Article Energy Proceedings Gasal 2122.pdf

by

ISSN 2004-2965 Energy Proceedings, Vol. 22, 2021

International Conference on Applied Energy 2021
Nov. 29 - Dec. 5, 2021, in Thailand/Virtual
Paper ID: 747

Increasing Quality of Health and Income Per Capita with Household Biodiesel Production from Chicken Fat and Waste Cooking Oil

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ABSTRACT

Cardiovascular disease and obesity are the number one causes of death. Consumption of unhealthy chicken fat and waste cooking oil in Indonesia is still very high with the aim of reducing household spending without reducing the quality of the taste of the food. This study produces biodiesel using a modified reactor which is applied in the home industry using feedstocks of mixture of chicken fat and waste cooking oil with various compositions, calculates the economic value of biodiesel products, and tested with biodiesel properties. The purpose of this research is to produce biodiesel from home industries that fulfill the biodiesel properties standards and calculate the economic value of the biodiesel produced so that it can increase the income per capita of the Indonesian people.

The research method is a development research of applied biodiesel production in the home industry from feedstocks mixture of chicken fat and waste cooking oil 1:3, 1:1, and 3:1 with a modified biodiesel reactor with a capacity of 5-8 liters. Biodiesel production by esterification-transesterification reaction. Biodiesel from home industry is calculated for its economic value and business opportunities, and then tested with fuel properties: flash point ASTM D 93, cloud point ASTM D 975, density ASTM D 1268, kinematic viscosity ASTM D 445, and alkyl ester content EN 12514.

This study includes a cost analysis of the proposed biodiesel production method to evaluate whether the method would be a feasible alternative for low income families to develop it as a home industry as a mean to ammend their income. The result of the analysis shows that the production cost of the proposed method is lower than the current selling price of the Government's subsidized biodiesel price, making the method to be an attractive choice for a home industry alternative.

Keywords: renewable/green energy resources, applied energy technologies, chicken fat, waste cooking oil, increasing quality of health, increasing income per capita.

NONMENCLATURE

Abbreviations	
APEN	Applied Energy
Symbols	
n	Year

1. INTRODUCTION

Cardiovascular disease is a non-infectious disease that is the number one cause of death. The diseases classified as cardiovascular disease are coronary heart disease, heart failure, hypertension, dyslipidemia, arrhythmia, and stroke. This disease is very common in low-middle income countries. One of the factors of cardiovascular disease is obesity [1].

Obesity is a high-risk factor for dyslipidemia. Dyslipidemia is the imbalance of lipids such as cholesterol, low-density lipoprotein cholesterol, (LDL-C), triglycerides, and high-density lipoprotein (HDL). Hypercholesterolemia, one of the symptoms of dyslipidemia, is a plasma cholesterol level that exceeds the normal threshold and is a major factor in cardiovascular disease [2]. In 2008 there were 35.1% of the Indonesian population suffering from

Selection and peer-review under responsibility of the scientific committee of the 13th Int. Conf. on Applied Energy (ICAE2021).

hypercholesterolemia, while in the 1990 survey there were 2-3% of children aged 5-17 years suffering from obesity. The prevalence of obesity in children in Indonesia increased from 5% in 1990 to 16% in 2001 [3]. One of the causes of hypercholesterolemia is excessive consumption of saturated fatty acids in the fast food, also as those found in chicken fat and waste cooking oil.

Based on data of Indonesian Central Bureau of Statistics during 2007-2015, the largest average per capita consumption per week of animal protein foods comes from chicken eggs, followed by chicken meat. Meanwhile, consumption of beef and seafood is still far below [4]. Broiler chicken meat contains 21% protein, 19% fat, and 3.2% mineral substances. Overall in the slaughterhouses, there is an average of 2.54% of chicken fat separated from the meat.

People often use cooking oil repeatedly. The use of cooking oil repeatedly will cause the oxidation of unsaturated fatty acids which then form peroxide groups and cyclic monomers. Several animal studies have shown that large doses of peroxides can stimulate colon cancer. Therefore, the use of waste cooking oil repeatedly is very dangerous for health [5].

Consumption of chicken fat and waste cooking oil has been studied to have a negative impact on health quality. Therefore, it is necessary to find an alternative utilization of chicken fat and waste cooking oil that has economic value in the community. In a study conducted by Soegiantoro et al [6], chicken fat and waste cooking oil can be produced into biodiesel on a small scale, but they are still less efficient because the production capacity is too small to be worth selling.

Chicken fat and cooking oil are harmful to health, so they are not safe for consumption. However, in reality there are still many who use it for economic reason. The best solution is using chicken fat and waste cooking oil as feedstocks for biodiesel, for it will increase economic value, prevent disease, and support the government's program to increase the biodiesel ratio by 30% [7]. So far, research of biodiesel is still on a laboratory scale and can not be applied in the home industry as a entrepreneur business unit. Research is needed for household production scale so that can have a direct impact to society.

In this research the size of the biodiesel reactor developed by Soegiantoro et al has been upscaled to a home industry capacity of 5-8 liters. In addition to that, ratios of 1:3, 1:1, and 3:1 for the proportion of the chicken fat to the used cooking oli for the feedstock's mixture have been adopted, which are different than the ratios of the two substances adopted in the previous study.

This study aims to utilize chicken fat and waste cooking oil as feedstocks for biodiesel so that it still has economic value and is no longer waste in the process of cooking food. Then calculate the economic value of chicken fat and waste cooking oil based on the cost of biodiesel production in the household industry. This study examines the quality of biodiesel properties with various compositions of a mixture of chicken fat and waste cooking oil.

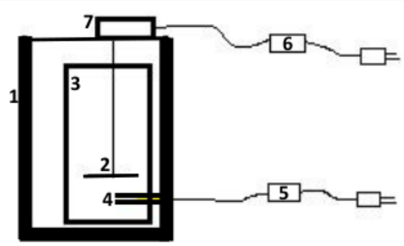
This research is useful for prevent disease and increasing of quality health due to not consuming chicken fat and waste cooking oil, increasing income per capita due to the economic value of chicken fat and waste cooking oil by using for biodiesel feedstocks in household industry, assist the government's efforts to increase the biodiesel ratio of 30%.

2. MATERIAL AND METHODS

2.1 Material

In this study, chicken fat and waste cooking oil were waste as feedstocks for biodiesel production. Chicken fat was supplied from a chicken slaughterhouse and waste cooking oil supplied from street food stall at Centre 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. NaOH and H_2SO_4 supplied from CV Dian Fajar Yogyakarta.

Household biodiesel reactor was modified using big chamber, heating element, hand grinding machine, dimmer or potentiometer, stainless steel rotator, and digital automatic thermostat as shown in Fig. 1. This material is easy to find in the technical store and the price is not expensive to assemble a biodiesel reactor.



1. Stainless steel mainframe
2. Stainless steel rotator
3. Stainless steel chamber (capacity 30L)
4. Heating element
5. Thermostat
6. Dimmer or potentiometer
7. Hand grinding machine

Fig. 4. Biodiesel Reactor for Home Industry

2.2 *Methods*

The research method is a development research of applied biodiesel production in the home industry [6]. The novelty of this research are using biodiesel feedstocks from mixture of chicken fat and waste cooking oil 1:3, 1:1, 3:1, and a modified biodiesel reactor with a home industry capacity of 5-8 liters.

FFA analysis were determined by volumetric titration method with methanol and sodium hydroxide. The FFA content was calculated by multiplying alkaline volume with alkaline normality, followed by dividing the product by the samples' volume[8]. If the resulting FFA number is more than 5%, then esterification process had to be done to prevent the saponification reaction in the transesterification [9].

Esterification was carried out by mixing 55% methanol by volume of fat with sodium hydroxide catalyst of 1% by volume of fat. This mixture was heated to 63ºC for 2 hours while stirring in a closed container using a biodiesel reactor. The product of this reaction was allowed to stand for 12 hours. Then, the mixture was separated between the alkyl ester and water. [9].
The mixture with low FFA was transesterified by adding methanol six time the weight of fat and sodium hydroxide catalylist 6% of the weight of fat. The catalyst used was sodium hydroxide. This mixture was heated to 60°C for 90 minutes while being stirred in a closed container using a biodiesel reactor. The reaction product was allowed to settle for 12 hours. The methyl ester and glycerol were then separated [6].

Biodiesel production cost was calculated by the yield percentage and all of raw material price and electricity cost. Meanwhile the quality of biodiesel produced from home industries is determined based on the fuel properties which are flash point ASTM D 93, cloud point ASTM D 975, density ASTM D 1268, kinematic viscosity ASTM D 445, and alkyl ester content EN 12514[10].

3. THEORY/CALCULATION

The esterification process was to reduce the FFA content on the biodiesel fat source. The esterification mechanism is as shown in figure below [11].

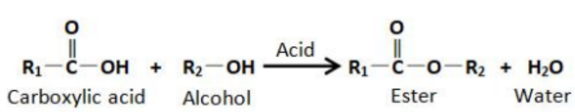


Fig. 2. Esterification mechanism

The transesterification reaction was a basic reaction in producing biodiesel. The transesterification mechanism is as shown in figure below [11].

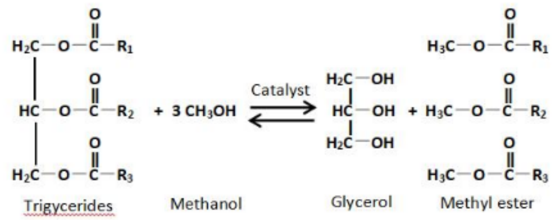


Fig. 3. Transesterification Mechanism

4. RESULT

The calculation of the economic value of biodiesel produced by the home industry are as shown as in the table below

Composition Feedstocks		Cost of Production in Rupiahs (per Liter), updated September 2021				
		Feedstock	Methanol	other Chemical	Electricity Cost	TOTAL COST
Chicken Fat	Waste Cooking Oil	as composition	industry grade	technical grade	for 3 hrs	in Rupiahs
25%	75%	550	3,645	98	57	4,350
50%	50%	700	3,645	98	57	4,500
75%	25%	850	3,645	98	57	4,650
Reference (selling price Biosolar, government subsidized solar price)						5,150

Fig. 4. Biodiesel Economic Value

It should be mentioned here that the above cost analysis does not include the labour charge, which, in Indonesia, varies from region to region. Neitehr has the cost of the production of the biodiesel reactor (which in the case of this research amounts to IDR 600.000) and the maintentance cost been factorized in the analysis.
The quality properties of biodiesel produced by the preceeding process, namely the flash point, cloud point, density and the kinematic viscosity are as shown as in the following table together with the accepted values as stipulated by the relevant ASTM standards.

Composition Feedstocks		Biodiesel Quality Parameter				
		Flash Point PM.c.c. (°C)	Cloud Point, (°C)	Density at 15°C (g/ml)	Kinematic viscosity at 40°C (mm^2/s)	Concentration Alkyl Ester
Chicken Fat	Waste Cooking Oil	ASTM D 93	ASTM D 975	ASTM D 1268	ASTM D 445	EN 12514
25%	75%	59.5	-8.0	870.3	4.0	97.6
50%	50%	63.1	2.0	888.8	4.3	98.8
75%	25%	57.1	-7.0	877.8	5.0	97.4
Reference		60 - 80	-15.0 - 10.0	860 -900	2.0 - 5.0	>96.5

Fig. 5. Home Industry Biodiesel Properties

The Table clearly shows that, except for the slightly less than the minimum requirement of flash point belonging to the biodiesel produced by the feedstock with 1:3 and 3:1 chicken fat to waste cooking oil ratios, the properties of the biodiesel produced by from the home industry process carried out in this research are within the ASTM requirements.

5. DISCUSSION

Based on the testings results, all biodiesel met the biodiesel quality requirement, even though the biodiesel using the chicken fat and waste cooking oil with ratio of 1:1 had greater difference in cloud point, flash point, and density than the other two variables and those two variables had a slightly lower flash point than that is required in ASTM D 93. These proved that biodiesel produced from chicken fat and waste cooking oil mixture by households can satisfy the quality required. However, regular quality control of biodiesel still required in each households producing biodiesel to ensure the consistency of quality performed.

Based on the economic calculation, biodiesel production cost didn't varies greatly. This is important, since price over-fluctuation can harm the market and the biodiesel producer itself. The biodiesel produced cost lower than the goverment's subsidized diesel fuel price. This indicated that biodiesel produced by households can be an entrepreneurial opportunity. However, biodiesel reactor deprecation costs hasn't been determined.

6. CONCLUSIONS

Household industry biodiesel from chicken fat and used cooking oil can be used as a solution to improve the quality of health and increase per capita income, because it can divert the consumption of chicken fat and waste cooking oil by increasing its economic value into biodiesel that can be sold the same as the selling price of government subsidized diesel by earning a profit so as to increase per capita income. The quality of home industry biodiesel produced with the composition of chicken fat and waste cooking oil 1:3, 1:1, and 3:1 fulfill the standard fuel properties in flash point ASTM D 93, cloud point ASTM D 975, density ASTM D 1268, kinematic viscosity ASTM D 445, and alkyl ester content EN 12514 relatively. However, further study considering biodiesel reactor's maintenance cost would be needed to determine the depreciation cost.

ACKNOWLEDGEMENT

Dr. Eka Setyaadi, M.Pd.K. (rector of Immanuel Christian University) who has facilitated obtaining funding sources from the government for this research, Kusworo, S.Pd., M.Hum. (principal of 3 Senior High School, Padmamba) who has provided a laboratory for this research, Muslikhin Hidayat, S.T., M.T., Ph.D. (chief of Chemical Engineeriing Department, Gadjah Mada University) for laboratory testing of biodiesel properties.

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