Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.6, No.22, 2016

The Effect of KOH Catalyst Concentration and Reaction Time on the Biodiesel Quality from Yellowfin Tuna Offal

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The research is financed by Asian Development Bank. No. 2006-A171(Sponsoring information)

Abstract

The aim of study is determine the effect of concentration and a longer reaction time and the best treatment on the quality of biodiesel from yellowfin tuna fish offal. Biodiesel processing using a two step of esterification and transesterification reactions are graded with KOH catalyst in the treatment of each catalyst concentration of 1.0%; 1.5% and 2.0% with a reaction time of 90 and 120 minutes. Analysis of biodiesel quality that using methods of FT-IR (ester functional group), 1H-NMR (conversion of methyl ester), GC-MS (fatty acid composition) and physical quality. Based on statistical analysis, it is known that the treatment concentration and reaction time did not significantly affect on the biodiesel quality. FFA content of oil extracts of yellowfin tuna innards of 4.415%. Treatment KOH 2% on a long reaction time of 90 minutes to produce the best biodiesel (with yield biodiesel esterification reaction yield of 89.5% and a transesterification reaction amounted to 84.71% has a compound with a functional group of alkanes, alcohols and esters of saturated and unsaturated. The chemistri composition of fatty acid of biodiesel contains three main types of compounds, respectively: methyl palmitate (19.45%), methyl oleate (17.37%) and methyl eicosa (7.56%.) Based on the analysis of physical properties of biodiesel, it was only pour point parameter that meets of the standard quality biodiesel (9ºC) with a flash point is 64ºC compliant 48 diesel oil. The specific density and kinematic viscosity not meet quality standards.

Keywords: KOH catalyst concentration, reaction time, esterification, transesterification, tuna offal, biodiesel

1. Introduction

Based on FAO data of 2014, mentioned that Indonesia is one of the country's second largest tuna producer in the world and supplies more than 16% of the total world production of tuna. In 2015, total production of tuna Indonesia reached 613,575 tonnes per year with a production value of Rp. 6.3 trillion (Ministry of Maritime Affairs and Fisheries, 2015). Tuna fish processing into processed commodities diverse on the one hand an enormous economic impact but on the other hand cause environmental pollution (water bodies, soil and air).

The waste produced by the fishing industry ranged between 25% to 30% per ton of raw material, and reached 3.6 million tonnes per year (Ministry of Maritime Affairs and Fisheries, 2007). Solid waste generated from tuna processing industry may be leftover pieces of meat, skin, head, viscera, bones, scales and fins. Tuna fillet processing waste to produce 30% to 40% of the total net weight (Silva et al., 2014). Tuna fish innards of waste was utilized for processing silage, protein hidrolizat, bekasang, and biodiesel as one of the new and renewable energy (Sahubawa, 2012). Waste offal large pelagic fish (tuna, yellowfin tuna, marlin) containing fat / oil in bulk (Sahubawa, et al. 2016). Based on the calculation, 1 tail tuna weighing 75 to 90 kg produce 3 to 5 kg of offal and fish marlin weighing 90 to 100 kg produces 6.5 kilograms ± offal (Sahubawa, 2012). Potential large pelagic fish offal wastes has the potential to be processed into biodiesel in order to reduce dependence on the population of the dangers of fuel oil (BBM) from fossils.

Fuel consumption in Indonesia in the period 1 January to 30 September 2014 has reached more than 34 million kiloliters (Pertamina, 2014). The number is expected to continue to increase and the more difficult to keep pace with the growth of motor vehicles. Petroleum fuels are increasingly unable to balance the needs of industry and households. Oil reserves has decreased as a result of continuous exploitation. The use of fossil fuels cause global warming, so we need an alternative fuel that is able to meet the needs of national fuel environmentally friendly. Biodiesel is one of the alternative fuels to meet the needs of diesel oil in Indonesia. Biodiesel is made from vegetable oils and animal fats that contain triglycerides, which consist of three fatty acid chains that are linked by glycerol molecule. According Schuchardt et al (1998) the process of making biodiesel is the process of glycerol molecule reaction with methanol to form fatty acid methyl ester (FAME) that triglyceride ester unit which is converted into another ester (fatty acid alkyl ester) through petukaran part alkoxide contains.

Fauzi et al. (2014) says that the fat/oil from tuna fish offal can be converted into 100% biodiesel obtained with a yield of 86.01%. Junengsih et al. (2015), the use of acid catalysts can convert the fat/oil from fish offal yellow fin tuna become 52.63% biodiesel, which contains fatty acids palmitic (43.64%) and oleic (32.08%). Biodiesel containing palmitic acid (saturated fatty acids) capable resistant to oxidation because it has a high octane number (Gultom, 2001). If the industrial waste processing of fish (especially offal and skin) may ditangi professionally to serve as a new and renewable source, it will be a source of alternative energy to meet the needs of the rural population in the centers of the fishery industries.

2. Materials and Methods

2.1. Material and Aparatus

Materials that used are yellowfin tuna offal was obtained from KUB Fresh Fish, Bantul, Yogyakarta. Hexane (technical), methanol (PA/Merck), sulfuric acid (PA/Merck), Na_2SO_4 anhydrous (PA/Merck), aqudest (Technical), ethanol (PA/Merck), the indicator PP (technical), NaOH (PA/merck) were used for chemical process. Aparatus that used are three-neck flask (500 ml per pyrek), thermometer (Celsius per pyrek), magnetic stirrer (1.5 cm), turning cooler (spiral shapes per pyrek), analytical balance (320 gr x 0.01 gr per Shimadzu and 1000 g x 0.1g per Tanita, hot plate stirrer (temperature max 400 and the stirrer max 10 per BSI), evaporator (heidolp), pipette, measuring cups (250 ml, 100 ml per pyrek), funnel separator (250 ml; 500 ml per Herma), water pump (400 liters per hour, aquila), H-NMR (500 MHz per aligent), FT-IR, GC-MS (Shimadzu QP-2010S), ASTM D.

2.2. Methods

2.2.1. *Preparation oil*

Preparation of materials per samples (yellowfin tuna offal). Extraction of oil from tuna fish offal to the method. Filtering the oil to get the oil without pulp using filter paper. Evaporation of the hexane contained in the oil using an evaporator to obtain pure oil. Test FFA oil, with the following formula.

$$FFA(\%) = \frac{a \times M \times 282 \times 100}{g \times 1000}$$

a : NaOH volume (ml)
M : NaOH molarity
g : Sample weight (g)
282 : The molecular weight of oleic acid (g/mol)

2.2.2. *Esterification reaction*

Esterification reaction process begins with the heating oil at 70^0C for 1 hours, with the aim of eliminating the water content in the material, allowed to stand up to a temperature at 60 ^{0}C, the preparation of esterification. The esterification reaction is done by setting up oil extracted from tuna fish offal 300 g and methanol as much as 7.17 g. Mix both ingredients and then add 1% H_2SO_4, stirring until homogeneous. Heat at a temperature of 65^0C untuil 1.5 hours in reflux system. Cooling for separating oil, dirt and fat. Oil put into the separating funnel.

2.2.3. *Transesterification reaction*

Transesterification reaction carried out by reacting with a solution of H_2SO_4 fish oil in accordance with the treatment, which was dissolved in methanol at a temperature of 90^0C and 120^0C for 90 and 120 minute at reflux system. The process of settling (separation) is performed to separate between biodiesel and glycerol produced, settling time depends on the clear separation (biodiesel on the upper surface and soap or glycerol on the bottom surface). The separation process using a funnel separator. Washing the biodiesel with distilled water, in order to dissolve the methanol, glycerol and soap were still ending up after the separation process. Washing is done approximately three times or until aquades seen more clearly. The addition of anhydrous Na_2SO_4 to absorb the water content still present in order to obtain pure biodiesel. The filtration biodiesel to separate the dirt mixed in pure biodiesel. Biodiesel that apart from the dirt and dust anhydrous Na_2SO_4.

2.2.4. *Conversion of methyl ester*

To determine the conversion of fish offal oil yellow fin tuna as methyl esters (biodiesel) is done with 1H–NMR methods using the following formula:

$$C_{ME} = 100 \times \frac{5 \times I_{ME}}{(5 \times I_{ME} + 9 \times I_{TAG})}$$

C_{ME} : conversion of methyl ester (%)
I_{ME} : integration of peak methyl ester (%)
I_{TAG} : integration of peak triacylglycerol (%)

The percentage results of the transesterification reaction can be calculated based on the percentage of proton spectra on the type of bond proton spectra glycerides and methyl esters. Factor five and nine are the result of the fact that glycerol in triglyceride has five protons and three methyl ester produced from a triglyceride has nine protons.

2.2.5. *Identification of methyl ester*

Identification of the compound methyl ester/biodiesel used FT-IR test.

2.2.6. *Composition of methyl ester*
Analysis the composition of fatty acid compound forming biodiesel used GC-MS test.

2.2.7. *Biodiesel quality*
The biodiesel quality tested with ASTM Standard methods, include specific density, flash point, kinematic viscosity, water content, pour point, and could point.

2.3. Treatment

The treatments of transesterification reaction is a variation of KOH catalyst concentration of 1.0%, 1.5% and 2.0% of the total weight of the oil and methanol (w/w), with a mole ratio of oil : methanol was 1 : 9 at 90^0C and 120^0C. The ratio of 1 : 9 produces the largest biodiesel yield.

2.4. Statistics analysis

ANOVA test to determine the effect of treatment on the quality and characteristics of biodiesel from yellowfin tuna offal. To determine the best data further based on its rank test DMRT (Duncan Multiple Ranges Test) with uses SPPS version 22. Data was tested is the yield of the transesterification reaction that use KOH catalyst with concentrations of 1.25 %, 1.50 % and 1.75 % with a temperature at 90^0C and 120^0C.

3. Results and Discussion

3.1. Offal Oil Extraction Yellow Fin Tuna

3.1.1Yield and Free Fatty Acid Levels (FFA, %)

The extraction of fats/oils obtained from two replicates of a total of 500 grams of tuna offal is 18.41% with a free fatty acid content of 4.42% (Table 1). The results of this research indicate that yields of oil produced is higher compared to the results of research Junengsih et al. (2015) dn Fauzi et al. (2014), but lower than the results of research Kuriawan et al. (2012). Free fatty acid produced was higher than the results of research Junengsih et al. (2015), Fauzi et al. (2014) & Ningtyas et al. (2011, but lower than the research Pamungkas et al. (2012)

Table 1. Production of fat/oils yield from fish wastes

No	Parameter	Fat/Oils Yield					
		Bimo et al. 2016	Junengsih, et al. 2015	Fauzi et al. 2014	Pamungkas et al. 2013	Kuniawan, et. al. 2012	Ningtyas et al. 2011
1	Fat/Oils Yield, %	18,41	16,58	15,47	-	30,99	-
2	FFA Content % (wb)	4,42	2,33	2,34	4,86	-	3,8

The yield difference of the extracted oil can be based on the level of non-polar solvent. Hexan a non-polar solvent that has a high ability to extract oil. The differences are expected because there are impurities in the extracted oil mixture. FFA content in the oil/fat yellow fin tuna fish offal is quite high (4.415%), suggesting the existence of other impurities in large quantities (especially water, soap glycerol). According Kurniati and Wahono (2015), FFA levels are still high due to the presence of water in oil can improve the hydrolysis process. Extraction of oil from fish offal black tilapia with nonpolar solvents (methanol 96%) carried out by Kurniawan (2012), Junengsih et al. (2015) using hexan solvent extraction of yellow fin tuna fish offal and Mudawamah (2007) using ether and chloroform extracts oil on the meat lemuru. If you look at the electric constants of every solvent, then hexan has constant 2, ether and chloroform have a constant 4.3 4.8. Hexan solvent should be the most bsar generate yield. The yield difference can also be influenced by the ratio of solvent material: raw materials. The greater the ratio of solvent used, the greater the yield obtained.

FFA content of these results are above the standards set (<1%) that need to be done before the esterification reaction transesterification reaction. FFA content exceeding 1.0% causes a reaction between the catalyst with a lot more free fatty acids to form soap (saponification reaction), thereby inhibiting separation of biodiesel to the maximum (Haryanto, 2002). FFA relatively high in the biodiesel can lead to corrosion of the kiln. Free fatty acids in the transesterification process also consumes the catalyst, so we need to change the process of esterification of free fatty acids into alkyl esters. FFA levels are very dependent on the different composition of these oils. The oil has a high water content tends to contain high FFA because the water will form a hydrolysis reaction during the storage process so that triglycerides can react to form glycerol and FFA (Kurniati, 2015).

3.2. Esterification reaction

The esterification reaction is the conversion stage of free fatty acids into esters by reacting fats / oils and alcohols (methanol) with an acid catalyst (H_2SO_4) in the mole ratio of fat / oil and methanol 1: 9. Results esterification of fats/oils yellow fin tuna fish offal (300 grams) to produce biodiesel yield of 268.5 grams (89.5%) (Table 2). The research results Junengsih et al. (2015) shows production of biodiesel amounted to 94.67% and Kurniawan (2012), which uses the ratio of fat/oil and methanol 1: 6 only produces biodiesel yield of 81.38%. Results strongly influenced by the type of esterification catalyst, wherein the reaction will be run optimally on the use of an acid catalyst.

3.3. Transesterification reaction

Transesterification reaction is carried out at a temperature of 65ºC using KOH catalyst treatment is 1.0% ; 1.5% ; 2.0% with the difference of reaction time of 90 minutes and 120. The yield of biodiesel from the transesterification reaction can be seen in Table 3, the color of biodiesel produced as shown in Figure 1. Based on the results of analysis of variance, it is known that there is no real effect for a long time factor reaction and concentration of catalyst to total yield. Table 3 shows that the catalyst concentration 2.0 is not yet optimal concentration in the conversion yield of biodiesel so it is still possible to increase the concentration of the catalyst. Pamungkas (2013) using the catalyst KOH with a concentration of 1.5% in the waste oil can produce a sardine fish flour yield of 71.57% and Fauzi et al. (2014) using CaO catalyst with a concentration of 1.5% in the yellow fin tuna fish offal produce a yield of 86.71%.

Table 2. The yield of oil from the esterification reaction

Reflication	Fish Oil (gr)	Yield (gr)	(%)
1	300	265.0	88.4
2	300	272.0	90.6
Total	600	531.0	189.0
Avarage	300	268.5	89.5

Table 3. The yield of oil from the transesterification reaction

Reaction Time (minutes)	Chatalysts Concentration (%)	Biodiesel Yield (%)		
		reflication 2	reflication 1	Average
90	**1.0**	76.30	78.12	**77.21**
	1.5	82.01	86.70	**84.36**
	2.0	83.77	85.65	**84.71**
120	**1.0**	80.66	82.63	**81.65**
	1.5	84.68	79.33	**82.01**
	2.0	82.87	81.50	**82.19**

Table 3 shows that the production yield of biodiesel is directly proportional to the increase in the concentration of catalyst. This is due to the increasing methoxide ion which is a true catalyst in the reaction of alcoholysis (transesterification) so more alcohol involved react and bergerser equilibrium towards the formation of biodiesel (Ningtyas, et al., 2011). Based on research Ningtyas et al. (2011), it is known that the base catalyst 2.0% is the highest concentration threshold. Provision of basic catalyst is greater than 2.0% are likely to convert oil into soap. The results obtained yield when compared to research Junengsih et al. (2015) which uses oil and methanol mole ratio of 1: 9 turns tend to be lower. The use of sulfuric acid catalyst is able to produce the results of the transesterification yield up to 84.21%. Ningtyas et al. (2011), the use of oil and methanol mole ratio of 1: 6 produce a yield of 80.96% with NaOH catalyst. This is presumably because trigiserida can completely reacted with methanol to form methyl esters.

The results obtained in the transesterification reaction with KOH catalyst varies depending on the type and quality of the oil used. Freedman et al. (1984), says that NaOH is more effective in the conversion of biodiesel as NaOH mixture with methanol would produce less water during the formation methanolic ions, so that the resulting yield will be greater. According Jumaeri (2003) there are three factors that lead to more reactive catalysts NaOH than KOH: (1) the value of the Na atom electronegativity greater than K atom, (2) ionic radii 1.33ºA K is larger than the ionic radius of Na (0.95ºA), shows the Na ion exchange capacity to release OH- ions to molecules larger NaOH and (3) number of spin Na is 3s1 while K is 4s1, which indicates the amount of skin Na less than K making it easier to react. Nonetheless, when compared with other alkaline catalyst (NaOH), then the use of KOH will be more secure because it is easily soluble in alcohol and is not corrosive to the processing equipment (Alkabashi et al. 2009).

Figure 1. Production of biodiesel from yellowfin tuna offal
with unsing the KOH catalyst concentration (1.0 ; 1.5 ; 2.0%) for the 90 and 120 minutes

3.4. Identification of Methyl Ester (Biodiesel)

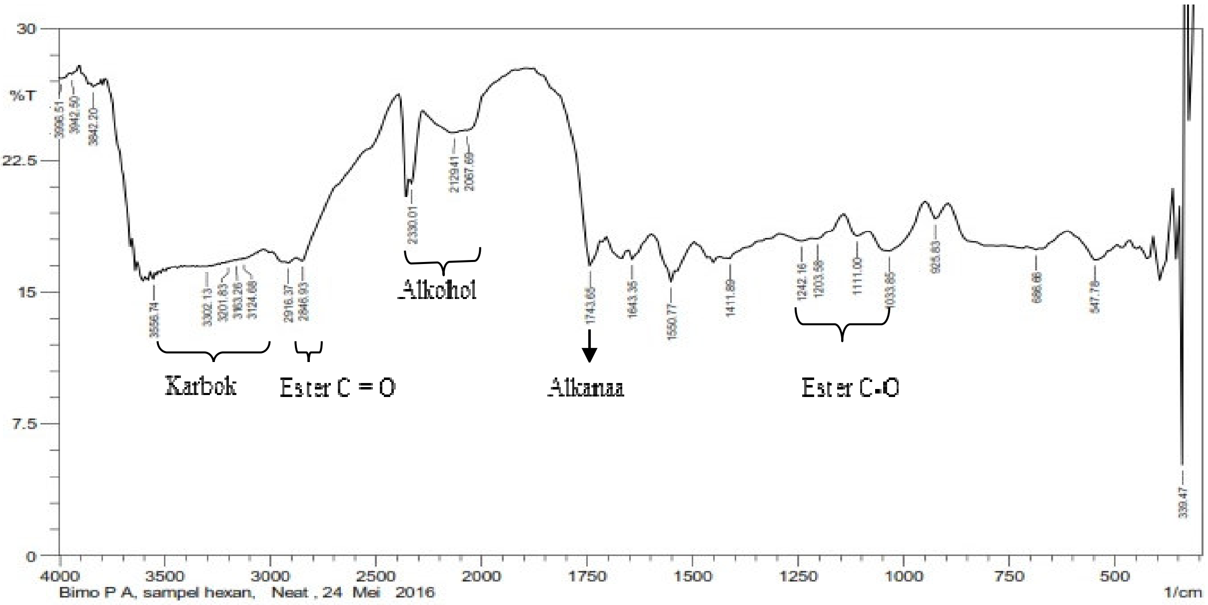
3.4.1. *Analysis ester*

Methyl ester was analyzed qualitatively with the FT-IR method to prove the product ester transesterification. Based on the analysis looks their ester based observations typical absorption in group C=O, C-O and C-H (Figure 2). Group C=O has absorption area between 1,690 to 1,760 cm^{-1}, C-O at 1,080 to 1,300 cm^{-1} and C-H groups alkane in the interval 2,850 – 2,960 cm^{-1}. The existence of ester can be seen in uptake in the area of 1,743.66 cm^{-1} which is the wave number for the C=O ester. Weak absorption area seen between 1,000 cm^{-1} to 1,300 cm^{-1} which is an area of the C-O ester uptake. Absorption occurs in the wavenumber 2,916.37 cm^{-1} and 2,846.93 cm^{-1} is the group C-H absorption of the fatty acid chain. Based on this, it is known that these compounds contain hydrocarbon having ester groups. Uptake widened between 3,500 cm^{-1} and 3,000 cm^{-1} is still due carboxylate (carboxylic acid group catchment area). The existence of the carboxylic group allegedly as a result of the esterification process is less than perfect in converting fatty acids into esters. Pamungkas (2013) say that their strong absorption area 1,743.65 cm^{-1}. Fauzi et al. (2014), which uses yellowfin tuna offal as oil resources are also getting a strong absorption at the same wavelength.

3.4.2. *Conversion Analysis of methyl esters (1H-NMR spectra)*

1H-NMR spectra analysis using the Agilent 500 MHz instrument with DD2 console system that operates at a frequency of 500 MHz (1H) as well as solvent used is chloroform CDCl3. Biodiesel conversion calculation shows that the highest conversion rates reached 100% with the cathalyst concentration of 2.0% on the time of 90 minutes in the transesterification reaction and long transeserifikasi 120 minutes at a concentration of 1.0% KOH catalyst (Table 3). This research has higher than the conversion of biodiesel from sadine fish oil (Pamungkas, 2013), which only reached 43.08% with 1.5% KOH catalyst in the transesterification process is 120 minutes long. Fauzi et al. (2014) which uses a catalyst CaO on the extraction of tuna offal find all triglyceride converted into methyl ester up to 100% on the catalyst concentration of 1.5% with a reaction time of 90 minutes.

Based on Table 3 shows that the lowest point of biodiesel conversion occurs on the catalyst concentration of 1.5% for 120 minutes. The low conversion of biodiesel with a base catalyst due methoxide ions which react participate in deciding not work optimally triglycerides (Ningtyas et al., 2011). The low conversion of methyl ester may also be due to the evaporation of methanol during the reaction that takes place at selamg a relatively long time so that the reaction does not take place methanolyisis perfect to produce methyl esters. Methanol is an alcohol-forming methyl ester important because the structure of the resulting methyl ester comely shorter with lower vapor point (Fauzi et al. 2014). Treatment catalyst concentration 1.5% at over 120 minutes to produce the lowest yield, presumably because the evaporation of methanol for the transesterification reaction does not take place so methanolysis maximum.



Gambar 2. Spectra FT-IR of biodiesel

Table 3. Results methyl ester conversion based on 1H-NMR spectra

Time of Transesterification Reaction (minutes)	Conversion of methil ester (Biodiesel) (%)		
	KOH 1.0%	KOH 1.5%	KOH 2.0%
90	94.3	93.8	100.0
120	100.0	88.3	93.3

Based on the analysis of the spectra (Figure 3), look no emergence of peaks in the area of 4 to 4.3 ppm, although there are some very small peaks between 4.128 to 4.146 ppm which can not participate in the read 1H-NMR analysis. The entire group proton glycerides in biodiesel product does not appear to be ensured that all the glycerides had been converted into methyl esters. Values that appear in the area of 2.3 to 2.5 ppm are α-CH2 protons, whereas in the area of 1 to 2 ppm can appear peak width and height due to the CH2 protons are so close that the summit will merge into one singlet with the middle peak a multiplet with the edge that tapers (Fessenden, 1999). Spectra arise in the area of 5 to 6 ppm is an indicator of the long-chain aldehyde fall fatty acids. Conversion of methyl ester can be influenced by several factors, such as temperature, reaction time and catalyst concentration. Research using alkaline catalyst (KOH) of 1.5% is capable of producing biodiesel conversion up to 80.96% (Ningtyas et al. 2011), Nurul and Yulianna (2010) using a 1.75% NaOH catalyst to produce yield of 84.93% and Awwaludin (2008) using a 1.5% CaO was only biodiesel conversion gain of 73.65%. This indicates that the alkaline catalyst can produce methyl ester conversion more.

3.4.3. *Analysis of Fatty Acid Composition*

GC-MS testing was conducted to determine the type of fatty acids that make up biodiesel from yellow fin tuna fish offal. Tests conducted with the catalyst KOH 2.0% (the best sample) with a reaction time of 90 minutes. Biodiesel compounds analysis performed on the peak of fragmentation that has been identified as biodiesel compounds based on similarity index with a standard compound. A compound can be said to be similar if the pattern of fragments and molecular weight compounds as well as the index looks identical kemiripak of both compounds should be high. Based on the analysis, formed 10 peaks with different retention times as shown in Figure 4.

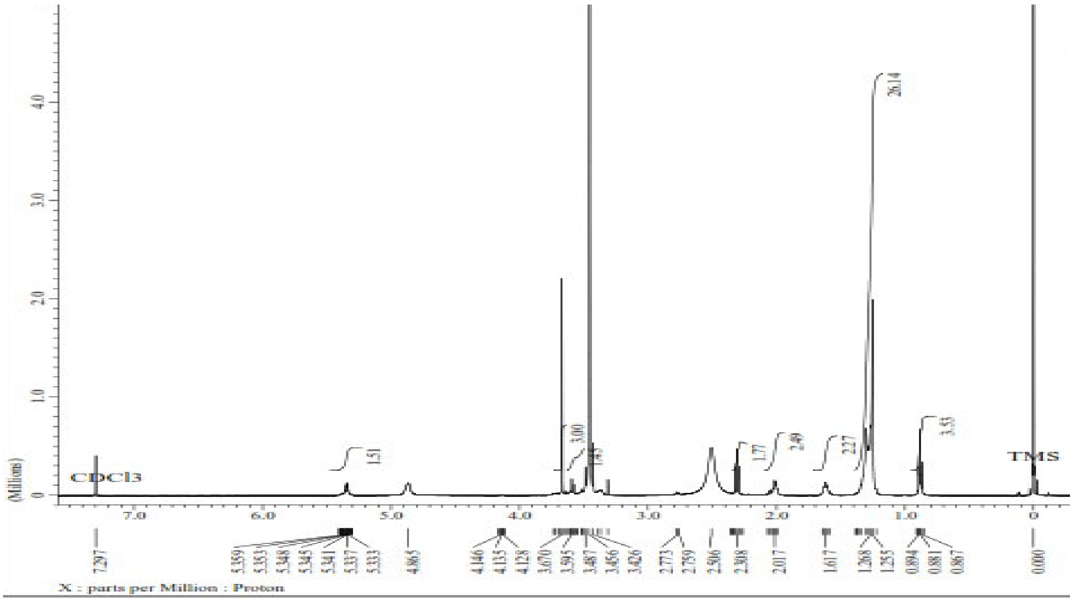


Figure 3. Spectrum 1H-NMR of Biodiesel with catalyst KOH 2% on a reaction time of 90 minutes

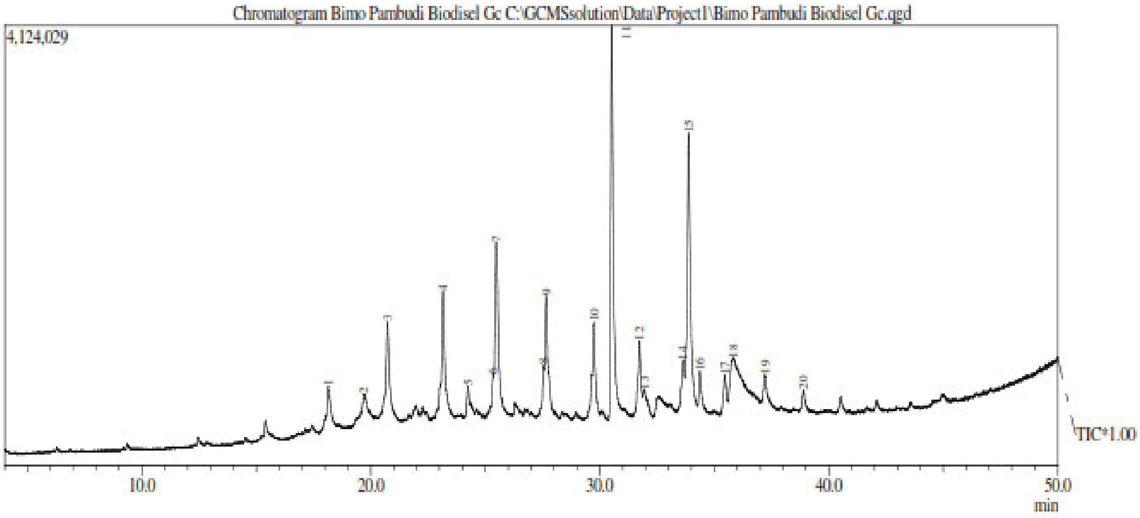


Figure 4. GC-MS chromatograms KOH 2% biodiesel with a reaction time of 90 minutes

The results of GC-MS analysis shows there are 10 peaks with 2 peaks higher (Figure 4). Peak detected spectra is the peak of the line 11 as methyl palmitate and an area of 19.45% and the peak of the line to 15 as methyl oleic cotton area of 17.37%. Palmitic acid is a saturated fatty acid that important, whereas oleic acid with one double bond are unsaturated fatty acids that play a role in determining the quality biodiesel skelter (Gultom, 2001). From the analysis, it is known there are 10 kinds of chemical compounds forming biodiesel from yellow sirif tuna fish offal (Table 3). Alkane hydrocarbon group that appears as hexadecane to nonadekana derived from residual hexane is used. Heptadekana have the formula $C_{17}H_{36}$, while methyl palmitate has the formula $C_{17}H_{34}O_2$. Cluster alkanes results in lower flash point of biodiesel so that a longer light up if exposed to sparks (Hardjono, 2001).

Table 3. Types of fatty acids in biodiesel

No	Type of chemical compunds	Peak	Percentage (%)
1	Heksadekana	3	6.16
2	Eicosa	4	7.56
3	Heptadekana	7	11.21
4	Oktadekana	9	6.61
5	Nonadekana	10	5.57
6	Metil Palmitat	11	19.45
7	Hexatriacontan	12	4.35
8	Methyl Oleat	15	17.37
9	Methyl Stearat	16	1.81
10	Linoleat acid	18	3.23

Fauzi et al. (2014), biodiesel from yellow fin tuna fish offal containing methyl palmitate with the percentage of 43.79% area. Ningtyas at all. (2011), which produces biodiesel from waste oil sardine fish meal, it contains methyl palmitate with the percentage of 20.31% area. Methyl Palmitate is the main compound in methyl ester ($C_{17}H_{34}O_2$), has a short carbon chain so as to appear earlier than methyl oleate. From the results of GC-MS analysis, it can be concluded that biodiesel from animal fats dominated by the content of fatty acid methyl palmitate.

3.5. Physical Quality

The biodiesel conversion results obtained from the treatment of KOH catalyst concentration of 2.0% with long time transesterification 90 minutes, then used to test the chemical and physical quality of biodiesel and compared with the standard quality (Table 4).

3.5.1. *Specific density*

Specific density value of biodiesel from yellow fin tuna offal amounted to 0.8065. This value indicates that the biodiesel produced do not meet the standard ASTM D 6751 Biodiesel and petroleum diesel and biodiesel SNI. It sdikarenakan density of biodiesel is low because almost all of the triglyceride ester molecules have become three. According Sulistyoningrum (2004), specific density value associated with the ability of burning or heating value of the fuel, where the value is the amount of heat generated in a fuel burning. The higher the value of the specific heat of the better quality of biodiesel produced.

Table 4. The physical properties of biodiesel from yellowfin tuna offal versus biodiesel quality standards

No	Physical Properties	Test Result	ASTM Biodiesel D.6751 (B100)		Olil Solar 48		SNI Biodiesel	
			Min.	Max.	Min.	Max.	Min.	Max.
1	Specific density 60/60°F (gr/ml)	0.806	0.840	0.920	0.820	0.870	0.850	0.890
2	Kinematic viscosity (cSt)	7.647	4.5	7	1.6	5.8	2.3	6
3	Flash point °C	64	130	-	60	-	100	-
4	Pour point °C	9	-	-	-	18	-15	13

3.5.2. *Kinematic viscosity*

Value kinematic viscosity of biodiesel amounted to 7.647 (not standard). Ningtyas et al. (2011) to get the value of the kinematic viscosity of biodiesel from waste oil sardine fish meal amounted to 4.1133, while Fauzi et al. (2014) found a higher viscosity value (9,980). High viscosity grades that can result in slow flow rate of biodiesel so that the combustion process is not running smoothly. According to Imad (2008), the viscosity of biodiesel is very dependent on the success rate of conversion of biodiesel. Conversion biodiesel still low due to the number of molecules contained glycerides in biodiesel. Cluster hydroxide at glycerides molecules can lead to the formation of hydrogen bonds so strongly that increasing the density value of intermolecular glycerides. High viscosity can also be caused by the persistence of the content of water and methanol in biodiesel.

3.5.3. *Flash point*

Biodiesel produced has a flash point of 64°C, otherwise meet the quality standards of diesel oil 48 (minimum 60°C). Compared with SNI 04.7182.2006 Biodiesel and biodiesel ASTM D-6751, the value of the flash point is still below the limit. Flash point is the lowest temperature of biodiesel, in which the vapor mixture biodiesel fuel with air will light the flame when it is given. Biodiesel produced from fish oil sardine using KOH catalyst has a flash point of 172.5°C (Pamungkas, 2013). Ningtyas et al. (2011) found a higher flash point (180°C), with the indication may provide an advantage when the fuel storage for fuel vapors are not susceptible to flame. The advantage of a low flash point is the ease and energy efficiency in misting and evaporation when the combustion process in the cylinder (Yusufa, 2008).

3.5.4. *Pour point*

Value pour point of biodiesel produced with the catalyst KOH 2.0% at an interval of 90 minutes is at 9ºC, otherwise meets the biodiesel quality standard (SNI 04-7182-2006 Biodiesel and diesel by 48). Biodiesel with a low pour point has advantages when used at a low temperature and the engine is rarely used. Biodiesel can be said to be the better quality if the lower value tuangnya point (Sulistyoningrum, 2004). Pour point is the lowest temperature that still allows the flow of fuel. Fuel can not flow when it is below the minimum value because of fuel pour point formed a solid gel.

3.6. CONCLUSIONS AND RECOMMENDATIONS

3.6.1. *Conclusion*

(1). KOH high catalyst concentration can increase production yield of biodiesel. The yield on the long reaction time of 90 minutes longer than 120 minutes.

(2). The biodiesel conversion percentage resulting from treatment of reaction time of 90 minutes with 2.0% KOH concentration and reaction time of 120 minutes at a concentration of 1.0%, reaching 100%

(3). Biodiesel is dominated by fatty acid methyl palmitate and methyl oleate respectively 19.45% and 17.37%.

(4). Characteristics flash point and pour point already meet the standards of quality biodiesel, while the kinematic viscosity and specific density not meet quality standards.

3.6.2. *Suggestion*

Further research is needed regarding the optimization of biodiesel production with a variation of the mole ratio of methanol and oil in order to obtain maximum yield, accompanied by an increase in temperature in the heating process prior to the esterification reaction so that water and solvent compounds that they have left can be removed (evaporated).

Acknowledgements

Thank you presented to the Honorable Mr. Latif Sahubawa, roomates Gives us the opportunity to help carry out research in the completion of my studies, and technician of FishTechnology Laboratory, Animal Feed and Nutrition Laboratory, Department of Fisheries Science, Faculty of Agriculture, Gadjah Mada University who has helped smooth the study

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