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Home-Made Eco Green Biodiesel From Chicken Fat (CIAT) and Waste Cooking Oil (PAIL)

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Abstract

Chicken fat and waste cooking oil commonly consumed in Indonesia, thereby causing health problem. In this study, chicken fat (CIAT) and waste cooking oil (PAIL) were used to produce methyl esters in a home-made biodiesel reactor. Transesterification is affected by alcohol type and base catalyst used. The reaction process were run for 90 minutes at 60°C and 2000 rpm stirring rate. Important properties of the biodiesel like density and kinematic viscosity has been estimated. According to the results, maximum methyl esters yield of 91% has been achieved. The fuel properties of methyl esters produced in home-made biodiesel reactor with methanol and sugarcane spirits were close to each other The home-made biodiesel properties using sodium hydroxide as catalyst were better than using calcium oxide. The production cost of CIAT and PAIL biodiesels with home-made biodiesel reactor were cheaper than government biodiesel selling price.

Keywords: Biodiesel, chicken fat, waste cooking oil

1. Introduction

Indonesian petroleum is expected to be run out in 2023 [1]. The biofuel research has been prioritized for biodiesel. Biodiesel has received significant attention since it is nontoxic, biodegradable and renewable diesel fuel [2]. Indonesia's Ministry of Energy and Mineral Resources (MEMR) issued a progressive target for a biofuel blending mandate over the 2008–2025 time frame. This regulation increases mandatory biodiesel blending from 10% to 15% for transportation and industrial uses, and it increases mandatory biodiesel blending to 25% for electricity generation [1].

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The world's highest cause of death according to WHO is heart disease and stroke (12.29 million) with triggering factors mainly due to the accumulation of cholesterol and triglyceride [3]. The greatest prevalence is found in the lower middle economic group. Chicken fat and waste cooking oil contain saturated fatty acids in large quantities, causing health problems. Street food shops using chicken fat rather than chicken stock and used cooking oil for economical reason. Waste cooking oil is a by-product from hotels, restaurants, and street food shops, while chicken fat is a by-product from chicken slaughterhouses. This street food shops usually throw away the waste cooking oil as it becomes very dark, while the chicken slaughterhouses throw away excessively chicken fat. The pollution caused by meat industries and street food shops increases with the growing annual consumption. It may be reduced and more valuable products can be obtained by converting them to biodiesel [4]. Hereinafter glycerol as by-product of biodiesel can be converted to many products that are more economically valuable such as triacetin [5,6] and 1,3-dinitroglycerin [7,8].

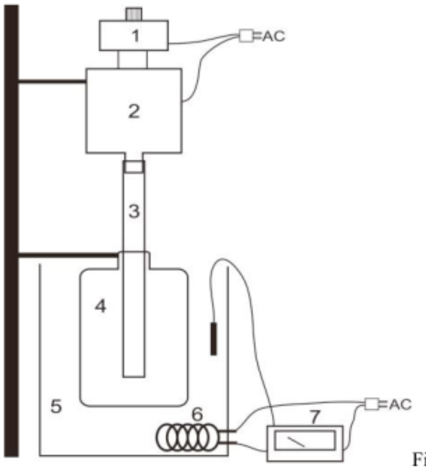
Many researchers were perform on producing biodiesel from waste vegetable oils [9] and animals fats in laboratory scales. Banerjee et al. [10] investigated biodiesel production using waste cooking oil as feedstock and base catalyst. Refaat et al. investigated biodiesel production from waste cooking oil with different molar ratios of methanol to oil (3:1, 6:1, and 9:1), potassium hydroxide and sodium hydroxide as catalyst with different concentrations (0.5% and 1% w/w) and reaction temperatures (25 and 65°C) [11]. Majority of researchers have used sodium hydroxide catalyst for transesterification reaction and believed that it is the best catalyst for waste cooking oil [12,13]. The base catalyst are preferred over acid catalysts, owing to their capability of completion of reaction at higher speed, requirement of lower reaction temperature, and their higher conversion efficiency as compared to acid catalysts [10]. Alptekin et al. reported the fuel properties of methyl esters from vegetable oils and waste animal fats with potassium hydroxide and methanol met ASTM D6751 (S500) biodiesel fuel standards [2]. Saini reported methanol is the most suitable alcohol [14]. Marnoto and Effendi investigated biodiesel production using sugarcane spirits as alcohol and calcium oxide as catalyst [15]. But no work appears to have been reported on home-made biodiesel production from chicken fat and waste cooking oil using home-made biodiesel reactor.

The present study deals with using methanol and sugarcane spirits as alcohol and sodium hydroxide and calcium oxide as catalyst for transesterification reaction. The objective of the study was to optimized the process with suitable alcohol and catalyst with home-made biodiesel reactor. The obtained methyl esters were characterized by determining their yield, fuel properties, and GCMS. The production cost is calculated for feasibility study compared with government biodiesel selling price. The purpose of the present study are to produce home-made biodiesel from chicken fat and waste cooking oil in a home-made biodiesel reactor, to reduce health risk factor from chicken fat consumption and waste cooking oil usage, to reduce pollution with waste management of chicken fat and waste cooking oil.

2. Materials and Methods

In this study, chicken fat and waste cooking oil were used as feedstocks for home-made biodiesel production. Chicken fat was supplied from a chicken slaughterhouse and waste cooking oil supplied from street food shops in South Yogyakarta, Indonesia. This chicken fat was transformed into liquid form by a rendering process. The waste cooking oil was filtered. Methanol in this study supplied from CV Oralarang Chemindo and usually used for perfume and laundry softener solvent. Sugarcane spirits is a waste treatment product from Madukismo sugar factory and distributed by UD Soegijoko. Calcium oxide is well known as "*gamping*", used as traditional building and painting material in Indonesia, supplied from building material stores in Yogyakarta.

Home-made biodiesel reactor was modified using glass bottles, heating element, dynamo motor, dimmer or potentiometer, rubber pipe, and digital automatic thermostat as shown in Fig. 1. These materials can be easily obtained in electronic and online shops. The dynamo motor for blender or mixer can be used for this biodiesel reactor. The water chamber with heating element can be obtained in all home appliance stores like electronic kettle.



1. Dimmer (potentiometer) to control stirring rate
2. Dynamo motor as rotator for the stirrer
3. Gasoline hose for motorcycle as stirrer
4. Glass bottle sealed with alumunium foil as reflux flask
5. Water chamber
6. Heating element to heat up water chamber
7. Automatic digital thermostat to control reaction temperature

Fig. 1. Home-made biodiesel reactor

The first process was dissolving 4.5g of catalyst (sodium hydroxide or calcium oxide) in measured quantity of 690 ml alcohol (methanol or sugarcane spirits) without any application of heat. After complete dissolution, this mixture heated into 60°C. In the 1000 ml glass bottle, 90g liquid chicken fat or waste cooking oil was heated into 60°C. After both of them reached 60°C, the mixture of catalyst and alcohol was added into oil. The reaction was carried out for 90 minutes at 60°C and the stirring rate was maintained at 2000 rpm. The bottle was sealed using alumunium foil in order to prevent alcohol from evaporating.

After the reaction completed, the mixture was allowed to settle overnight and the bottle was sealed to prevent leakage. The mixture form two distinct layers, the upper phase contain methyl esters, while the lower one contain glycerol.

Biodiesel from the upper layer was washed using warm distilled water (55°C). The volume of distilled water used was two times the volume of biodiesel obtained. After the biodiesel and water form into two layers, the biodiesel in the upper layer was separated from the water.

Density of biodiesel was measured in analytical balance using a picnometer glass with distilled water as the standard. Kinematic viscosity was measured using ostwald viscometer with water as the reference liquid. The Gas Chromatography-Mass Spectroscopy (GCMS) was tested at Ahmad Dahlan University. Production cost was measured with biodiesel yield and all materials cost.

3. Result and Discussion

In the process of producing home-made biodiesel using home-made biodiesel reactor, chicken fat and waste cooking oil were evaluated as feedstocks. Reaction conditions (temperature, stirring rate, reaction time) were selected with taking into account of the previous researches. Yield of biodiesel optimized as using sodium hydroxide as catalyst rather than calcium oxide, while the yield of biodiesel produced using methanol and sugarcane spirits as alcohol were close to each other.

The fuel properties of produced biodiesel (density and kinematic viscosity) were determined and compared with GCMS. Density of fuel is an important characteristic and directly affect the engine performance because it influences the efficiency of atomization of the fuel [5]. The biodiesel produced in this study have density varied in the range of 0.810-0.876 g/cm^3.Viscosity is a measure of a fluid's resistance to flow. Viscosity influence the quality of combustion [2]. In this study, the viscosities of biodiesel varied in the range of 1.823-2.741 mm^2/s. GCMS resulted in this study have procentage of methyl esters varied in the range of 7.64-84.48%. The fuel properties of produced biodiesel perform better with sodium hydroxide rather than calcium oxide as catalyst, but the fuel properties of biodiesel with sugarcane spirits and methanol as alcohol were close to each other (Table 1.).

Table 1. Eco Green Biodiesel Quantity, Quality, Economic Analysis.

Sample Code	Independent Variables			Yield (%)	Density (gram/cm^3) 40°C	Kinematic Viscosity (mm^2/s) 40°C	% Methyl esters	Production cost, IDR
	Fatty Oil	Reactan	Catalyst					
A	Chicken Fat	Sugarcane spirits	Sodium hydroxide	83	0.863	2.741	65.23	4,863
B	Chicken Fat	Sugarcane spirits	Calcium oxide	65	0.872	2.659	18.99	6,075
C	Chicken Fat	Methanol	Sodium hydroxide	91	0.850	2.391	82.05	1,549
D	Chicken Fat	Methanol	Calcium oxide	69	0.814	1.823	11.,21	2,024
E	Waste cooking oil	Sugarcane spirits	Sodium hydroxide	74	0.876	3.142	74.69	5,391
F	Waste cooking oil	Sugarcane spirits	Calcium oxide	62	0.866	2.413	7.64	6,403
G	Waste cooking oil	Methanol	Sodium hydroxide	77	0.840	2.227	84.48	1,847
H	Waste cooking oil	Methanol	Calcium oxide	56	0.810	2.101	24.40	2,502

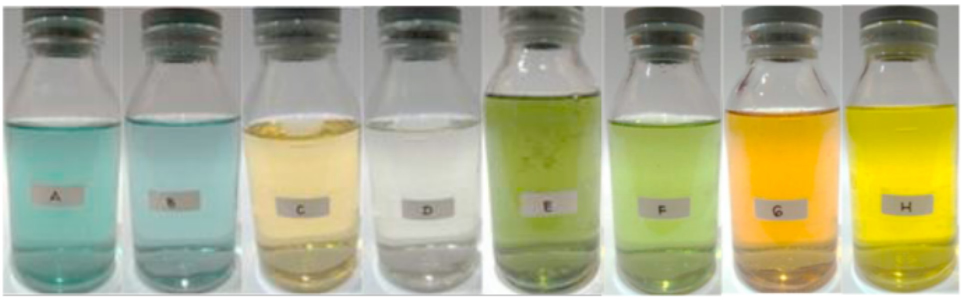


Fig. 2. Eco-green biodiesel product using home-made biodiesel reactor

The colour of biodiesels from chicken fat (CIAT) using sugarcane spirits were light blue, while biodiesel using methanol were clear and yellowish. The colour of biodiesels from waste cooking oil (PAIL) using sugarcane spirits were green, while using methanol were light yellow and pale orange (Fig. 2.). The Indonesian sugarcane spirits were colored blue as following government regulation for the safety reason and this blue colour indicates it is not edible.

It is known that feedstocks cost is the major problem to the market feasibility of the biodiesel. In this study, low cost and high availibility feedstocks such as chicken fat and waste cooking oil were used for biodiesel production, also low cost alcohols such as methanol and sugarcane spirits. The prices of the feedstocks and chemicals were obtained from the local market. However, the prices may different to the other country due the currency and resources availibility differences. Therefore, it should be noted that the final costs of the home-made biodiesels in this study are valid only for Java, Indonesia. Production cost in this study range from IDR 1,549-6,075 per litre. The highest production cost in this study is still cheaper than government biodiesel selling price (IDR 8,100).

4. Conclusion

The objective of this study was to produce home-made biodiesel using home-made biodiesel reactor from chicken fat (CIAT) and waste cooking oil (PAIL). For this aim, methanol and sugarcane spirits were used as alcohol, while sodium hydroxide and calcium oxide were used as catalyst. Home-made biodiesel reactor made from materials which can be obtained in local electronic or online shops and easily built in every household. According to the results, there were significant differences in the biodiesel yield and properties of methyl esters between methanol and sugarcane spirits. But, the biodiesel yield and properties using sodium hydroxide as catalyst were better than using calcium oxide. According to the economic analysis, the production costs CIAT and PAIL biodiesels produce using home-made biodiesel reactor were cheaper than government biodiesel fuel selling price.

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