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ORIGINAL RESEARCH ARTICLE

Biodiesel from waste cooking oil produced via ultrasonic-assisted transesterification and its optimal performance in light truck

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ABSTRACT

This work studied the production of biodiesel from waste cooking oil using an ultrasonic reactor and the testing of biodiesel fuel performance in a diesel engine on a light truck. The process for biodiesel production consisted of several steps, including waste cooking oil filtration, esterification, ultrasonic-assisted transesterification, biodiesel separation using the decantation process, washing, and drying. The main transesterification reaction was conducted using methanol with a molar ratio to the oil of 6:1 and a KOH catalyst of 1%. The reaction was accomplished at 60℃ in 30 minutes. Biodiesel produced was tested to reveal its main characteristics, i.e., flash point, density, viscosity, FAME content, and caloric values. Biodiesel was then mixed with commercial diesel fuel at various ratios (B40, B45, B50, B55, B60, and B65) and tested to evaluate their performance as fuel in a diesel engine on a light truck. A chassis dynamometer was used to measure vehicle torque and power in light trucks that resulted from biodiesel fuel, which was mixed with fossil diesel fuel at a range of ratios. The test revealed that the biodiesel fuels met the standards of fuel characteristics, and the performance in a diesel engine was comparable to that of a diesel engine powered by diesel oil.

Keywords: biodiesel; waste cooking oil; ultrasonic; transesterification; diesel engine performance

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1. Introduction

Biodiesel is one of the most promising alternatives to petroleum-based diesel engine fuel. Biodiesel can help reduce reliance on fossil fuels[1,2], as well as environmental concerns, energy security, and the need to minimize greenhouse gas emissions[3]. Biodiesel can be made from vegetable oil, animal fat, palm oil, cooking oil, waste cooking oil, and oils produced by microbes. Biodiesel is a highly biodegradable fuel since it is derived from these raw materials[4-6]. Biodiesel is regarded as an environmentally benign, biodegradable, non-toxic, and carbonneutral fuel. Biodiesel can also be produced from edible or non-edible oil feedstocks, such as triglyceride sources[7,8,40]. Biodiesel can be used in diesel engines as an alternative fuel to minimize pollutant emissions. Conventional diesel engines can run on biodiesel without any changes[9]. The process of producing biodiesel is known as transesterification. The transesterification process combines the reactions of alcohol and triglycerides with the help of a catalyst. Alcohol and triglycerides, both insoluble liquids, form distinct phases in the mixture. As a result, the traditional method of producing biodiesel requires extensive mixing to speed up the chemical interaction between triglycerides and alcohol[10]. Ultrasonic technology can be utilized to speed up the process because it increases biodiesel yield. This acceleration is caused by the production and collapse of bubbles (cavitation) at the molecular level, resulting in high temperature and pressure conditions. The quick collapse of the bubbles creates micro-flows or light eddies that induce significant local heating, high pressure, and brief durations[11]. When a sufficiently significant negative pressure gradient is introduced to the liquid, the gap between the molecules expands above the critical molecular length, the liquid compresses, and cavities form, known as cavitation bubbles[12,13]. Ultrasound can produce highly reactive radicals like H, OH, and HO_2 in the reacting media, leading to quicker reaction kinetics. Thus, the primary advantages of ultrasonic-assisted transesterification over conventional transesterification include reduced reaction time, catalyst amount, and alcohol-to-oil molar ratio, as well as reduced energy consumption[14].

Several prior research have been carried out to investigate the usage of biodiesel fuel in diesel engines. Abed et al.[15] conducted an experiment with a Kirloskar single-cylinder, four-stroke, direct injection diesel engine capable of producing 5.775 kW at 1500 rpm. Biodiesel blends with diesel fuel have less thermal efficiency than diesel fuel and higher specific fuel consumption. Belal et al.[14] did another experiment using a direct injection, 4-stroke, single-cylinder, air-cooled diesel engine to evaluate its mechanical performance and emissions. The results indicated that biodiesel and diesel performed similarly, with a modest rise in specific fuel consumption and a slight drop in thermal efficiency. Anwar et al.[16] did another study that focused on biodiesel blends and their interacting effects on engine performance utilizing a Kubota V3300 indirect injection, a static diesel engine, a vertical, 4-cycle liquid-cooled diesel with four cylinders and a 3.318 L capacity. These findings suggest that biodiesel-diesel blends can be used as diesel engine fuel without requiring any engine modification. Several further research have been undertaken on static diesel engines and single-cylinder diesel engines. As a result, in this work, an ultrasound-assisted transesterification biodiesel experiment was done on a multi-cylinder diesel engine directly on a light truck vehicle to acquire a realistic picture of the performance of biodiesel-powered vehicles.

This study produced biodiesel from used cooking oil through ultrasonic-assisted esterification and transesterification processes. The performance of the resulting biodiesel fuel was tested in a diesel engine. The study also did not examine exhaust emissions, as many studies have shown that exhaust emissions are generally lower than those from petroleum-based diesel fuel.

2. Materials and methods

2.1. Biodiesel Production

The equipment used to produce biodiesel was: 1) digital scales with an accuracy of 0.01 g and a maximum capacity of up to 5000 grams, and 2) EIWEI ultrasonic generator, capacity 30 L, power <800 W, voltage 110 V-220 V, ultrasonic cleaner with number E Series model, dual frequency 28 kHz-40 kHz, normal key 28 kHz, and pulse key 40 kHz. Biodiesel is made from waste cooking oil received from food traders, as well as methanol (CH_3OH) with a boiling point of 64.5°C, density of 0.78663 g/cm^3, and purity of 99.95% by weight (minimum); 3) vinegar with a content of 25% acetic acid and 75% water for washing biodiesel; 4) KOH with the specification of shape, white flakes, molecular weight 56.11 g/mol, purity 90%, density 2.044 g/mol; and 5) aquadest with a pH of 5.0 to 7.5 at 25°C. **Figure 1** shows the biodiesel production process scheme.

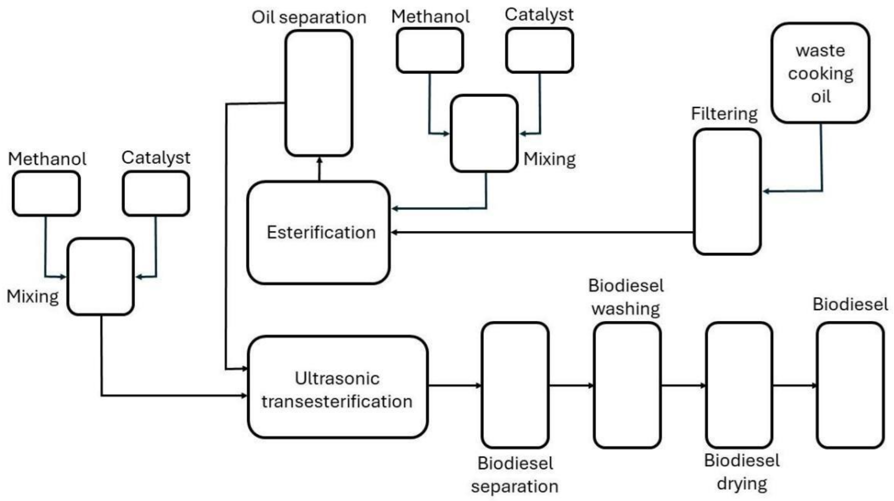

Figure 1. Schematic of ultrasonic assisted biodiesel production.

For used cooking oil has an FFA content of more than 0.3%, esterification is necessary to reduce the FFA content before transesterification[39]. The esterification process involved the following steps: 1) Preparing equipment for the reaction; 2) Preparing materials for the esterification reaction, such as filtered used cooking oil, methanol (CH_3OH) in a 7:1 ratio to the amount of oil, and sulfuric acid (H_2SO_4) up to 5% of the amount of oil; 3) Mixing methanol and sulfuric acid (H_2SO_4); 4) Heating the used cooking oil in the reactor with a stirrer to ± 55°C; 5) Adding a mixture of methanol and H_2SO_4 to the stirred reactor that already contains oil; 6) Stirring the reactor while maintaining the temperature at ± 55°C for ± 30 minutes; 7) Removing the reactant from the reactor and place it in a container, then leave for 6-24 hours for separation; 8) Transferring the oil to a clean container; 9) Continue the process with transesterification.

The ultrasonic-assisted transesterification process was carried out with the following steps: 1) preparing the oil from the esterification process, methanol (CH_3OH) in a ratio of 6:1 to the amount of oil, and potassium hydroxide (KOH) as much as 1% of the amount of oil; 2) mixing methanol with KOH; 3) heating the oil in an ultrasonic generator until the temperature is stable at around 60°C; 4) adding a mixture of methanol and potassium hydroxide to the ultrasonic generator containing the oil; 5) activating the ultrasonic generator for 30 minutes at a temperature of around 60°C; 6) turning off the ultrasonic generator and moving the reactants into a separator tank and settling the oil for 24 hours; 7) separating glycerol from biodiesel.

The steps for washing and drying transesterified biodiesel were as follows. 1) Heating 1 liter of distilled water with 25 ml of acetic acid to 40°C; 2) Mix biodiesel with distilled water in a 2:1 ratio and stir; 3) Allowing the washing results to stand until the water separates; 4) Separating the water. 5) The second washing technique did not require vinegar; it simply mixed with distilled water and washed three times. 6) Heating the washed biodiesel to a temperature over 100°C; 7) The biodiesel was ready for use.

2.2. Preparation for Biodiesel Testing on Vehicles

The test vehicle used was a light truck with the following specifications: The Isuzu Panther brand was produced in 2015, with an engine capacity of 2500 CC, 4 cylinders, 4 strokes, direct injection, model and engine type 4JA1L with a turbocharger, transmission model MSG5K (manual), maximum power of 80 PS (58.84 kW) / 3500 rpm, and maximum torque of 19.5 kgm (191.2 Nm) / 1800 rpm. The vehicle was tested without making any modifications to the engine components. **Figure 2** shows the light truck used for biodiesel.

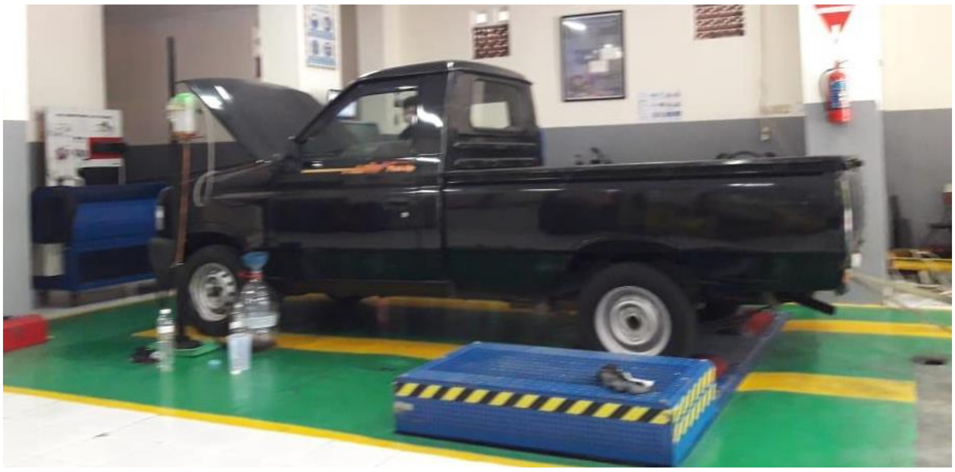

Figure 2. Light Truck for Biodiesel Fuel Performance Testing.

The fuel used in this study was Commercial Diesel Fuel (CDF), which was diesel fuel produced by Pertamina, the Indonesian Oil and Gas Mining Company. This fuel was used as a comparison for the biodiesel blend fuel to be studied. The specifications of this fuel based on laboratory test results were calculated cetane index 55.5 (ASTM D4737-21), density at 15°C is 829.8 kg/m^3 (ASTM D1298-12b), viscosity (at 40°C) 2.897 cSt (ASTM D445-23), calorific value 44.87 MJ/kg (ASTM D240), and flash point 46°C (ASTM D93-20).

The pure biodiesel produced (B100) tested on vehicles had the following characteristics: density at 15°C was 883.4 kg/m^3 (ASTM D1298-12b); viscosity (at 40°C) was 6.217 cSt (ASTM D445-23); calorific value was 39.87 MJ/kg (ASTM D240); and flash point was 198°C (ASTM D93-20). The fuels used during testing on vehicles consisted of several types, namely pure diesel fuel (CDF), B40 (a mixture of 40% biodiesel and 60% CDF), B45, B50, B55, B60, and B65. All the fuels tested are presented in **Figure 3**.

Notes: CDF (1), B40 (2), B45 (3), B50 (4), B55 (5), B60 (6), and B65 (7)

Figure 3. Fuels tested in Light Truck.

2.3. Testing on Light Truck Vehicles

The procedure for testing diesel engine performance on a vehicle was as follows: 1) Placing the car on a dynamometer; 2) Securing the back of the car with a safety rope; 3) Setting up a blower to maintain engine temperature. 4) Placing the oil temperature sensor stick in the oil stick holder. 5) Checking the engine's coolant. 6) Preparing the fuel tank and connecting it to the fuel line as a substitute for the fuel tank. 7) Adding fuel to the fuel tank. 8) Start and warm up the engine until it reaches operational temperature. 9) Turning on the computer on the dynamometer; 10) Adjusting the computer settings to the car specification. 11) Placing the gears in positions 1, 2, 3, and 4 consecutively, as if driving a car (data recording by the computer is done when the transmission is in 4th gear); 12) pressing the acceleration pedal until the data readout on the dynamometer computer screen was complete; 13) Conducting the second and subsequent experiments by changing the fuel variations in the fuel tank. Each fuel variation was tested for performance three times, and the average of the tests was taken to produce accurate data. After the test was finished, turning off the engine and blower, printing the torque and power calculations, turning off the computer, removing the straps, and restoring the car and equipment to their original locations were done. A schematic diagram of the vehicle performance testing scheme is demonstrated in **Figure 4**.

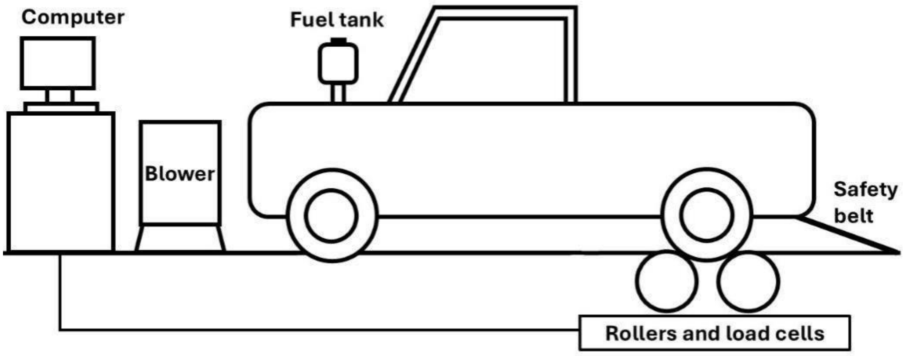

Figure 4. Vehicle performance testing scheme.

3. Results

3.1. Biodiesel Characteristic

Based on the results obtained after esterification, transesterification, separation, washing, and drying from 10 liters of used cooking oil, 8 liters of pure biodiesel were obtained, or a yield of 80%. Fuel characteristic testing in this study was conducted only for CDF, B100, and B40 fuels to see the general characteristics of the fuel. The test results can be seen in **Table 1** below.

Table 1. Biodiesel characteristics.

No	Fuel Characteristics	Units	Fuels			Method
			CDF	B40	B100	
1	Flash point	°C	46	63	198	ASTM D93-20
2	Density (15°C)	kg/m3	829.8	853.3	883.4	ASTM D1298-12b
3	Viscosity (40°C)	cSt	2.897	4.062	6.217	ASTM D445-23
4	FAME	% v/v	2.59	35.1	89.0	ASTM D7371-14
5	Caloric value	MJ/kg	44.87	43.10	39.87	ASTM D 240

Based on the statistics in **Table 1**, biodiesel produced had a greater flash point than CDF. The flash point was an important metric that impacted fuel storage, transportation, and handling. Fuel having a higher flash point is safe to store and transport[17]. Biodiesel produced in this work had a 50% higher flash point than diesel, making it suitable for storage and transportation[18]. Flash point is the lowest temperature at which a fuel contains enough vapor to ignite a combustible mixture above the fuel surface if a spark occurs. Biodiesel produced in this work had somewhat higher density than CDF. The density of biodiesel fuel had a direct impact on engine performance and exhaust emissions. Higher density leads to higher viscosity. Fuel with a high density can produce larger droplets (atomization) when sprayed into the combustion chamber, affecting combustion and exhaust gas[19].

The viscosity of biodiesel produced exceeded that of CDF. Fuel viscosity has a direct effect on combustion in diesel engines[20]. Lower fuel viscosity can cause wear on fuel system components[21], whereas higher-viscosity fuel produces larger droplets when injected into the combustion chamber, resulting in increased smoke emissions. High fuel viscosity can result in incomplete combustion[22]. The greater viscosity of biodiesel fuel leads to poor spraying and atomization[23]. Based on FAME testing using the ASTM D7371-14 method, the results showed that the resulting B100 biodiesel had a FAME of 89.00% v/v. This indicates that the FAME content in the produced biodiesel reached 89%.

The calorific value of the biodiesel produced in this work was slightly less than that of CDF. The most essential attribute of gasoline is its calorific value, which determines the power generated by the engine[24]. Biodiesel-diesel mixtures had a higher calorific value than biodiesel but lower than standard diesel fuel (diesel)[25]. Increasing the proportion of biodiesel in the fuel mixture reduced the calorific value, which could affect engine performance[26].

3.2. Biodiesel Fuel Performance Testing on Light Truck

Biodiesel was made using an ultrasonic-assisted transesterification technique and tested on a diesel engine to determine its performance with biodiesel fuel. The following were the findings of diesel engine torque testing for biodiesel produced using ultrasonic-assisted transesterification (**Table 2**).

Table 2. Diesel Engine Torque for Various Biodiesel Mixed Fuel from Used Cooking Oil at Different Engine Speed.

Engine Speed (rpm)	Torque (Nm)						
	CDF	**B40**	**B45**	**B50**	**B55**	**B60**	**B65**
2200	63.90	64.10	62.30	64.17	63.97	63.03	61.30
2400	87.07	85.20	81.73	84.37	85.03	84.83	80.13
2600	116.40	116.67	115.67	116.30	114.90	112.57	113.43
2800	116.47	115.57	116.20	115.67	114.30	113.73	114.60
3000	113.23	114.43	112.77	112.73	110.57	110.30	110.77
3200	110.03	108.53	109.27	109.10	107.50	106.90	107.63
3400	106.47	106.33	107.17	107.03	105.13	104.87	105.37
3600	103.57	104.77	105.47	105.33	102.73	102.97	103.57
3800	102.20	102.37	103.10	103.07	99.53	100.10	101.30
4000	102.03	102.27	102.63	102.57	99.67	99.47	100.03
4200	102.77	102.83	103.43	103.17	101.10	100.70	101.23
4400	103.30	103.70	104.17	104.07	101.47	102.10	102.57
4600	103.53	104.63	104.67	104.90	102.93	102.47	102.97
4800	101.50	103.47	103.13	103.23	102.10	101.10	101.77
5000	99.45	101.97	101.27	101.53	99.90	99.57	99.60
5200	96.47	97.53	96.73	96.87	96.13	95.00	95.60
5400	92.77	91.40	90.70	91.13	90.63	89.07	90.87

Based on **Table 2**, it was revealed that diesel engines using B40, B45, B50, B55, and B65 fuels produced torques that were similar to diesel engines using CDF. This demonstrated that the fuel produced during the ultrasonic-assisted transesterification process was of high quality.

Table 3. Diesel Engine Power with Several Variations of Biodiesel Mixed Fuel from Used Cooking Oil.

Engine Speed	**Power (kW)**						
(rpm)	**CDF**	**B40**	**B45**	**B50**	**B55**	**B60**	**B65**
2200	14.42	14.47	14.04	14.44	14.42	14.22	13.87
2400	21.48	21.03	20.11	20.73	20.90	20.93	19.79
2600	31.07	31.15	30.70	30.95	30.62	30.08	30.33
2800	33.48	33.23	33.33	33.13	32.81	32.71	32.98
3000	34.90	34.53	34.63	34.63	34.00	34.00	34.18
3200	36.17	35.67	35.79	35.72	35.27	35.15	35.40
3400	37.16	37.11	37.31	37.24	36.61	36.61	36.84
3600	38.28	38.73	38.88	38.80	37.88	38.08	38.33
3800	39.89	39.94	40.12	40.07	38.75	39.05	39.57
4000	41.91	42.01	42.06	41.98	40.86	40.89	41.14
4200	44.34	44.37	44.52	44.32	43.52	43.45	43.70
4400	46.68	46.88	46.95	46.88	45.79	46.16	46.38
4600	48.92	49.42	49.32	49.39	48.52	48.42	48.67
4800	50.07	51.01	50.73	50.71	50.24	49.89	50.21
5000	51.04	52.37	51.85	51.95	51.18	51.16	51.18
5200	51.53	52.10	51.50	51.55	51.23	50.76	51.08
5400	50.74	50.68	50.16	50.36	50.16	49.42	50.41

Based on **Table 3**, it can be explained that the power produced by diesel engines using B40, B45, B50, B55, and B65 fuels was not much different from the power of diesel engines using CDF. This showed that the fuel produced from the transesterification process of used cooking oil was of good quality.

4. Discussion

Figure 5 depicts the test results for various types of biodiesel fuel blends. Based on the torque graph above, it can be concluded that the torque produced by a diesel engine using CDF was similar to that produced by a diesel engine using B40, B45, B50, B55, and B65 fuel. This was evident from the overlapping torque graphs for all fuel types utilized in the test. Torque increased between 2600 and 2700 rpm, then declined as engine speed increased. Torque decline with speed can be attributed to the higher frictional resistance and volumetric efficiency[27].

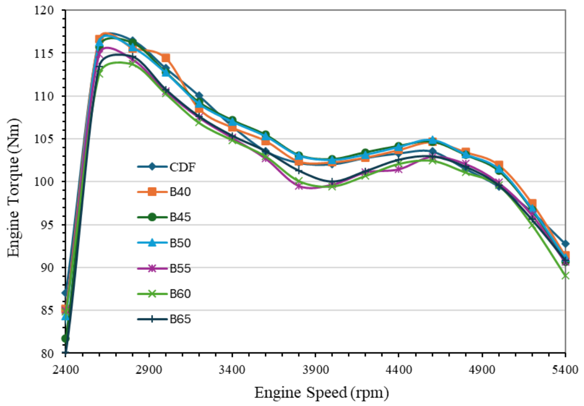

Figure 5. Relationship between Torque and Engine Speed at Various Biodiesel Mixed Fuel.

Meanwhile, increased torque at low engine speeds resulted from the reduced braking power and combustion efficiency[28,16]. Higher rotation rates limited the efficiency of air intake into the combustion chamber. In addition, increasing engine speeds caused more friction on the cylinder walls. The piston did not have enough time to completely suck in air. As a result, the amount of air entering the combustion chamber reduced, as did the compression pressure, resulting in an incomplete combustion process. As a result, torque production diminished[29]. A comparison between average torque of the diesel engine using CDF and various biodiesel mixture is presented in **Figure 6**.

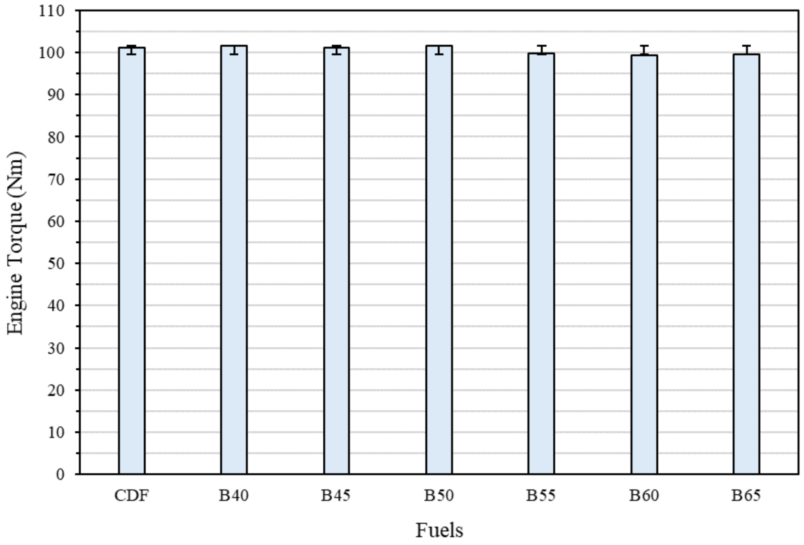

Figure 6. Comparison of Average Torque of Diesel Engine Using CDF and Various Biodiesel Mixture.

Based on **Figure 6**, the torques of diesel engine using B40 and B50 fuels were slightly greater by 0.27% and 0.24% compared to the average torque of diesel engines using CDF. However, this change was relatively small since the difference did not surpass 1%. The torques of diesel engine using B45, B55, B60, and B65 fuels were 0.04%, 1.36%, 1.88%, and 1.65% less than the average torque of diesel engines using CDF, respectively. It demonstrates that, in general, adding more biodiesel blend to CDF reduced the diesel engine’s torque. This could be due to biodiesel's slightly lower calorific value compared to CDF[15,30,31]. Therefore, adding a biodiesel mixture to CDF reduced the calorific value of the fuel compared to CDF. This was consistent with the test results in **Table 1**, which showed that biodiesel had a lower calorific value than CDF. As a result, adding an appropriate amount of biodiesel mixture to CDF reduced torque slightly but not dramatically, which was still reasonable[32]. In general, increasing the amount of biodiesel mixture reduced diesel engine performance[33,34]. This was also consistent with Emaish et al.'s finding[35] that increasing the percentage of biodiesel resulted in less performance since biodiesel had a lower calorific value than diesel. The elevated oxygen level in biodiesel diminishes its calorific value, leading to decreased energy output and worse brake power relative to diesel[41].

Based on average diesel engine torque data, the B40 mixture was the optimum mixture for producing the most diesel engine torque compared to other mixtures, and it was even slightly greater (0.27%) than diesel engine torque produced with CDF. This B40 fuel mixture was ideal for producing torque in diesel engines. This was most likely due to the compatibility of the B40 combustion characteristics in the diesel engine with the engine's operating conditions, which included final compression pressure and injection timing, resulting in combustion at the optimal piston point several degrees after top dead center.

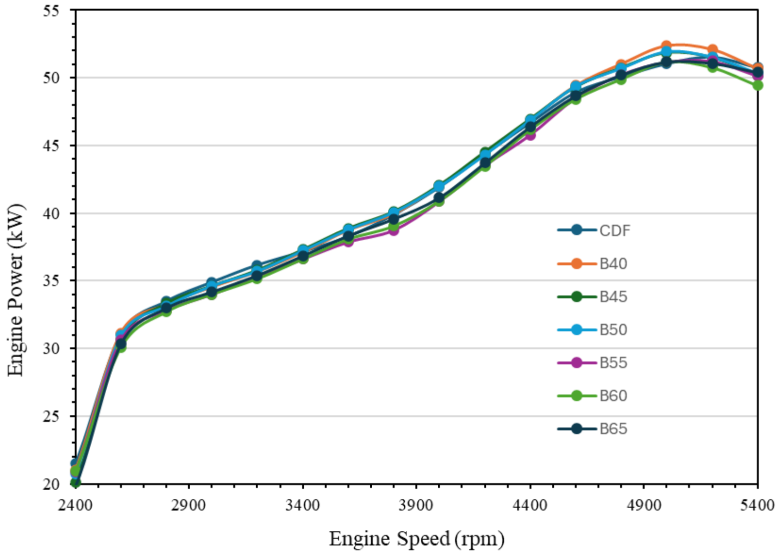

Figure 7. Relationship between Power and Engine Speed on Several Biodiesel Fuel Variations.

Figure 7 shows that the higher the engine speed, the higher the diesel engine power was, and at a certain speed, the power decreased. At roughly 5100 rpm, all fuels produced their peak power. A diesel engine using CDF produced about the same amount of power as a diesel engine using B40, B45, B50, B55, or B65 fuel. In general, adding a blend of biodiesel to CDF reduced power slightly, but not much.

The drop in power was due to biodiesel's slightly lower calorific value compared to CDF. This was in line with the result of Gad et al.[36], in which increasing the proportion of biodiesel in the mixture resulted in a modest drop in engine power due to the lower calorific value of biodiesel. A lower calorific value indicated that less energy was released after burning[37]. The higher viscosity of biodiesel caused a loss in engine output. Higher viscosity increased resistance in the fuel line for the nozzle system and fuel pump line, resulting in less-than-optimal fuel atomization during injection. As a result, both of these factors contributed to less power. The combustion delay period also increased with biodiesel blends due to their lower cetane number[37].

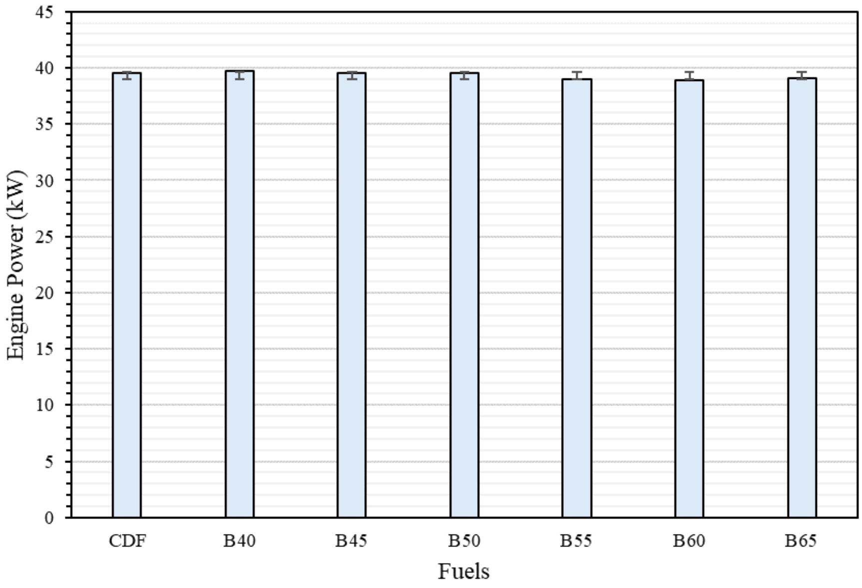

Figure 8. Comparison of Average Power of Diesel Engine with CDF and Biodiesel Mixture.

Based on **Figure 8**, it can be concluded that the average power produced by diesel engines using B40, B45, B50, B55, and B65 fuels was similar to the average power produced by diesel engines utilizing CDF. Diesel engines produced 0.39% and 0.12% more power for the B40 and B50 mixes, respectively, than diesel engines running on CDF. According to the results of this test, B40 fuel was an optimum blend for producing diesel engine power. This was most likely due to the compatibility of the B40 combustion characteristics in the diesel engine with the engine's operating conditions, which include final compression pressure and injection timing, resulting in combustion at the optimal piston point several degrees after top dead center. A diesel engine running on B60 fuel produces the least amount of power.

Similar studies have indicated that using B40 fuel yielded the highest diesel engine power. This demonstrated that the B40 blend had the maximum efficiency among all blends. Biodiesel produced utilizing ultrasonic technology can be blended with diesel and used in diesel engines without modifying the engine[38]. Other investigations found that diesel fuel could be replaced with WCO biodiesel produced using ultrasonic-assisted transesterification or biodiesel/diesel blends without modifying the engine. It was also discovered that the recommended blending ratio was B40, which had comparable engine mechanical performance to diesel fuel and lower exhaust emissions[14].

5. Conclusion

According to the test results, the vehicle torque increased as the engine speed increased at 2600-2700 rpm and then decreased as engine speed increased. The torque dropped after reaching maximum torque due to higher frictional resistance and decreasing volumetric efficiency. When compared to the average torque of a diesel engine using CDF, a diesel engine using B40 and B50 had a slightly greater torque of 0.27% and 0.24%, respectively. The torque of a diesel engine using B45, B55, B60, and B65 fuels was 0.04%, 1.36%, 1.88%, and 1.65% less than the average torque of a diesel engine using CDF, respectively. Based on this data, the best blend for the vehicle was B40. Vehicle power increased with the engine speed until roughly 5100 rpm, at which point it then declined. Diesel engines using B40, B45, B50, B55, and B65 fuels generated similar average power as diesel engines using CDF. Diesel engines produced 0.39% and 0.12% more power for the B40 and B50 mixes, respectively, than diesel engines running on CDF. Diesel engine power with B45, B55, B60, and B65 fuels was 0.002%, 1.37%, 1.64%, and 1.19% lower than the average power of diesel engines running on CDF. According to the test, B40 fuel was an ideal blend for producing torque and power in diesel engines. This was most likely due to the compatibility of the B40 combustion characteristics in the diesel engine without modification, as well as the diesel engine's operating conditions, which included the final compression pressure and injection timing, resulting in combustion at the optimal piston point several degrees after top dead center. Based on the vehicle performance, biodiesel produced using ultrasonic-assisted transesterification of used cooking oil met the criteria for biodiesel fuel characteristics and performance.

Author contributions

Conceptualization, Ratna Dewi Kusumaningtyas and Dwi Widjanarko; methodology, Dwi Widjanarko; software, Dwi Widjanarko; validation, Sucihatiningsih Dian Wisika Prajanti, Samsudin Anis, Harumi Veny, Hasan Maksum; formal analysis, Ratna Dewi Kusumaningtyas and Dwi Widjanarko; investigation, Riski Deriansyah, Indra Wahyu Kurniawan, Krisma Nandes Al Rafi; resources, Dwi Widjanarko; data curation, Ratna Dewi Kusumaningtyas; writing—original draft preparation, Dwi Widjanarko; writing—review and editing, Ratna Dewi Kusumaningtyas and Dwi Widjanarko; visualization, Dwi Widjanarko; supervision, Ratna Dewi Kusumaningtyas; project administration, Riski Deriansyah, Indra Wahyu Kurniawan, Krisma Nandes Al Rafi; funding acquisition, Ratna Dewi Kusumaningtyas. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare no conflict of interest.

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