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PRODUCTION OF BIODIESEL FROM CORN AND COCONUT OIL WITH LOCALLY JEMBER INDONESIA VEGETABLE OIL (An optimization of biodiesel parameters)

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In this study, experimental trials will be carried out to find out the optimal recipe for processing corn oil and biodiesel oil produced by UMKM in Jember Regency (Indonesia) into biodiesel known as biosolar. Experimental conditions will be optimized to obtain partial transesterification of coconut oil and corn oil using a variety of common methoxide for the production of biosolar. Biosolar production using conventional methods has not yet produced fuel that meets modern engine standards, further research is needed to overcome this problem, including by making an advanced processing method. The following experimental parameters will be varied : liquid temperature (40-60ºC), processing time (1800 to 3600 sec.), catalyst (0.5-1,25 % of total weight.), and proportional of methanol oil mix ratio (m/o) (1:3-1:6). The maximum value parameter of biodiesel reaching 98.12% was produced by methoxide from KOH at 60 minutes of process, in 60 ºC temperature and an oil – methanol mix ratio of 1:0.25. The optimal conditions for biosolar production also with biosolar fuel properties varied catalysts were tested with the standard methods of 14214EN and ASTMD6751. The results showed that optimum catalysts for biosolar production using coconut oil and corn oil are 0.8 % of total weight of either KOH and NaOH catalyst.

Keywords: *Biodiesel, Coconut Oil, Corn Oil, Transesterification.*

1. INTRODUCTION

The world's population wants energy sourced from fossils (petroleum, coal and natural gas) but currently it is difficult to realize it due to the issue of limited availability of resources and the high type of pollution. Biodiesel is known as a renewable fuel produced from home vegetable oils, new or used oils [1].

Compared to fossil base oil, biodiesel is laboratory proved for low-toxic, low-flammable, capable of being produced on a domestic scale, low sulfur and known as aromatics essence oil, and produces near low exhaust gas emissions and it has High Heating Value and Low Heating Value close enough compared to fossil fuels. Biodiesel is a fuel form as a mixture of fossil diesel fuel can reduce air pollutants [2]. In Indonesia a mixture of biodiesel and diesel is sold by PT. PERTAMINA with the name biodiesel with a mixture of 30% biodiesel and 70% diesel (B30).

Biodiesel is commonly produced from vegetable oil and sometimes from fat or lipids. It is produced with chemical alcohols usually methanol and base catalysts such as NaOH or KOH. Biodiesel on this day is produced from primary food oil sources such as soybean oil, palm oil, cottonseed, jatropha, poor sesame oil, goat fat, chicken lipid, and also used vegetable oil (restaurant waste) [3]. Most biodiesel is produced during the methyl ester process (transesterification).

Biodiesel is a substance fuel made from chemical and thermal reaction from vegetable or animal lipids with triglycerides methyl esters ingredients and also with a short chain of chemical alcohols such as methanol or sometimes ethanol. To make a vegetable oil become biodiesel it is needed the methyl ester process carried out in the variety of presence for some types of catalysts. In theoretical, the catalysts commonly used in this esterification method is can be in the form of base catalysts such as KOH and NaOH, or acid catalysts even

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its not to popular such as H_2SO_4 and HCl, and researcher try to made it with a help of biotic enzymes [4].

The choice of base and acid catalysts is used because of their advantages, such that the less time and the less money spent on the esterification reaction of alkaline and acid catalysts is less than that of some biotic enzyme catalysts in the laboratory [5]. Several research have shown that the production of biodiesel is influenced by the many parameters like the variety of the type of catalyst, the volume or the weight of catalyst, the fluid mixing temperatures and the amount of reaction time and for the last which is the most important is by the methanol oil mix ratio (m/o) [6].

In this research, researchers try to produce the biodiesel from corn oil and coconut oil originally made by hand by UMKM in Jember Regency (Indonesia). Researchers mix both oils with 1:1 ratio. Researchers try to vary the type of base catalyst to get data which base catalyst will give an optimum result. Researchers mix the base catalyst with methanol to make a methoxide with 1% catalyst weight of methanol. This mix is for the methanol esterification process. The various variables and its effect and behavior on this local biodiesel resources production will be investigated, such as the effect of catalyst, The rise of reaction temperature, The amount of reaction time, and the m/o is considered. This research is intended to obtain an optimal chemical mixture recipe for a specific local raw material for local biodiesel produced in Indonesia.

The importance of this research, because it is in line with the President's working program which is related to the use of pure biodiesel towards 100% starting 2021. This research also tries to figure out the other potency of Jember's main commodities (corn & coconut) to become such a commercial product diversification, by combining solar thermal refining and chemical refining methods to become a new method, named the Low Thermal Chemical Refining method, to produce biodiesel that meets the standards of the Ministry of Energy and Mineral Resources and as Politeknik Negeri Jember flagship innovation product.

2. METHODOLOGY

2.1 Chemical Material.

All raw material, chemicals, solvents and other tools used in this research used an international standard which is commonly used for the extraction and analysis of vegetable oils. The Indonesian energy ministry uses ASTM to analyze the grade of biodiesel, so we also used the same analytical grade and have been confirmed to ASTM D6751 standards. [7]

2.2 Sample Collection and Oil Extraction.

Coconuts and corn are purchased from farmers from Jember Regency, Jember Province in Indonesia. Coconut oil and corn oil are then processed by MSMEs (Micro, Small and Medium Enterprises) of the Jember community, which are fostered by the Jember State Polytechnic business in Jember Regency, Indonesia, to be bought again by researchers.

Corn oil and coconut oil were separated from 1 kg of corn and coconut fruit then washed to clean the product with distilled water to make sure it does not contain a dirt thing on the attached flesh. Then only the flesh of corn and coconut will be taken and then dried under ambient air for 12 hours. [7]

After the dry mass becomes powder after grinding, and stored in bags made of polyethylene, the powder is stored in controlled room temperature at 4^oC to maintain its condition for further analysis. Oil then will be extracted precisely using the Soxhlet standard apparatus and the Fatty Acid oil was carried out. [7]

The specimen of the oil that has been produced and extracted is put into a rotating evaporator at a temperature of 80^oC and then hold in that temperature using a thermo controller for precisely 1800 seconds until the chemical chain of n-hexane in it, all evaporates and then the specimen oil is put carefully into plastic bottle made of polyethylene, then stored at room temperature for biodiesel production [7].

2.3 Standard Research Method.

The physical characteristics which are important in biodiesel will be investigated. The characteristic is density of the oil specimen divided by the density of water (known as specific gravity), cloud point, kinematic of viscosity, cetane number, pour number point, acid number, and also a flash point as processing in the distillation rising temperatures were investigated using a standard method of EN14214 and will be continued with ASTMD6751 standards [7]. Methods of Gas chromatography (GC-FID) used with the CP3800 variant, will be used to measure the number of fatty acids in oil.

2.4 Coconut and Corn for Biodiesel Laboratory Production.

Coconut and corn oil extricates were put on a heat exchanger at temperatures kept in 85^oC to dissipate the presence of the water from the oil. At that point coconut oil and corn oil are blended in a proportion of 1:1 and exchanged into a carafe and put on a radiator to reach the specified temperatures. A blend of base catalyst and methanol was included to the oil specimen made from the mixed oil of corn oil and coconut oil and the simplified esterification chemical reactions was carried out to the specified temperatures 60°C. After that researcher drove the response, and then the arrangement was poured carefully into an isolating pipe and cleared out at normal environment room temperature 25°C. It will be continuously held for 24 hours until it becomes biphasic. After that the biodiesel within the upper stage supernatant, and raw glycerol, abundance of some methanol and base catalyst were watched within using the lowest stage.

2.5 Biodiesel Cleaning (Washing and Filtering).

After division of raw glycerol, then the biodiesel continued by washing it a couple's times with refined water or aquades at temperatures 70°C to evacuate remaining catalyst and methanol. At that point around 15 grams of sodium sulfate were included and blended for about 20 minutes. As a conclusion point, the biodiesel was sifted with a Whatman filter methods channel beneath vacuum and put away in a plastic bottle cap for assist investigation.

2.6 Optimal Conditions of Coconut and Corn for Biodiesel Laboratory Production.

The rise of Temperatures and the amount of response time, sort and dosage of base catalyst and methanol oil mix ratio proportion (m/o) became vital parameters in the research of biodiesel generation. Numerous ponders have been carried out on some uncovered parameters [9]. In this ponder the temperatures was 60°C, time was 3600 seconds, the sum of catalyst was 1 % of total weight for both sodium hydroxide and potassium hydroxide base oil catalysts, and oil methanol proportions (methanol/oil) = 1:3, 1:4, 1:5, 1:6 were carried out. After deciding the ideal m/o and KOH and NaOH catalysts, the response to the ideal temperature of 60°C, time of 3600 sec. and diverse sums of catalyst = 0.5; 0.8; 1; 1.25 % of total weight) for both catalysts were carried out. According to the variety, the ideal temperature will be shifted = 40°C; 50°C; 60°C; 70°C and the time = 1800, 2400, 3000 and 3600 sec. will too be decided by the analysts. Within the current consideration, all responses at barometrical weight and warm and mixing of the warming arrangement were prepared with a mechanical demonstration.

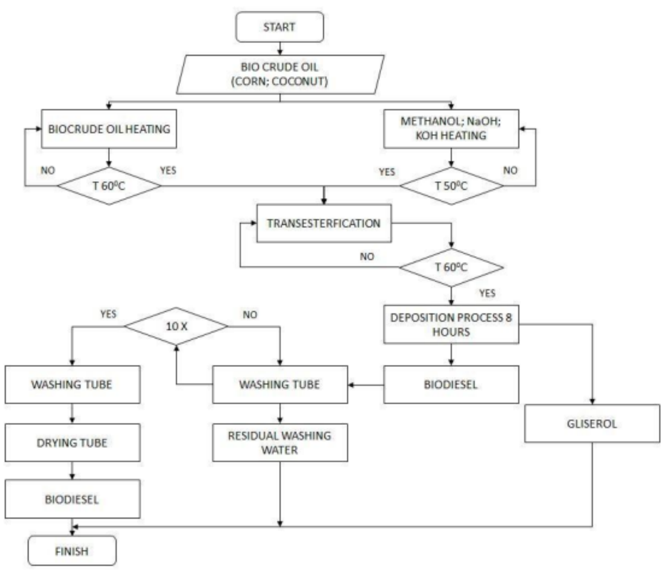

Figure 1: Biosolar Production Flow Chart

2.7 Gas Chromatography Analysis of Coconut Oil and Corn Oil.

The composition of fatty acid from corn oil and coconut oil was determined using CP3800 FID variant of Gas Chromatography, equipped with a 30 mm capillary glass column. Respectively Helium gas (as a carrier gas) flow rate held in 30 ml/min and nitrogen gas (as a make-up gas) flow rate held in 30 ml/min, and also hydrogen gas flow rate held in 300 ml/min [8].

The initial glass column of temperature after one minutes (60 seconds) was increased from 149ºC to 225ºC at a rising temperature rate of 0.2 ºC/sec and continuously remained at 225ºC temperature for 120 seconds [8].

After some period, the recorded temperatures increased to 245ºC with a temperature rate of 0.2ºC/sec and continuously remained at 245ºC temperature for 120 second also [8].

After all of that, the temperature raised reached 265 ºC at the similar temperature rate and remained held for 2 minutes at this temperature. At last, it finally reached 275ºC at a temperature rate of 0.2 ºC/sec and also it was kept at 265 °C as declared as a final temperature for 1800 seconds [8].

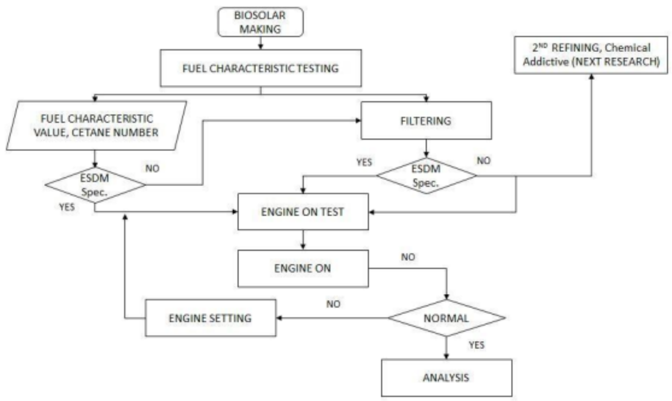

Figure 2: Biosolar Testing Flow Chart

3. RESULTS AND DISCUSSION

3.1 Fatty acid of corn and coconut oil.

The fatty acids of local corn and local coconut oil were analyzed using a standard gas chromatography method and the results shown below. Researcher compared the fatty acid oil ingedients data with existing studies that shown in table 1.

Table 1. Fatty acids of corn and coconut oil (main ingredients vegetable oil for biodiesel).

Fatty acids	Local Corn oil (%)	Local Coconut oil (%)	USA Corn oil (%)*	USA Coconut oil (%)**
Palmitic acid (C16:0)	38.71±0.18	9.30±0.3	12.57±0.014	8
Stearic acid (C18:0)	5.30±0.4	4.95±0.2	2.02±0.057	2
Oleic acid (C18:1)	43.44±0.85	35.33±0.95	29.7±0.113	16
Linoleic acid (C18:2)	14.71 ± 0.25	58.86±1.23	52.68±1.435	52
Linolenic acid (C18:3)	-	0.21±0.78	1.12±0.007	1
Myristic acid (C14:0)	0.98±0.14	0.17±0.14	-	8

*[9] ; **[10]

3.2 Optimum composition for biodiesel production from corn and coconut oil.

The physics optimum composition parameters such as the amount of response time, the rise of response temperatures, measurements and sort variety of base catalyst and also the proportion of methanol oil mix ratio data were finished to known for it optimized value and inspected in biodiesel generation within some nearness of two base catalyst, NaOH or KOH catalysts presented in below table.

Table 2. The Recorded Optimum Data Parameter In Biodiesel Research Production.

Parameters	Catalyst	
	KOH	NaOH
Proportion of methanol-oil	0.25: 1	0.25: 1
Response temperatures (ºC)	60-65	60-65
Mixing times (sec.)	3600	3600
Percentages of catalyst (%)	0.8	0.8
Mixture (%)	98	96

3.3 The Proportion Effect of methanol oil mix ratio on biodiesel production of corn and coconut oil.

Methanol oil mix ratio is the vital parameter in biodiesel generation. In this research, we vary it in 3:1, 4:1, 5:1 and 6:1 proportions for both catalysts (KOH or NaOH). Researcher concern in search for its ideal values. For the assessment of the ideal methanol oil mix ratio, the parameters of response rising temperature, sum of the catalyst and also response time will be investigated in specific conditions, which are 60 ºC, 1% wt. % (% wt.) and at 3600 sec., for each test parameter can be seen in Figure 1. Most extreme biodiesel generation is accomplished at a proportion of 0.25:1 for both sorts of catalysts shown in Figure 1.

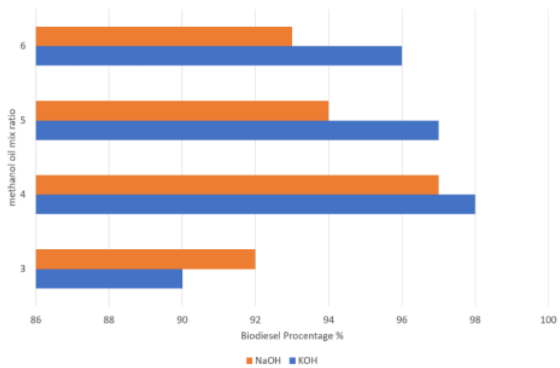

Figure 3: The methanol oil mix ratio for corn and coconut oil on the yield of biodiesel (temperature = 60 ºC, time = 3600 sec, percentage of catalyst = 0.8% wt.).

3.4 The Catalytic Effect of added on Coconut and Corn Oil in Biodiesel Production.

Two imperative variables in creating biodiesel abdicate are the sum and sort of catalyst, since the response rate changes through hydrolysis and saponification instruments [11]. To realize the ideal sum of the catalyst, the esteem is 0.5-1.25 wt. %. will be utilized. As characterized in Figure 2, biodiesel generation is expanded by expanding the sum of catalyst; on the other hand, for the using of catalyst more than 0.8 wt. %, the data showed that biodiesel generation diminished with its increasing value (catalyst percentage). Hence, the most optimal sum of catalyst to deliver biodiesel utilizing coconut oil and corn oil was 0.8 wt. % shown in Figure 2.

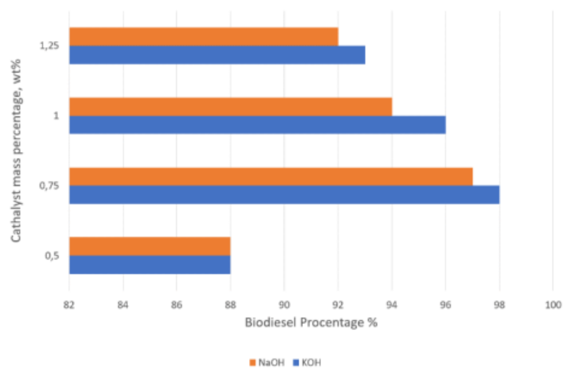

Figure 4: Effect catalyst on biodiesel production (methanol/oil = 4:1, temperature = 60 ºC, time = 3600 sec.)

3.5 The Mixing Time Effect and Temperature Set on Coconut and Corn Oil Biodiesel.

The esterification preparation is significantly affected by response time, the rate of the esterification response to create biodiesel and also temperatures [12]. Researchers are concerned about the effect of the response time on biodiesel generation and temperature. Data were analysed and shown in Figures 3 and figure 4. The temperature slowly rises by heating it from 40 to 70ºC. The response time then varies from 1800 to 3600 sec. Biodiesel generation is starting at 40ºC and more noteworthy than some time recently with expanding temperature. Greatest biodiesel generation was obtained at a temperature of 60ºC, where the sum of NaOH catalysts or KOH catalyst were recorded in 98.4% and 97.5%, individually.

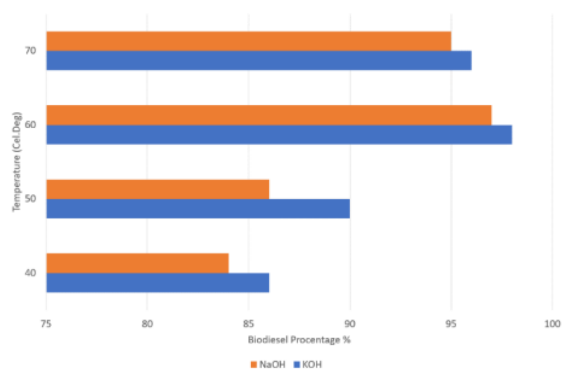

Figure 5. Temperature effect on biodiesel yield (methanol/oil = 0.25:1, time = 3600 sec. , percentage catalyst = 0.8% wt.).

An assist working parameter in biodiesel generation is response time, but researchers think it has a less impact than other parameters. This is based on the fact that the researcher found that only few differences were found in response times within the run of 1800 to 3600 sec. were utilized to decide the ideal time. To make it so, researchers varied the oil mix ratio, temperature and the sum of the catalyst were 1:0.25, temperature set on 60 ºC and catalyst weight set to 0.8 wt. %, individually as a condition to deliver biodiesel generation. The increment in biodiesel generation is straightforwardly corresponding to the response time shown in Figure 4.

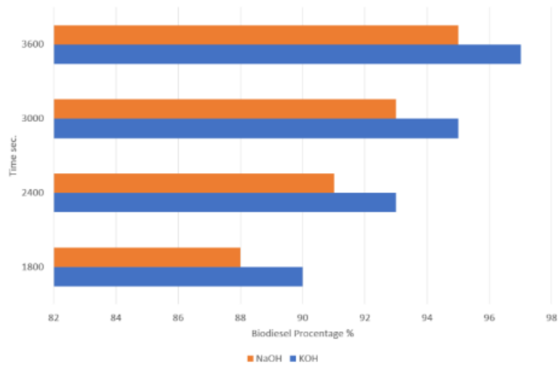

Figure 6. Reaction time effect on the yield of biodiesel (methanol/oil = 4:1, time = 3600 sec., Percentage catalyst = 0.8% wt.).

3.6 Measurement and Characterization of Coconut Oil and Corn Oil Biodiesel.

Moreover, the biodiesel properties were tried to be analysed such as thickness, kinematic consistency, corrosive number, cetane number, refining temperature, cloud point, pour point, and also streak point. Thickness is not as you think as a common dimension parameter, in this research, thickness is declared to be one of the foremost critical characteristics of a fuel. It will ensure that the infusion framework, by the pump is always maintained perfect in ideal proportion of air fuel ratio to be discharged to the engine [13].

Thickness is one of the parameters of the fuel which is defined as the amount of weight or sometimes mass in a certain volume of a liquid or a fluid at specific temperature 60ºF or 15ºC compared to mass volume of water at the same temperature [14]. In this search of this parameter, researchers used a hydrometer to know specific density to calculate the thickness of the fluids. These methods are based on standard EN14214. Researchers found that the research biodiesel gets 875 kg/m^3 for a specific density. Researchers compared this value to a standard common specific density of the biodiesel which has a thickness around 860-900 kg/m^3 [15]. This value is in a range of standards. An Ostwald viscometer is a tool standardized by ASTMD445 to get kinematic consistency data. Kinematic thickness is estimated by the time (sec.) needed to navigate some given volume of test in a capillarity weight calibrated viscometer for the weight at the optimal column sample.

According to the ASTMD664 standard, we can evaluate the corrosive acid value. Some researchers are comfortable using the EN14214 method. The method of the test is to evaluate the response of acidic corrosive at proportion 1 : 1 of toluene dissolvable to 1 N NaOh or KOH and the particular gravity. The conclusion is researcher can figure out the value of response point that shows the corrosive esteem which concurring to the demonstrated standard in 0.5 (mg KOH/g) or (mg NaOH/g). A researcher commonly gets corrosive levels of less than 0.5. EN14214 and ASTM-D6751 are standard to investigate the cetane numbers [16]. Cetane Number formula shown below.

$$CN\ (Cetane\ Number) = \sum n \text{ of } \%Wt_{methylestr} \times CN_{methylester} \quad (1)$$

Where :

CN = the cetane number of biodiesels;

$\%Wt_{methyleseter}$ = the percentage by weight of each methyl ester

$CN_{methylester}$, -.= the cetane number of each methyl ester

n = the number of specimen (n = 1, 2, 3, …..)

To determine the cloud point of the test, the examination was carried out agreeing to ASTM D2500 [14].

To begin with, a certain volume of sample which is being tested will be cooled with a certain cooling rate and considered at certain temperature intervals. The which clouds (white blobs) temperature when it starts to make are at that point watched at the lower side of the bottom of the holder for the primary time will be recorded as clouds point. Using ASTMD2500, the least and greatest cloud point values for biodiesel, not been detailed, but in numerous studies that have been utilized to create biodiesel from different sources the cloud point values have been detailed to be around 15 to 22. The standard values for biodiesel ASTMD6751 and EN14214 have been detailed in a few ponders based on ISO 3016 [17].

The ASTMD6751 and EN14214 standard methods were utilized to determine the fire and refining temperature. Table 3 and table 4 show the data of biodiesel properties created utilizing KOH catalyst and NaOH catalyst.

Table 3. Research Biodiesel Properties of corn and coconut oil Biodiesel Production using KOH and its comparison with current standard

Properties	Biodiesel Properties Test Value	Standard Reference Value EN - 14214	Standard Reference Value ASTM- D6751
Density 15 °C (Kg/m³)	874	860-900	-
Viscosity 40 °C (mm²/S)	4.3	3.5-5	1.9-6
Acid value (mg KOH/g)	0.14	0.50 max	0.50 max
Cetane number	56	Min. 51	Min. 47
The Cloud (blobs) point (°C)	8	-	-
The pour point	4	-	-
The Flash point (°C)	171	Min. 101	Min. 93
Distillation Temperature (°C)	345	-	Max. 360

On the other hand, the properties of corn and coconut biodiesel production with NaOH catalyst are close enough similar compared to KOH catalysts. For biodiesel properties quality referred to standard value EN-14214 [18] and Standard Reference Value ASTM- D6751 [19]. The comparison shown in next table

Table 4. Research Biodiesel Properties of corn and coconut oil Biodiesel Production using NaOH and its comparison with current standard

Properties	Biodiesel Properties Test Value	Standard Reference Value EN – 14214	Standard Reference Value ASTM- D6751
Density 15 °C (Kg/m³)	877	860-900	-
Viscosity 40 °C (mm²/S)	4.7	3.5-5	1.9-6
Acid value (mg KOH/g)	0.15	0.50 max	0.50 max
Cetane number	58	Min. 51	Min. 47
The Cloud (blobs) point (°C)	7	-	-
The pour point	5	-	-
The Flash point (°C)	178	Min. 101	Min. 93
Distillation Temperature (°C)	350	-	Max. 360

The ideal condition (optimum) for biodiesel generation from oil is the truth that the ideal proportion of methanol oil mix ratio is at a blend proportion of 6:1, response temperature is 60 C, response time is 60 minutes, the catalyst utilized is 1% KOH and the ideal condition for biodiesel generation is 88%.; whereas the abdicate of biodiesel generation from a blend of palm oil and coconut oil beneath ideal conditions utilizing KOH and NaOH catalysts were 98.2 and 97.4%, individually. To deliver biodiesel from coconut oil employing a catalyst concentration of 1% catalyst KOH the most extreme productivity is 96%.

3.6 Comparison of Property Properties of coconut and corn oil biodiesel against Ministry of Energy and Mineral Resources standard.

Although the nature of the raw material oil used as raw material for biodiesel production may vary widely, the properties of biodiesel must be the same if it is to be used in the automotive sector, and must comply with the requirements set by Indonesian standards.

Indonesia has a standard for biodiesel oil, this is stated in the Decree of the Director General of Oil and Gas, Ministry of Energy and Mineral Resources of the Republic of Indonesia No. 0234.K/10/ DJM.S/2019 concerning Standards and Quality (Specifications) of 30% Biodiesel Mixed Diesel Fuel Oil (B-30) Marketed Domestically [20]. Comparison of the test biodiesel properties with the standard and quality of biodiesel blends according to the Ministry of Energy and Mineral Resources, can be seen in Table 5 below.

Table 5. Comparison of Properties of Biodiesel Production with Quality Standards of the Ministry of Energy and Mineral Resources (ESDM).

Properties	Biodiesel Properties Test Value KOH	Biodiesel Properties Test Value NaOH	Biodiesel Properties Reference ESDM*
Density 15 °C (Kg/m 3)	874	877	815-880
Viscosity 40 °C (mm 2/S)	4.3	4.7	2 - 5
Acid value (mg KOH or mg NaOH/g)	0.14	0.15	0
Raw Cetane number	56	58	48
Cloud point (°C)	8	7	0 - 18
Pour point	4	5	0 - 18
Flash point (°C)	171	178	Min. 52
Distillation temperature (°C)	345	350	Max.370

* [21]

From table 5 it is known that the production of biodiesel oil used in this study in general has met the quality standards of the Ministry of Energy and Mineral Resources, except for the acid value. The presence of acid values in biodiesel production is a matter of further research to make the value zero. The presence of acid values will be the cause of the acceleration of the corrosion rate in diesel engine components.

It is interesting that the biodiesel tested has a higher cetane number, namely max. 58 for production using NaOH, 10 points higher than the minimum standard reference cetane number, which is 48. However, there are values that need to be considered to be derived through advanced refining methods, namely density and viscosity properties. If we can reduce the density and viscosity values, this biodiesel material will be safer if used in common rail type diesel engines (modern diesel engines).

4. CONCLUSION

Biosolar generation from vegetable oils is a promising renewable fuel resource for now. The Indonesian government, through Pertamina, has started using biodiesel as a diesel mixture. Corn oil and coconut oil are utilized to create biodiesel, which is plentiful in Jember Indonesia. Biodiesel was created by mixing the coconut oil and corn oil in a proportion of 1:1. The results for both KOH and NaOH using as a catalyst, didn't record any significant differences in their fuel characteristic. Using methanol as a catalyst solution is more preferred than ethanol. Researchers found that mixing corn oil and coconut oil for a raw material in biodiesel generation was more productive than if we use them as raw materials alone. Examination of biodiesel using an ASTMD6751 and EN14214 standard test, can be utilized as the required fuel source demand in unadulterated frames or blended with other powers. The corn and coconut oil base biodiesel laboratory tested gain a good fuel characteristic compared to its international or Indonesia diesel oil standard.

5. ACKNOWLEDGEMENT

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