Soursop leaf extract as biodiesel antioxidant and the effect on automotive diesel engine performance

Soursop leaf extract as biodiesel antioxidant and the effect on automotive diesel engine performance

D Widjanarko[1], S Azhar[1], and Megawati[2]

[1]Department of Mechanical Engineering Faculty of Engineering Universitas Negeri Semarang
[2]Department of Chemical Engineering Faculty of Engineering Universitas Negeri Semarang

dwi2_oto@mail.unnes.ac.id

Abstract. This study aims to determine the effect of soursop leaf extraction as biodiesel antioxidants on the torque and power of diesel engines. Fuels were made by mixing the soursop leaf antioxidants of 50 ppm, 100 ppm and 150 ppm, to 1 litre of B30 fuel. The fuels were applied to diesel-engine vehicles. Diesel engine performance was tested by a chassis dynamometer. The results showed that the use of an antioxidant mixture of 50 ppm, 100 ppm, and 150 ppm in biodiesel caused a decrease in torque of 12.61%; 17.37%; 16.69% respectively, and the power was also decreased of 12.34%; 18.16% and 16.37% compared to biodiesel without antioxidant mixture.

1. Introduction

Biodiesel is currently widely used as a mixture of diesel fuel [1] for it is one of prospective renewable energy due to its superior properties as diesel fuel such as non-toxic, environment friendly, resulting low pollutant emission, and biodegradable [2]. However, biodiesel has a disadvantage, the quality decreases due to oxidation. The low oxidation stability of biodiesel causes degradation. Gurau et al. [3] stated that oxidation in biodiesel occurs through three stages, namely initiation, propagation, termination. This degradation occurs caused by carboxylic acid contain [4], storage conditions (closed/open), temperature, metal elements, and peroxides [5]. To prevent degradation, it is necessary to add antioxidants to biodiesel. The addition of antioxidants to biodiesel can inhibit the oxidation process [6]. One of the natural ingredients that can be made antioxidants is soursop leaves, because they contain flavonoid compounds and have antioxidant activity [7]. However, the addition of additives including antioxidants to the fuel can affect the characteristics of the fuel [8] so that it can affect engine performance as well [9].

Several studies of natural ingredients as antioxidants have been conducted. The addition of natural antioxidants from soursop leaf extract and mangosteen peel extract to biodiesel (B20) can inhibit oxidation in bio solar (B20) [10]. Natural antioxidants can also be made from extracts of banana peels to inhibit oxidation reactions in biodiesel [6]. However, the substitution of antioxidants to biodiesel can affect the viscosity and density of biodiesel, but not significantly [11].

Antioxidant consists of two types, namely natural antioxidants and artificial antioxidants (synthetic). Natural antioxidants can be made from plants, one of which is soursop leaves. Soursop leaf extract showed the strongest antioxidant activity with a high percentage of inhibition [7]. Soursop leaf anti-oxidants can be applied as additives in biodiesel to inhibit the oxidation, but the addition of additives to fuel can affect fuel characteristics [8].

Fuel characteristics, such as viscosity, can affect the operation of a diesel engine. Biodiesel has higher viscosity compared to diesel fuel. Higher viscosity of fuel can have a negative impact on fuel fogging in diesel engines [12]. Viscosity can affect fuel evaporation and the combustion process [12]. By adding antioxidants to the fuel, the characteristics of the fuel will also change [11] and will affect engine performance [13]. For this reason, this article will discuss the effect of adding soursop leaf extraction antioxidants to biodiesel on diesel engine torque and power.

2. Methods

The fuels that have been prepared in this study were applied on a diesel engine to evaluate the diesel engine performance. A chassis dynamometer was used to measure the performance of diesel engine on vehicles. The chassis dynamometer specifications used were the MAHA Dynamometer type LPS 3000 Roller set R100/1; Eddy Current Brake; Air cooling system; Max speed test 260 km/h; Wheel power max. 260 kW; Traction max. 6 kN; and Measurement accuracy of ± 2%.

The diesel engine used for this research was a diesel engine on an Isuzu Panther vehicle 2015. The specifications of the vehicle used were: MSG5K engine; 2,499 cc cylinder Capacity; Maximum torque of 19.5 kg_fm/1,800 rpm; Maximum Power of 80 PS/3,500 rpm; Number of cylinders: 4 in line; Diameter x stroke 95.4 mm x 87.4 mm; 5 speed transmission.

The tested fuels were made by mixing antioxidants of 50 ppm, 100 ppm and 150 ppm (43.5 mg, 87 mg and 130.5 mg) to 1 liter of biodiesel (B30). The mixing was carried out in the Erlenmeyer, which was placed on the hotplate stirrer. Each mixture of antioxidant and B30 was stirred using a magnetic stirrer at a temperature of 40^{o}C for 30 minutes so that it become B30 fuel with a mixture of 50 ppm, 100 ppm and 150 ppm respectively. The fuels were then allowed to stand for 24 hours so that the mixed particles settled. Finally, the fuels then filtered to get fuel being free from soursop leaf extract particles.

In this study, there were four types of fuel that will be tested on a diesel engine, namely B30 fuel (without antioxidants), a mixture of B30 + 50 ppm antioxidants, B30 + 100 ppm antioxidants, and B30 + 150 ppm antioxidants. The procedures for testing the diesel engine performance in vehicle were: 1) positioning and tying the vehicle safely on the dynamometer; 2) placing the blower in front of the vehicle to keep the engine temperature; 3) inserting the oil temperature sensor stick into the oil stick holder; 4) preparing the fuel reservoir instead of the fuel tank; 7) filling biodiesel (B30) in the reservoir; 8) starting and warming the engine up until gaining engine working temperature; 9) turning on the dynamometer computer; 10) adjusting the car's specifications on the computer; 11) positioning the transmission gear to 4th position; 12) stepping on the acceleration pedal until the computer dynamometer reading was completed; and 13) conducting next similar steps for B30+50 ppm, B30+100 ppm, and B30+150 ppm. Each fuel variation was tested twice. The simple scheme of the test is shown in Figure 1.

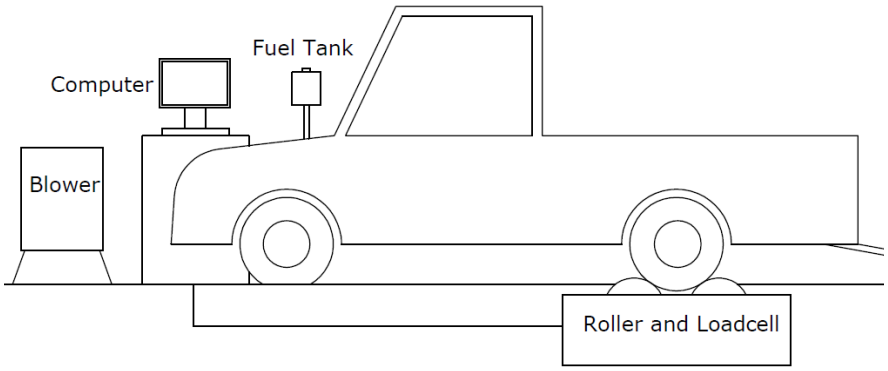

Figure 1. Schematic of the diesel engine performance testing

Data obtained from the roller and load-cell was processed by a computer to produce the torque and diesel engine power values of the vehicle being tested.

3. Result and Discussion

Based on research data, it can be explained that the addition of antioxidants to B30 fuel can affect the torque of the diesel engine. The higher amount of soursop leaf antioxidants in biodiesel B30, the engine torque tends to decrease. The average torque produced by a diesel engine with B30 fuel (without antioxidants) is 108.71 Nm, while the torque produced by adding antioxidants 50 pp, 100 ppm, and 150 ppm are 98.25 Nm, 91.80 Nm, and 91.63 Nm respectively. The results of torque testing on several fuels can be seen in Figure 2.

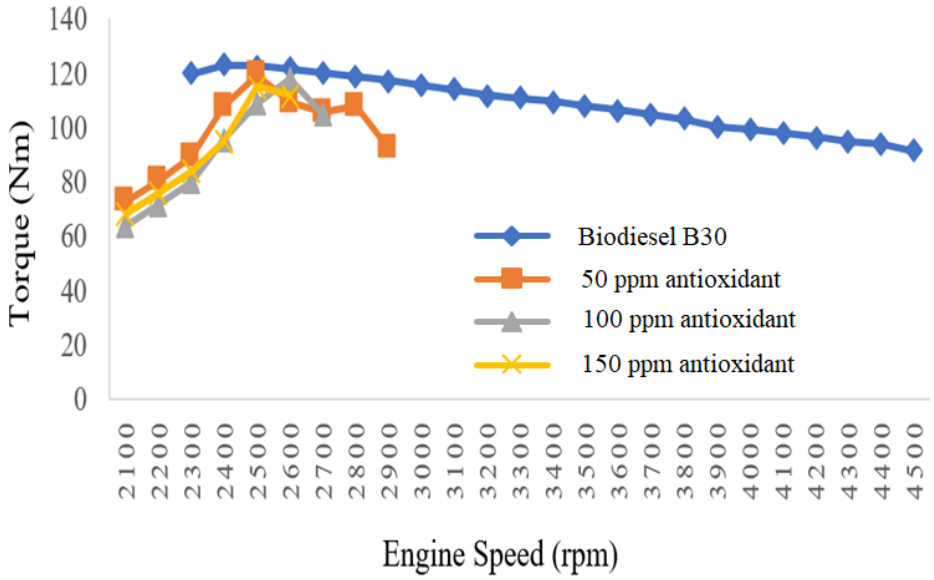

Figure 2. Engine speed vs torque

Based on Figure 2, the addition of antioxidants in B30 with 50 ppm, 100 ppm and 150 ppm tend to decrease engine torque. These can be caused by the lower calorific value of the soursop leaves (kaempferol), thus reducing the heating value of B30. In soursop leaves, the main chemical compound component is kaempferol [14]. According to Kasenov et al. [15] the calorific value of kaempferol compound ($C_{15}H_{10}O_6$) in the liquid state is 66.8 kJ/mol or about 234 kJ/kg, this value is much smaller than the calorific value of biodiesel which is 40,763 kJ/kg [16]. The weakness of the addition of this antioxidant also causes the torque to decrease and was not readable by the computer because the engine performance decreases at rotation above 2900 rpm for antioxidant content of 50 ppm. At a content of 100 ppm and 150 ppm, the highest engine speeds at which the computer could read were 2700 rpm and 2600 rpm, respectively. So, besides causing the torque to drop, adding more antioxidants can also cause a decrease in the maximum speed of the diesel engine.

If specifically studied at 2300 to 2600 rpm, all torque data could be read by computer. The resulting torque is as shown in table 1. When compared with the fuel torque of B30, the average torque after adding the antioxidants of 50 ppm, 100 ppm and 150 ppm of soursop leaves decreased by 12.61%; 17.37% and 16.69%. The addition of antioxidants can cause changes in the viscosity and density of biodiesel [11] so that the torque becomes affected.

Table 1. Engine torque

Engine Speed (rpm)	Torque (Nm)				
	Biodiesel B30	50 ppm Antioxidant	100 ppm Antioxidant	150 ppm Antioxidant	Average
2300	119.8	89.3	80	84.1	93.3
2400	122.9	107.8	95.7	94.6	105.25
2500	122.6	119.2	108.6	115	116.35

2600	121.6	109.2	118	111.9	115.175
Average	121.725	106.375	100.575	101.4	

The addition of antioxidants to B30 fuel can also affect diesel engine power. The more the amount of soursop leaf antioxidants in biodiesel B30, the engine power also tends to decrease. The average power produced by the diesel engine with B30 fuel (without antioxidants) is 38.06 kW, while the power produced by adding antioxidants 50 pp, 100 ppm, and 150 ppm are 25.96 kW, 23.22 kW, and 22.85 kW respectively. The results of testing for several types of fuel being tested can be seen in Figure 3.

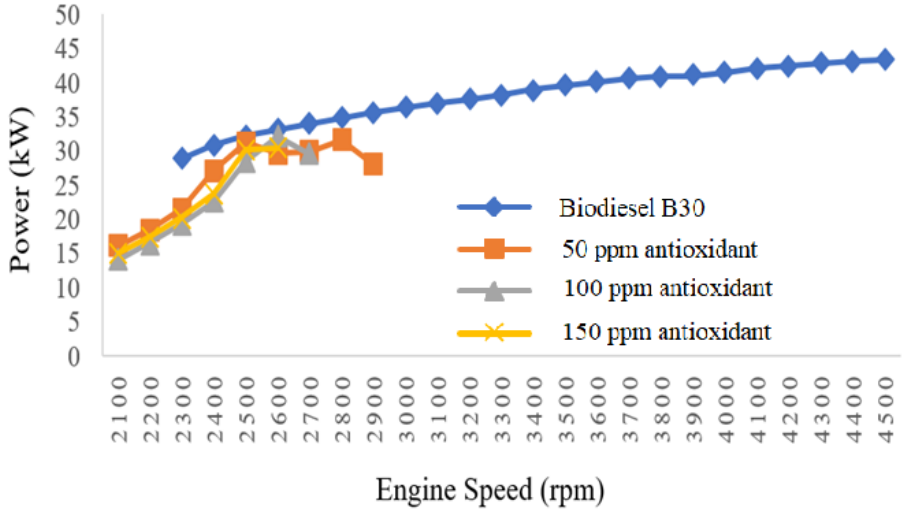

Figure 3. Engine speed vs power

Based on Figure 3, the addition of antioxidants to B30 with 50 ppm, 100 ppm and 150 ppm tend to decrease the power along with the addition of antioxidants. The decrease in power can be caused by the small antioxidant calorific value of the soursop leaves (kaempferol) so that it will affect the calorific value of B30. In soursop leaves, the main chemical compound component is thought to be kaempferol [14]. According to Kasenov et al. [15] the calorific value of kaempferol compound ($C_{15}H_{10}O_6$) in the liquid state is 66.8 kJ/mol or about 234 kJ/kg, this value is smaller than the calorific value of biodiesel which is 40,763 kJ/kg [16]. The weakness of the addition of this antioxidant also causes the power to decrease and could not be read by the computer because the engine performance decreases at rotation above 2900 rpm for antioxidant content of 50 ppm. At a content of 100 and 150 ppm, the highest engine revolutions that computer could read were 2700 rpm and 2600 rpm, respectively. So, besides causing the power to drop, adding more antioxidants can also cause a decrease in the maximum speed of the diesel engine.

If examined specifically, at 2300 to 2600 rpm, the torque and power of the diesel engine could be read by computer. The resulting data is presented in table 2. When compared with the value of the B30 fuel, the average of the power after being added the antioxidants of 50 ppm, 100 ppm and 150 ppm of soursop leaves, the power decreased respectively by 12.34%; 18.16% and 16.37%. This decrease can be due to the addition of synthetic antioxidants which can cause changes in the viscosity and density (density) of biodiesel [17] so that their power was affected.

Table 2. Engine power

Engine speed (rpm)	Power (kW)				
	Biodiesel B30	50 ppm Antioxidant	100 ppm Antioxidant	150 ppm Antioxidant	Average
2300	28.87	21.52	19.27	20.25	22.4775
2400	30.95	27.11	22.54	23.77	26.0925
2500	32.17	31.19	28.44	30.12	30.48

2600	33.1	29.82	32.12	30.46	31.375
Average	31.27	27.41	25.59	26.15	

The results of this study that indicated a decrease in power due to the addition of antioxidants was in line with research conducted by Fattah et al. [18], which explained that the addition of antioxidants to biodiesel can affect the characteristics of biodiesel and can reduce power when compared to the result of engine power when using pure biodiesel fuel.

4. Conclusion

The addition of soursop leaf extract antioxidants to biodiesel B30 can affect engine torque. The antioxidant mixture of 50 ppm, 100 ppm and 150 ppm soursop leaves can reduce torque by 12.61%, 17.37% and 16.69%, respectively. In addition, poor combustion of the engine is the reason the rotation cannot be stable so that the average recorded data is less than 2600 rpm. The addition of soursop leaf extract antioxidants to biodiesel B30 also affects engine power. The addition of antioxidants of 50 ppm, 100 ppm and 150 ppm of soursop leaves decreased their power by 12.34%; 18.16% and 16.37%. The use of antioxidants in fuels can affect combustion so that the resulting engine speed was unstable and the recorded data was not more than 2600 rpm.

References

[1] Ichsan M T, Anis S, and Widjanarko D 2018 Pengaruh campuran biodiesel minyak rumput laut gracilaria verrucosa dengan bahan bakar solar terhadap unjuk kerja dan emisi gas buang mesin diesel *Jurnal Teknik Mesin Indonesia* **13** 12-15

[2] Kusumaningtyas R D, Utomo M Y A, Nurjanah P R, and Widjanarko D 2020 Synthesis of biodiesel from kapok (Ceiba pentandra L.) seed oil through ultrasound-enhanced transesterification reaction *AIP Conference Proceedings* **2217** 030174

[3] Gurau V S, Mudit S A, Amit S, and Sarbjot S S 2016 An Experimental Study on Storage and Oxidation Stability of Bitter Apricot Kernel Oil Biodiesel *Energy Fuels* **30** 1-17

[4] Roliadi H, Sudradjat R, and Anggraini A 2012 Kemungkinan Penggunaan Antioksidan Guna Mempertinggi Ketahanan Oksidasi Biodiesel dari Minyak Biji Tanaman Jarak Pagar (Jatropha Curcas L) *Jurnal Penelitian Hasil Hutan* **30** 68-85

[5] Silviana and Luqman B 2015 Efek Penyimpanan Biodiesel Berdasarkan Studi Kajian Degradasi Biodiesel CPO *Reaktor* **15** 148-153

[6] Sanjiwani N M S, Suaniti N M, and Rustini N L 2015 Bilangan Peroksida, Bilangan Asam, dan Kadar FFA Biodiesel dengan Penambahan Antioksidan dari Kulit Buah Pisang Kepok (Musa Paradisiaca Linn.) *Jurnal Kimia* **9** 259-266

[7] Baskar R, Rajeswari V, and Kumar S T 2007 In Vitro Antioxidant Studies in Leaves Annona Species *Indian Journal of Experimental Biology* **45** 480-485

[8] Susilo J 2014 Penggunaan Minyak Atsiri Sebagai Aditif Dispersan untuk Mengatasi Deposit pada Ruang Bakar Mesin Diesel Berbahan Bakar B20 *Undergraduate Thesis* Pendidikan Kimia Universitas Islam Negeri Sultan Syarif Kasim Riau

[9] Tirtoatmodjo R and Willyanto 2000 Peningkatan Unjuk Kerja Motor Diesel dengan Penambahan Pemanas Solar *Jurnal Teknik Mesin* **2** 127-133

[10] Megawati, Handoyo and Setiawan II 2018 Kinetika Reaksi Oksidasi pada Biosolar (B20) dengan Antioksidan Alami *Jurnal Kompetensi Teknik* **10** 28-34

[11] Schober S and Martin M 2004 The Impact of Antioxidants on Biodiesel Oxidation Stability *Lipid Sci. Technol* **106** 382-389

[12] Dwipayana H 2016 Studi Analisa Pengaruh Sifat Fisik Biodiesel (Viskositas, Kadar Air dan Angka Setana) Terhadap Proses Pembakaran Bahan Bakar di Boiler Fire Tube *Jurnal Teknika* **3** 1-14

[13] Ariwibowo D, Berkah F T K, and Tony S 2011 Performa Mesin Diesel Berbahan Bakar Biodiesel *Prosiding Seminar Nasional Sains dan Teknologi ke-2 Universitas Diponegoro Semarang* 91-96.
[14] Asbanu Y W A 2019 Identifikasi Senyawa Kimia Ekstrak Daun Sirsak (Annona muricata L.) dan Uji Aktivitas Antioksidannya dengan Metode DPPH (2,2-Difenil-1- Pikrilhidrasil) *Indonesian Journal of Chemical Science* **8** 154-160
[15] Kasenov K B, Tukhmetova K Z, Kasenova S H, Abil'daefa A Z, and Adekenov S M 2004 Thermochemical Characteristics of a Series of Terpenoids, Alkaloids, and Flavonoids *Russian Journal of Applied Chemistry* **77** 508-510
[16] Aydin H and Ilkic C 2010 Effect of Ethanol Blending With Biodiesel on Engine Performance and Exhaust Emissions in a CI Engine *Thermal Engineering* **30** 1199-1204
[17] Schober S and Mittelbach M 2004 The impact of antioxidants on biodiesel oxidation stability *European Journal of Lipid Science and Technology* **106** 382-389
[18] Fattah I M R, Masjuki H H, Kalam M A, Mofijur M, and Abedin M J 2014 Effect Of Antioxidant On The Performance And Emission Characteristics of A Diesel Engine Fuelled With Palm Biodiesel Blends *Energy Conversion and Management* **79** 265-272