter was used, the yield of biodiesel tends to decrease. The ratio of diethyl eter to methanol 0,5 : 1 get the best biodiesel yield result, excessive addition of diethyl eter used in this study led to a decrease in the yield of biodiesel, due to a dilution effect of the reactants.

Influence of Reaction Temperature

Figure 2 shows that the higher the reaction temperature, the yield of biodiesel tends to increase. The reaction temperature used in this study was far below the boiling point of methanol (64,5^{o}C). This prevent evaporation of diethyl eter which boiling point is close to room temperature (34^{o}C). This condition can save energy in the production of biodiesel. The best reaction temperature used in this study is 35^{o}C which is similar to the condition reported by Encinar et. al [11]. But they used rapeseed oil as the feedstock for the production of biodiesel.

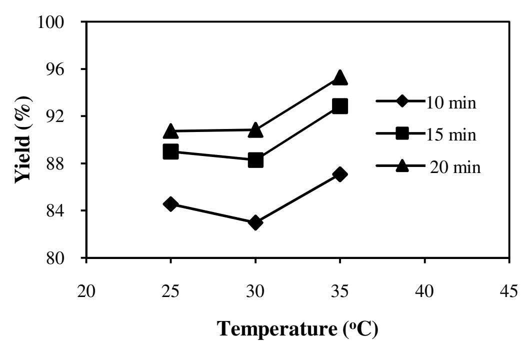

Fig. 2. Effect of Reaction Temperature in Biodiesel Yield at NaOH concentration of 0,8 wt%, and DEE:MeOH: 0,5:1

Influence of Reaction Time

Figure 3 shows that biodiesel yield tends to increase with increasing of reaction time. The reaction time needed in this process is faster than most of the transesterification reaction time, because the used of co-solvent can overcome the mass transfer between oil and methanol problem. This can increase the reaction rate. Therefore, the best result in this studies was obtained in 20 minutes reaction time.

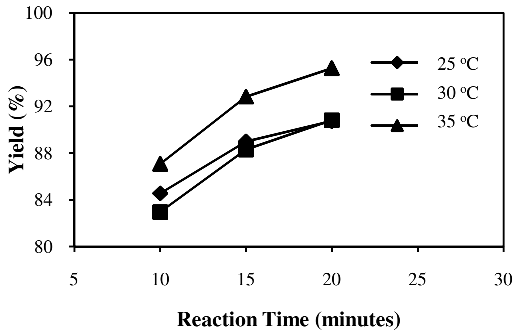

Fig. 3. Effect of Reaction Time in Biodiesel Yield at NaOH concentration of 0,8 wt% and DEE:MeOH: 0,5:1

Influence of Catalyst Amount

Figure 4 shows that biodiesel yield increased at 0,8% weight of catalyst amount and then the biodiesel yield decreased with increasing of catalyst used. The best result was obtained in 0,8% weight of catalyst amount. The excess of catalyst in transesterification process that involved co-solvent will decreased the biodiesel yield because it tends to form gel solution. This phenomenom is similar to the condition reported by Encinar et. al [11], but they used rapeseed oil as the feedstock for the production of biodiesel.

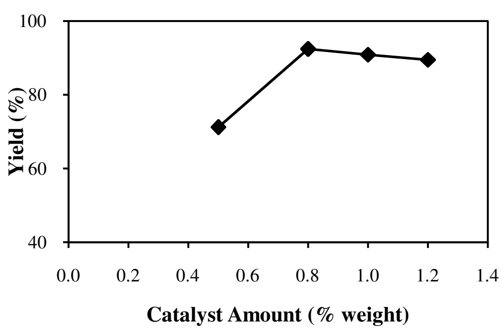

Fig. 4. Effect of Catalyst Amount in Biodiesel Yield at DEE:MeOH: 0,5:1, reaction time of 20 minutes, and reaction temperature of 30°C

Fuel Characterization

Sample of the biodiesel produced at the best conditions was characterized to ascertain its compostion and other relevant properties. Analysis by gas chromatography showed that the methyl ester content in the sample was 97,81%. This result has already fulfilled the Indonesian biodiesel standard (SNI).

Table 3 shows the comparative properties of the biodiesel from chicken fat with respect to Indonesian Standard for Biodiesel (SNI). The results of density and viscosity tested were 877 kg/m^3 and 3,46 mm^2/s. A 154°C flash point was obtain from the flash point analyzation of the biodiesel. The compositions and properties of the biodiesel were found to compare well with Indonesian Standard of Biodiesel.

Table 3. Properties of biodiesel produced

Property	Unit	SNI	FAME
Density	Kg/m^3	860-890	877
Viscosity	cSt	2,3-6	3,46
Methyl ester content	%	≥96,5	97,81
Flash point	°C	Min. 100	154

4. CONCLUSION

Co-solvent will faster the reaction time, however it also can lower the biodiesel yield if the excess amount of co-solvent was used. The biodiesel yield increased with the increasing of reaction time and reaction temperature. The excess amount of catalyst led to form gel solution. Diethyl eter as co-solvent is suitable in transesterification reaction for biodiesel production from chicken fat. The best condition in biodiesel production from chicken fat using diethyl eter as co-solvent are 0,5:1 of diethyl eter/methanol volume ratio, reaction temperature of 35°C, and reaction time of 20 minutes with biodiesel yield of 95,27%. The result of this work showed that the use of chicken fat is very suitable as low cost feedstock for biodiesel production.

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