China Petroleum Processing and Petrochemical Technology

Catalyst Research Volume 23, Issue 2, October 2023 Pp. 2320-2339

COMPARATIVE STUDY ON THE USE OF EDIBLE OIL-BASED BIODIESEL BLENDS ON ENGINE PERFORMANCE AND THEIR EMISSIONS

[1]Kishor Bhageriya*, [1]Sagar Kumar, [2]Anand Pawar

[1]Dr. K.N. Modi University Rajasthan, India

[2]Government Polytechnic, Aurangabad, Maharashtra, India

Corresponding author *

Kishor Bhageriya- kishor.bhageriya7@gmail.com

Co-authors

Sagar Kumar- sagar.me@dkmnu.org

Anand Kumar- anandpawar5000@rediffmail.com

Abstract

Over the past few decades, the growing worry about reducing global oil deposits and the adverse impact on the environment has escalated the need for creating renewable and eco-conscious fuels. In this context, edible oil-based biodiesel is one of the strong candidates. Presently, approximately 84% of global biodiesel production is sourced from rapeseed oil, with sunflower oil accounting for around 13%, palm oil for 1%, and soybean oil and other sources constituting the remaining 2% [1, 2]. Given that over 95% of biodiesel is derived from edible oils, this constitutes a significant proportion [1]. This work compares different edible oil-based (sunflower, soybean, cottonseed, and palm oils) biodiesel blends on CI engine performance. Based on brake power (BP), brake thermal efficiency, and specific fuel consumption, the engine performance was measured experimental at different blending ratios for each biodiesel. Emission gases for different biodiesel at different blending ratios were also measured. Results show that a 16 kg load, soy 10% (Soybean biodiesel with 10% soybean oil blend) shows a higher BP than other biodiesels. At 10% blending, Soybean biodiesel shows 4.81 kW BP which is 6.4% more than the sunflower biodiesel. And also, it is 21.4% more than palm biodiesel and 21.7% more than cottonseed biodiesel at the same blending percentage. Results indicate that the use of different biodiesels influences the chemical composition of emission gases.

Keywords- Biodiesels, Emission, Performance, chemical composition, specific fuel consumption

1. Introduction

The growing concerns over climate change and environmental sustainability have led to a renewed focus on alternative fuels in the transportation sector [3-6]. Biodiesel, a renewable fuel derived from vegetable oils and animal fats, has emerged as a promising solution due to its potential to reduce greenhouse gas emissions and dependence on fossil fuels [7, 8]. Biodiesel presents several advantages over traditional diesel fuel. It possesses a liquid form, ensuring easy transportation and widespread availability. Being derived from renewable sources, it contributes to sustainability. Moreover, it offers improved combustion efficiency, lower levels of sulfur and aromatic compounds, and a higher cetane number, which signifies its better ignition quality. Notably, biodiesel is safer to handle than conventional diesel fuel due to its significantly higher flash point of over 423 K, as opposed to petroleum diesel's 350 K [9]. It boasts a cetane number of around 50,

Catalyst Research Volume 23, Issue 2, October 2023 Pp. 2320-2339

indicating its readiness to auto-ignite upon injection into the engine. The absence of aromatics and sulfur, along with its oxygen content of 10-11% by weight, further highlights its cleaner composition [10]. The cetane number, a key parameter assessing diesel quality, reflects biodiesel's ignition attributes, which are influenced by the composition of its fatty acid methyl ester (FAME) component [11-14]. Importantly, biodiesel's viscosity closely approximates that of standard diesel fuels. This attribute is crucial, especially during cold temperatures, as high viscosity can hinder proper fuel injection equipment operation by impeding fuel spray atomization and injector precision [15-17]. However, the use of biodiesel is not without its challenges, as its chemical composition can vary depending on the feedstock and production process employed [18, 19]. These variations can significantly impact the emission characteristics and overall performance of engines using biodiesel fuels [20, 21].

Biodiesel production has predominantly relied on edible vegetable oils worldwide [22]. Presently, more than 95% of the global biodiesel output originates from edible oils, which are abundantly accessible from the agricultural sector [23-25]. The utilization of these oils, widely available on a large scale, has been instrumental in driving the expansion of biodiesel production[23]. Between the marketing years 2004 and 2007, the global consumption of edible oils grew at a faster rate than their production. During this period, there was an estimated surge of 6.6 million tons in the utilization of edible oils for biodiesel manufacturing. This increase accounted for approximately 34% of the overall rise in global edible oil consumption [1]. At present, the primary sources for biodiesel production are conventionally cultivated edible oils like rapeseed, soybean, sunflower, and palm oils [26]. These oils have become the predominant feedstocks for biodiesel production due to their established availability and suitability for large-scale processing [23]. One of the key factors affecting the emissions profile of biodiesel is its fatty acid composition [27, 28]. Biodiesel fuels are predominantly composed of fatty acid methyl esters (FAMEs) or fatty acid ethyl esters (FAEEs) produced through transesterification reactions [29, 30]. The chemical composition of emission gases, particularly nitrogen oxides (NOx) and particulate matter (PM), has drawn considerable attention due to their adverse environmental and health impacts [31-33]. NOx is a collective term for nitrogen monoxide (NO) and nitrogen dioxide (NO2), which are major contributors to air pollution and the formation of smog. PM consists of tiny particles suspended in the air, including solid and liquid particles that can penetrate deep into the respiratory system and cause various health issues [34, 35]. Understanding how different biodiesels affect the formation and release of NOx and PM is crucial for optimizing engine performance and mitigating environmental impact [34, 36, 37].

Furthermore, the performance characteristics of biodiesel in terms of combustion efficiency, engine power, and fuel consumption will also depend on different edible oils used for biodiesel production. Biodiesel fuels have different energy densities, viscosities, and cetane numbers compared to conventional diesel fuels [38, 39]. These variations can impact combustion, leading to engine performance and fuel economy differences. Investigating the performance attributes of different edible oil-based biodiesels will contribute to optimizing engine design and fuel formulation for enhanced efficiency and sustainability [40-42]. This work contains a comparative

Catalyst Research Volume 23, Issue 2, October 2023 Pp. 2320-2339

study of the use of different edible oil-based biodiesels on the performance and emission gases of single-cylinder CI engines. Commonly used edible oil biodiesels, such as soybean oil, sunflower, cottonseed, and palm oil were considered during this work with three different blending percentage that is 5, 10 and 15% by volume.

This comparative study will offer valuable insights to policymakers, engine manufacturers, and fuel producers, aiding in the development of more effective emission control strategies and fuel formulations for edible oil-based biodiesel. Additionally, the study will help identify the most favorable feedstocks and production methods for edible oil biodiesel production, considering both environmental and engine performance considerations. By understanding the intricate relationship between biodiesel composition, emissions, and engine performance, we can foster the development of cleaner and more efficient transportation systems, contributing to a greener and more sustainable future.

2. Materials and methods

Four commonly used edible oil-based biodiesels (i.e. sunflower, soybean, palm, and cottonseed oil) were considered during the work. Each biodiesel was prepared with different blending percentages (i.e. 5, 10, 15 blending percentages). This means the edible oil was added into conventional diesel at 5, 10, and 15% by volume. The blended biodiesels were provided by Apex Innovation, Sangli, India. The experimental analysis of different biodiesel was performed at Apex Innovations which is situated in the MIDC area, Kupwad, Sangli Maharashtra-416436. First, the blend of different compositions (i.e., B5, B10, and B15) was made through mechanical stirring and transesterification method, and then it is used as fuel in a single cylinder four stroke diesel engine. The experimental setup used for the analysis is shown in Figure 1.

Figure 1. Experimental setup used during the work

2.1 Parameters and equipment used during the Experiment

IC engine set up under test is research diesel having power-3.50 kW@1500 rpm which is 1 Cylinder, four-stroke, Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore-87.50 (mm), Stroke Length-110.00(mm), Connecting Rod length-234.00(mm), Compression Ratio-16.00, Swept volume-661.45 (cc). Specific Gas Const (kJ/kg K): 1.00, Air Density (kg/m^3): 1.17, Adiabatic Index: 1.41, Polytrophic Index: 0.98, Number of Cycles: 10, Cylinder Pressure

Reference: 5, Smoothing-2, TDC Reference: 0 Different performance parameters that are considered during the experimental are mention here. Orifice Diameter (mm): 20.00, Orifice Coefficient of discharge: 0.60, Dynamometer Arm Length (mm): 185, Fuel Pipe dia (mm): 12.40, Ambient Temp. (Deg C): 27, Pulses Per revolution: 360.

3.0 Result and Discussion

3.1 soybean as a Biodiesel

At the moment, soybean oil is one of the most important feedstocks for the manufacturing of biodiesel (NBB). The performance and emission evaluation of soybean biodiesel at different concerning loads is shown in Figure 2.

Catalyst Research Volume 23, Issue 2, October 2023 Pp. 2320-2339

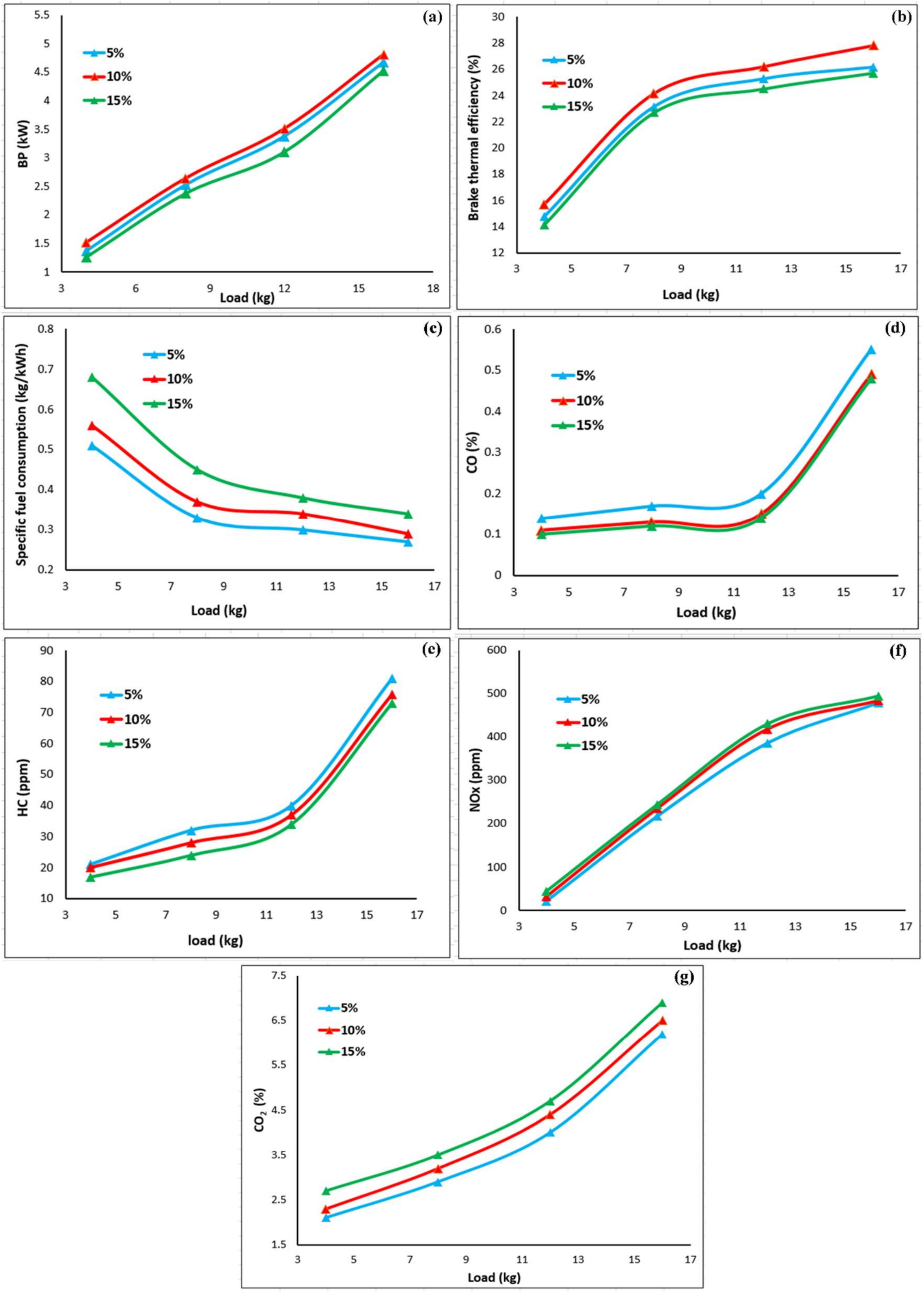

Figure 2. Performance of soybean biodiesel with different blending percentages (a) BP, (b) Bth Efficiency, (c) SFC, (d) CO, (e) HC, (f) NOx, (g) CO_2

Catalyst Research Volume 23, Issue 2, October 2023 Pp. 2320-2339

The BP of soybean biodiesel for different blending compositions at different loading conditions is shown in Fig.2(a). For a 16 kg load, the BP for B5, B10, and B15 blend biodiesel is 4.67, 4.81, and 4.53 kW respectively. Through the graph, it is found that, for B5 blending, with an increase in load, the BP of soybean biodiesel gets increases and follows the same nature for B10 and B15. B10 shows a higher value of BP as compared to B5 and B15 in soybean blending. The BthE of soybean biodiesel for different blending is shown in Fig2(b). Through the figure, it is found that with an increase in load, the BthE of the engine gets increases and maximum for 16 kg load. For B10 blending the BthE is higher as compared to B5 and B15 blending which is also confirmed through BP comparison. The SFC graph of soybean biodiesel at different loading conditions with different blending percentages is shown in Fig.2(c). For B5 blending the SFC at 4, 8, 12, and 16 kg load is 0.51, 0.33, 0.3, and 0.27 kg/kWh respectively. From the figure, it is found that as the blending percentage of soybean oil get increases the SFC get also increases. At 16 kg load, the value of SFC for B5, B10, and B15 is 0.27, 0.29, and 0.34 kg/kWh. This may be due to an increase in oxygen, carbon, and hydrogen content in biodiesel with the addition of soybean oil.

The CO content in the exhaust of soybean biodiesel fuel engine is shown in Fig.2(d). Through the figure, it is found that the CO percentage in exhaust gases gets increase with the increase in load. With the addition of soybean oil in diesel, the percentage of CO in exhaust gets decreases. At 16 kg load, the CO percentage in the exhaust for B5, B10, and B15 is 0.55, 0.49, and 0.48 %. This shows the clear reduction of CO content with the addition of soybean oil. For B5 blending the rate of decrement of CO in the exhaust is more as compared to B10 and B15 blending. With the increase in load, the percentage of CO get also increases. The HC content in exhaust also follows the same nature as CO (Fig.2(e)). With an increase in blending percentage, the value of HC content in exhaust gases gets decreases. At 16 kg load, the value of HC in the exhaust for B5, B10, and B15 is 81, 76, and 73 ppm. This gives a clear indication of a decrease in HC content with an increase in soybean oil addition. The increase in NOx and CO_2 content in exhaust gases (Fig.2 (f and g)) due to the addition of soybean oil correlate with the previously reported literature and follows the same trend. The increase in CO_2 is mainly due to the increase in oxygen, and carbon content in fuel.

3.2 Sunflower as a Biodiesel

Sunflower seed has a high oil content, sometimes exceeding 40 percent, making it an attractive candidate for use as a crop in the production of biofuel. Because it is already farmed on a large scale to use as a food oil, agronomic procedures for places where the sunflower is often found in field rotations are well established. The combustion of sunflower biodiesel with different percentages of blending was carried out at a compression ratio of 16. The brake power of sunflower biodiesel at different blending percentages is shown in Fig.3(a). The brake power for sunflower biodiesel get increases with an increase in load. Through the graph, it is found that for B10 blending sunflower biodiesel shows the maximum brake power and follows the same pattern at each load condition. At 4 kg load, B10 sunflower biodiesel has 1.42 kW BP, whereas for B5 and B15 it is about 1.32 and 1.21 kW. As compared to B5 and B15, B10 sunflower biodiesel shows 7.5 and 17.3 % higher power output. Through the graph, it is also observed that there is a marginal

Catalyst Research Volume 23, Issue 2, October 2023 Pp. 2320-2339

increment in BP for B10 as compared to B5, whereas there is a significant improvement as compared to B15. There is a marginal difference between B10 and B5 BthE, whereas for B10 and B15 the difference is much more. For a 16 kg load, the BthE for B10 is 26.43 % whereas for B5 and B15 it is near about 25.99 and 24.64 % respectively (Fig.3(b)). For four different loading conditions (4, 8, 12, and 16 kg) with B5 blending the SFC of fuel is 0.62, 0.47, 0.38, and 0.34 kg/kWh respectively (Fig.3(c)). Through the graph it is found that with an increase in load, the value of SFC gets decreases, this is mainly due to the high intake of air at higher loading conditions. B10 blending shows a lower SFC as compared to B5 and B15.

From Fig.3(d), it is found that the content of CO gets increases with an increase in load. Whereas with the increase in the percentage of addition of sunflower oil the CO percentage get decreases. For the 16 kg load condition, the value of CO for B5, B10, and B15 is 0.59, 0.54, and 0.51%. This shows that with an increase in sunflower oil addition, the percentage of CO in exhaust gases get decreases. The HC present in the exhaust emission of sunflower biodiesel is shown in Fig.3(e). The use of biodiesel should result in a decrease in the emission of hydrocarbons. According to the figure, there was a noticeable and appreciable drop in the amount of HC emissions with the use of sunflower biodiesel. As the combustion process becomes more thorough, there will be less dissociation, which will result in a lower concentration of hydrocarbons in the emissions. The reduction in hydrocarbon emissions from more than 40 ppm to less than 30 ppm is beneficial for the development of a fuel that is as effective as diesel fuel but less harmful to the environment.

Catalyst Research Volume 23, Issue 2, October 2023 Pp. 2320-2339

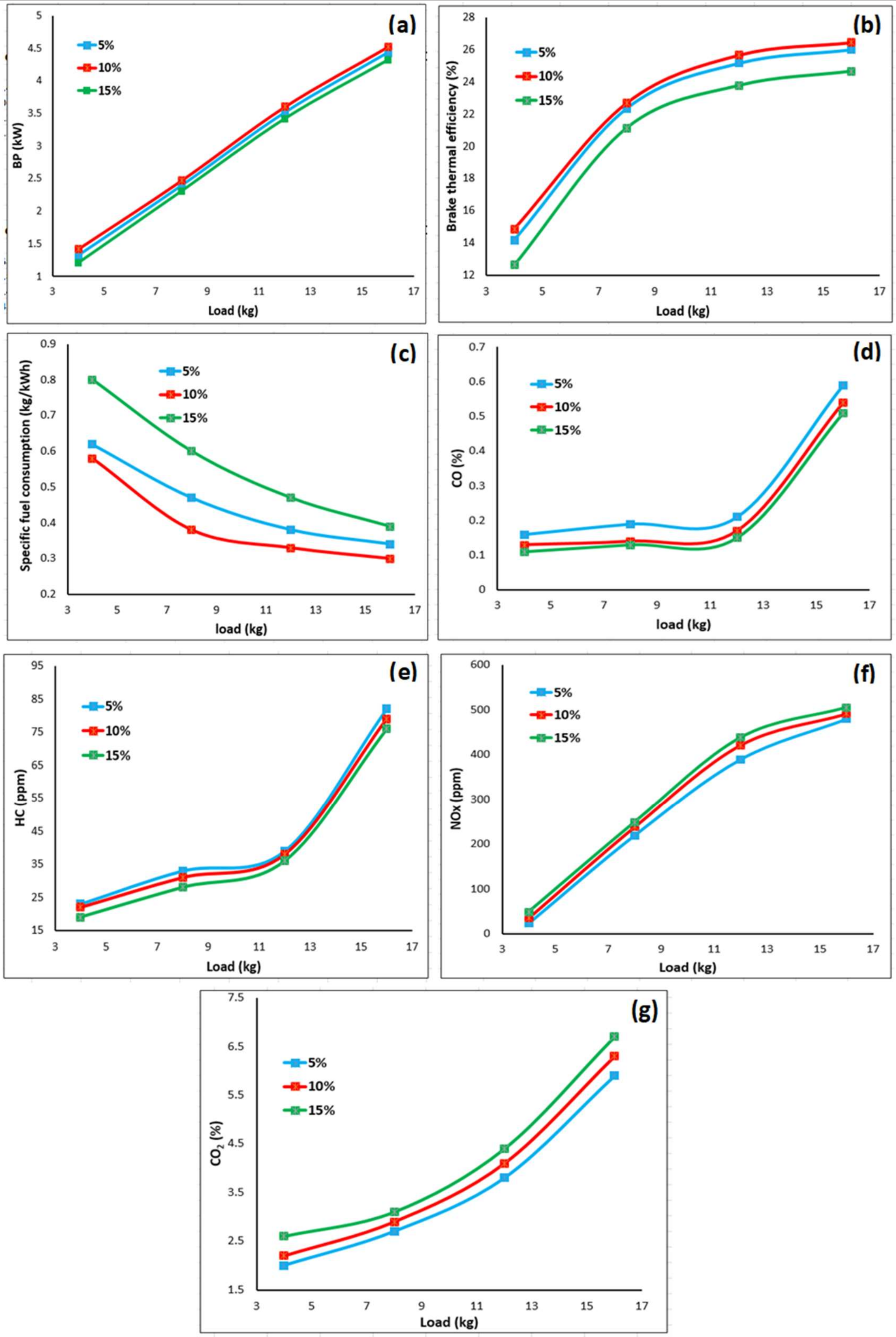

Figure 3. Performance of sunflower biodiesel with different blending percentages (a) BP, (b) Bth Efficiency, (c) SFC, (d) CO, (e) HC, (f) NOx, (g) CO_2

Catalyst Research Volume 23, Issue 2, October 2023 Pp. 2320-2339

It is found that the value of HC gets decreases with an increase in the percentage of blending. For sunflower biodiesel at 16 kg load, the value of HC for B5, B10, and B15 is 82, 79, and 76 ppm. This shows the successive decrement of HC with the addition of sunflower oil in diesel. For NOx and CO_2 (Fig.3(f and g)) same kind of nature was also seen. With the increase in load, both values increase for all the blending percentages. The increase in the percentage of sunflower oil in diesel reduces the presence of NOx and CO_2 in the emission.

3.3 Palm oil as a biodiesel

The palm oil biodiesel was evaluated experimentally with the same conditions as considered during the experimental analysis of sunflower and soybean biodiesel. The BP and BthE of the palm oil biodiesel-fueled CI engine is shown in Fig. 3(a and b). The BP get increases with an increase in load, at 16 kg load, the value of BP for B5, B10, and B15 is 3.18, 3.96, and 2.96 kW respectively. Through the graph, it is observed that for B10 the value of BP is more as compared to B5 and B15 blending and shows the same nature at each load. B10 blending shows a higher performance than the B5 and B15 blending and this is also confirmed with the BthE comparison graph (Fig.4(b)). In the case of palm oil, the B10 blend shows the minimum SFC which is subsequently followed by B5 and B15 (Fig.4(c)). At 16 kg load, the SFC for B5, B10, and B15 is 0.38, 0.32, and 0.41 kg/kWh.

The variation of CO and HC for palm biodiesel is shown in Fig.4(d and e). Through the figure, it is found that both CO and HC get decreases with an increase in the percentage of palm oil in diesel. As the percentage of CO and HC decreases in exhaust content, it means the proper combustion takes place inside the chamber. At a higher load that is 16 kg the value of CO for B5, B10, and B15 is 0.61, 0.59, and 0.55 %, whereas HC for B5, B10, and B15 is 84, 82, and 78 ppm. This shows the improvement in engine performance and also makes the CI engine more environmentally friendly. In terms of NOx and CO_2 emission, palm oil biodiesel with different blending percentages follows the same nature as followed by sunflower. With the increase in load, the percentage of both NOx and CO_2 in emission get increases and decreases with the increase in blending percentage of palm oil in conventional diesel (Fig.4(f and g)).

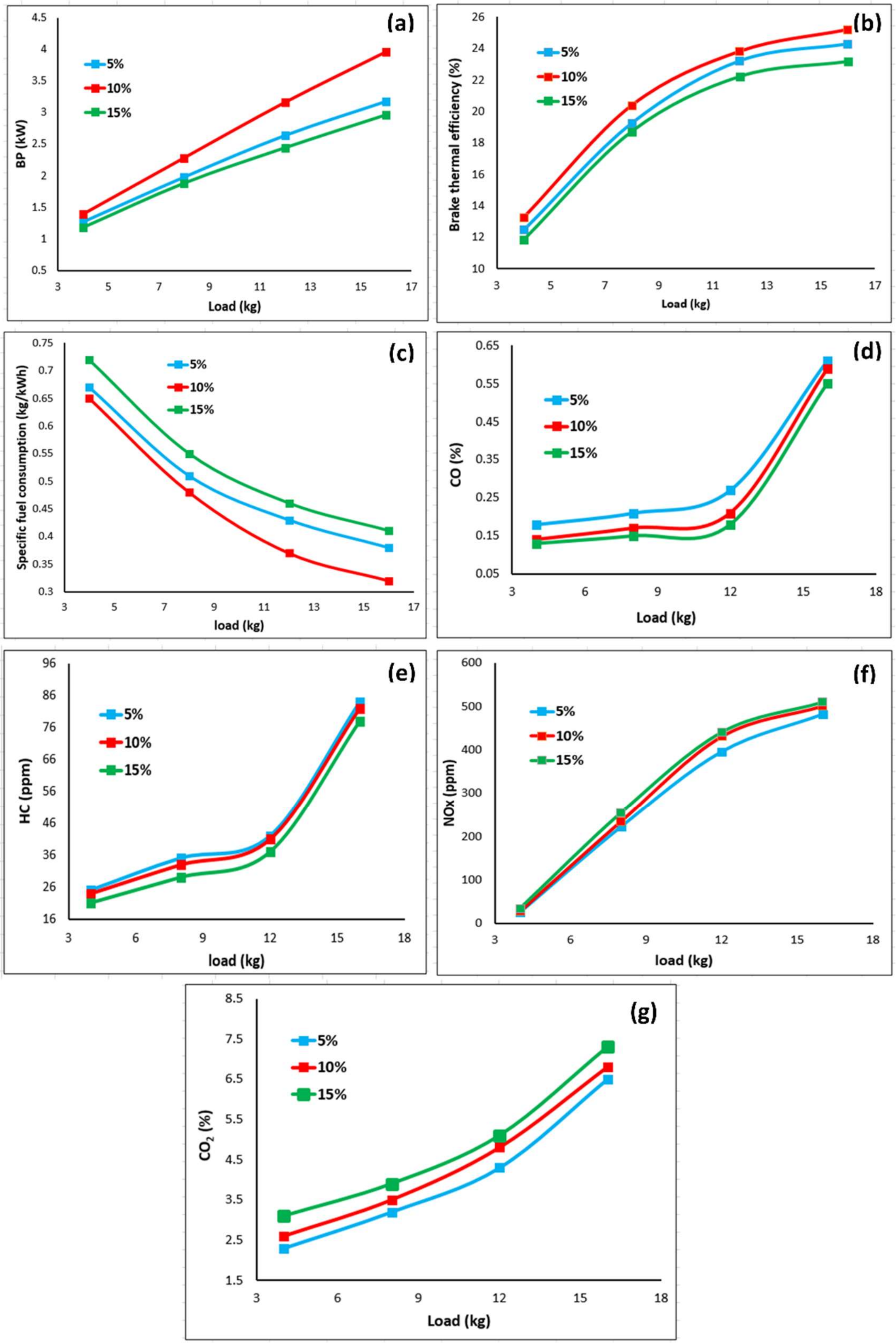

Figure 4. Performance of palm biodiesel with different blending percentages (a) BP, (b) Bth Efficiency, (c) SFC, (d) CO, (e) HC, (f) NOx, (g) CO_2

3.4 Cotton seed oil as biodiesel

Cotton seed biodiesel was also tested at the same parameters which were considered for the previous experiment. The BP and BthE of the cotton seed biodiesel are shown in Fig.5(a and b). From the figure, it is found that the value of BP gets increase with the increase in load and shows a linear increment with an increase in load. For B10 blending the value of BP and BthE is more as compared to B5 and B15. This shows the engine performs better with B10 blending as compared to others. For 16 kg load, the value of B5, B10, and B15 is 24.28, 25.19, and 22.91 kW, whereas for B10 blending at 4, 8, 12, and 16 kg load the value of BP is 13.26, 21.28, 23.81, and 25.19 kW. This shows the linear increment concerning load. The nature of SFC is just the opposite (Fig.5(c)). Through the graph, it is seen that the value of SFC get decreases with an increase in load whereas BP and BthE (Fig.5(b)) get increase. The SFC for B10 is less than the B5 and B15 blending. The cotton seed biodiesel shows a higher SFC as compared to previously reported other biodiesels.

Through Fig.5(d), it is found that the CO percentage in exhaust gases gets increases with an increase in load. With the addition of cottonseed oil in diesel, the percentage of CO in exhaust gets decreases. At 16 kg load, the CO percentage in the exhaust for B5, B10, and B15 is 0.61, 0.59, and 0.61 %. This shows the clear reduction of CO content with the addition of cotton seed oil. For B5 blending the rate of decrement of CO in the exhaust is more as compared to B10 and B15 blending. With an increase in load, the percentage of CO get also increases. The HC content in exhaust also follows the same nature as CO. With an increase in blending percentage the value of HC content in exhaust gases get decreases (Fig.5(e)). At 16 kg load, the value of HC in the exhaust for B5, B10, and B15 is 84, 82, and 80 ppm. This gives a clear indication of a decrease in HC content with an increase in cotton seed oil addition. With the addition of cottonseed oil in diesel, the content of NOx and CO_2 (Fig.5(f and g)) get increases and is higher for B15 blending as mentioned in the figure. The increase in NOx and CO_2 content in exhaust gases due to the addition of cotton seed oil correlate with the previously reported literature and follows the same trend. The increase in CO_2 is mainly due to the increase in oxygen, and carbon content in fuel.

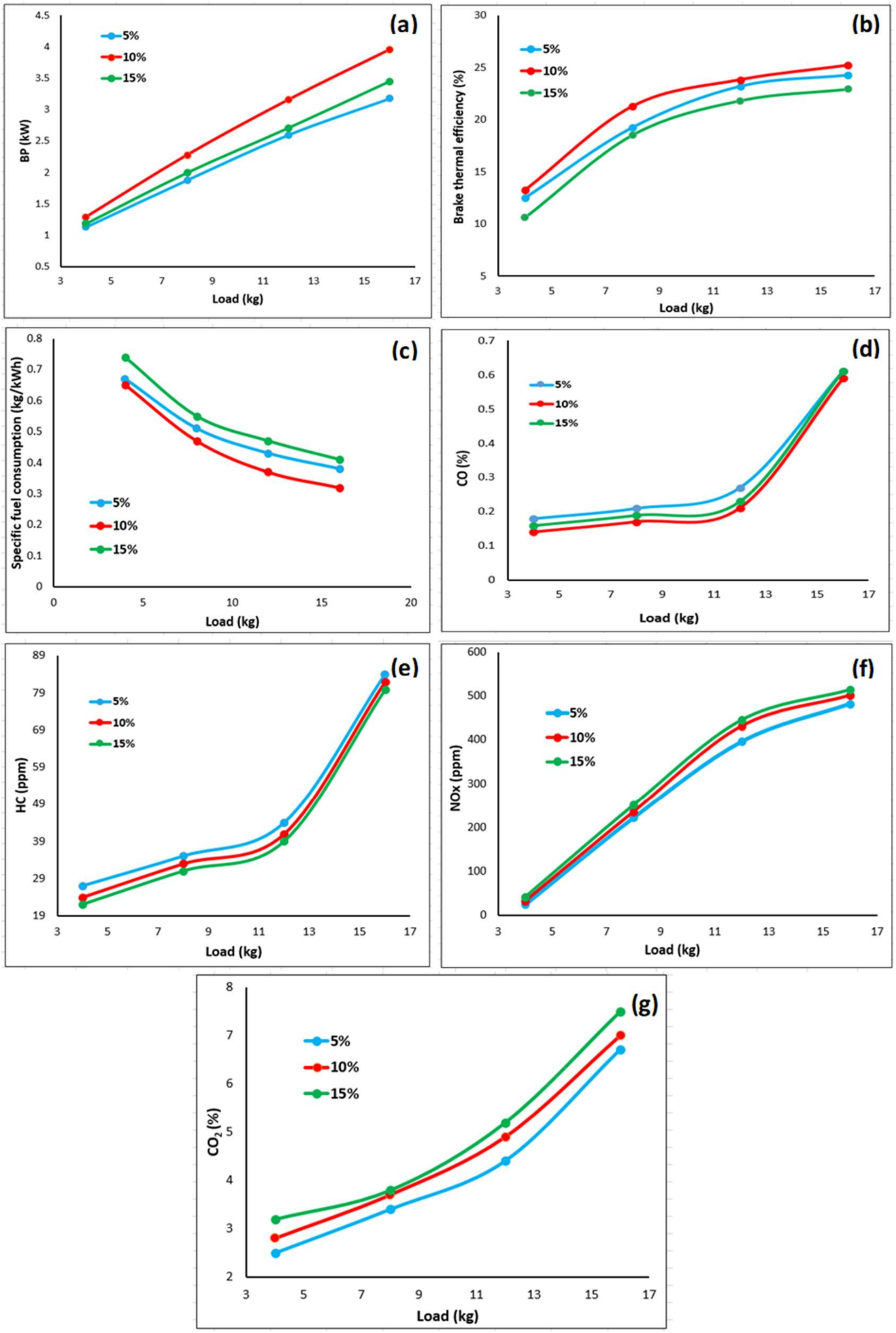

Figure 5. Performance of cottonseed biodiesel with different blending percentages (a) BP, (b) Bth Efficiency, (c) SFC, (d) CO, (e) HC, (f) NOx, (g) CO_2

4.0 Comparison of different biodiesel performance parameters and chemical Composition of emission

To compare the performance of sunflower, soybean, palm, and cottonseed oil biodiesel, the value of BP and BthE was compared. In the graph the sunflower biodiesel was denoted by Sun with different blending percentages (i.e., Sun5%, Sun10%, and Sun15%), the soybean is denoted by Soy with different blending (i.e., Soy 5%, Soy 10%, Soy 15%), the palm oil is denoted by Pal with different blending (i.e., Pal 5%, Pal 10%, Pal 15%), and the Cotton seed was denoted by Cot with a different percentage that is (i.e., Cot 5%, Cot 10%, Cot 15%).

4.1 Brake power (BP)

From Figure 6, it is found that the value of BP for soybean oil is more as compared to other biodiesel which is subsequently followed by sunflower palm oil and cotton seed oil. with B10 blending at 16 kg load, the value of BP for soybean biodiesel is 6.4 % more than the sunflower whereas it is 21.4 % higher than the Palm biodiesel and about 17.3% higher than the Cotton seed biodiesel. The same kind of nature was also seen in the BthE.

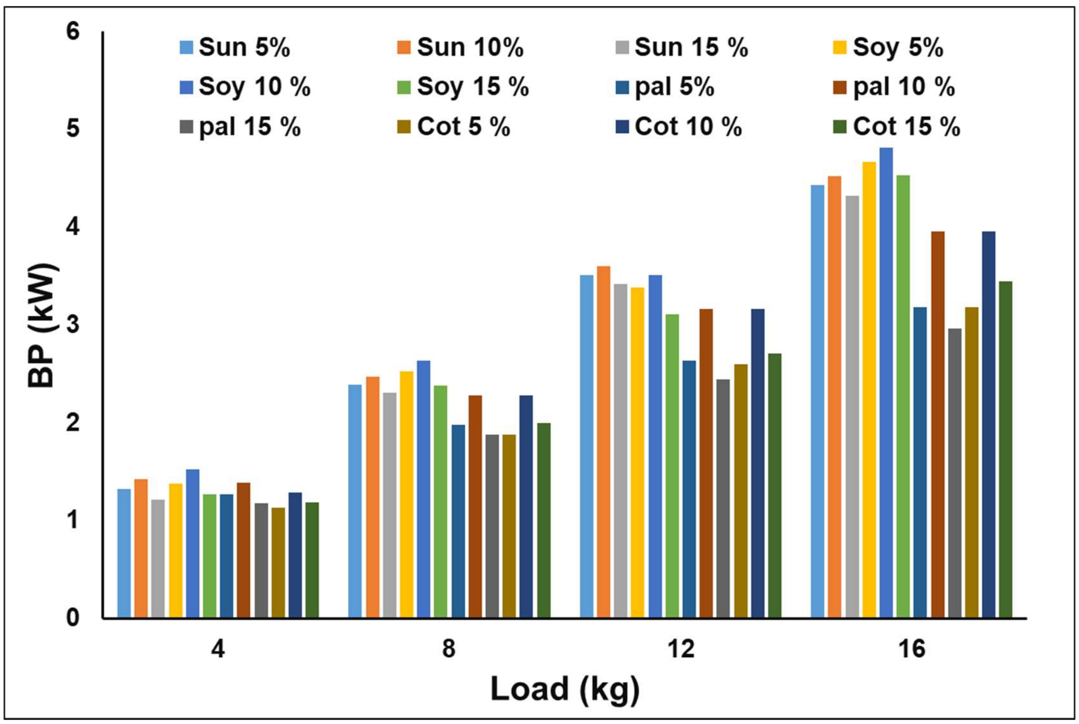

Figure 6. Comparison of the value of BP for different biodiesel at different loading conditions

Through the graph, it was found that compared to other BthE for soybean biodiesel is more at each blending percentage. For B10 blending each biodiesel shows higher BthE and BP as compared to B5 and B15 blending. For B10 blending at 16 kg load the BthE of soybean biodiesel is 5.2% higher than the sunflower biodiesel, whereas 10.4% and 15% higher than the palm and cotton seed biodiesel. So overall it is found that B10 blending shows better performance for all biodiesel.

4.2 Specific fuel consumption (SFC)

Fig.7 shows the comparison of the value of SFC for different biodiesel at different blending percentages. BthE and SFC follow the just opposite nature, which means as the BthE gets increases with load SFC to get decreases which are mainly due to the large amount of air intake during loading. For sunflower biodiesel, the SFC for B10 is less as compared to B5 and B15 blending. For soybean biodiesel, the SFC get increases with the increase of blending percentage and maximum for B15. In the case of Palm oil, the SFC for B10 is less as compared to B5 and B15 and shows the same kind of nature as sunflower biodiesel. Cotton seed biodiesel also follows the same nature as sunflower and palm. The SFC for cotton seed biodiesel is less for B10 blending as compared to others.

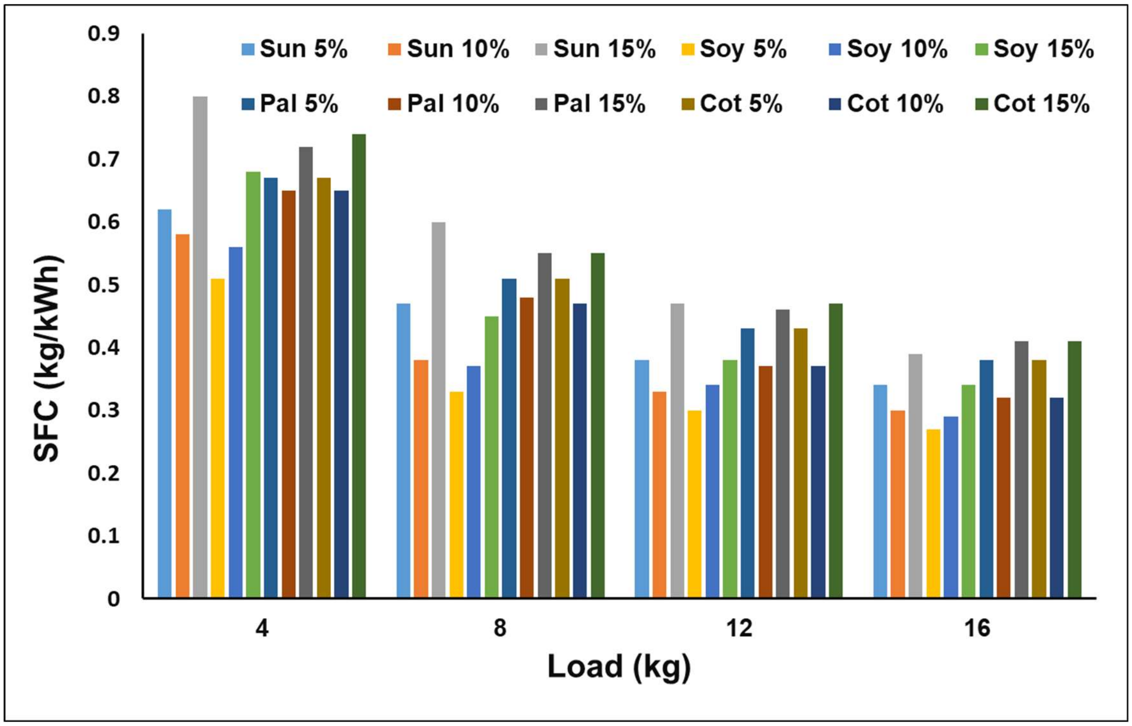

Figure 7. Comparison of SFC for different biodiesel at different loading conditions

4.3 CO and HC comparison

From Figures 8 and 9, it is found that at a higher load, the value of CO and HC production is more in the case of all biodiesels. The increase in the percentage of biofuel in diesel reduced the content of CO and HC in the exhaust which is mainly due to more addition of oxygen into diesel which helps in the proper combustion of fuel. For soyabean oil, the value of CO (Figure 8) is less at each blending composition as compared to other biodiesels. The same kind of nature is also observed in the case of HC (Figure 9). The HC percentage in exhaust decreases with an increase in the percentage of biofuel.

Catalyst Research Volume 23, Issue 2, October 2023 Pp. 2320-2339

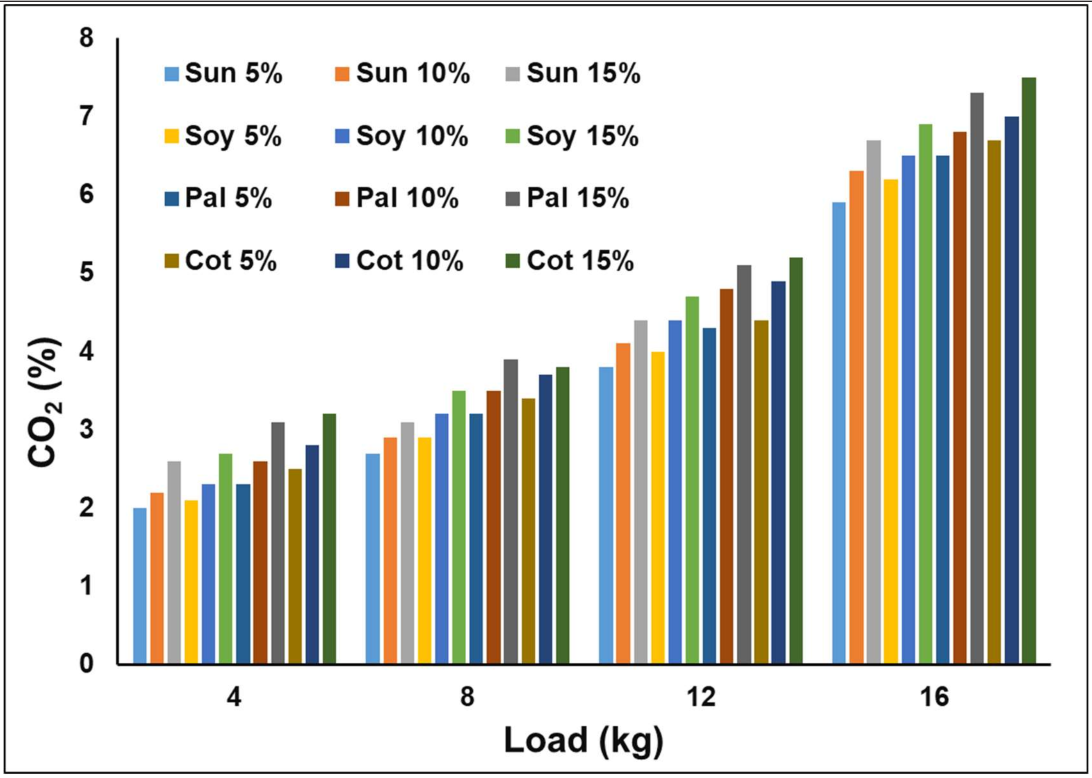

Figure 8. Comparison of the value of CO for different biodiesel

With the addition of biofuel in diesel, the value of CO2 and NOx get increases which are mainly due to the increase in oxygen and carbon content in diesel. The comparison of the value of CO2 and NOx for different biodiesel at different blending compositions is shown in the figure. From Figures 10 and 11 it is found that both the CO2 and NOx content in the exhaust for each biodiesel at each load get increases with an increase in biofuel percentage. For soybean biodiesel, the value of CO2 and NOx is less as compared to others.

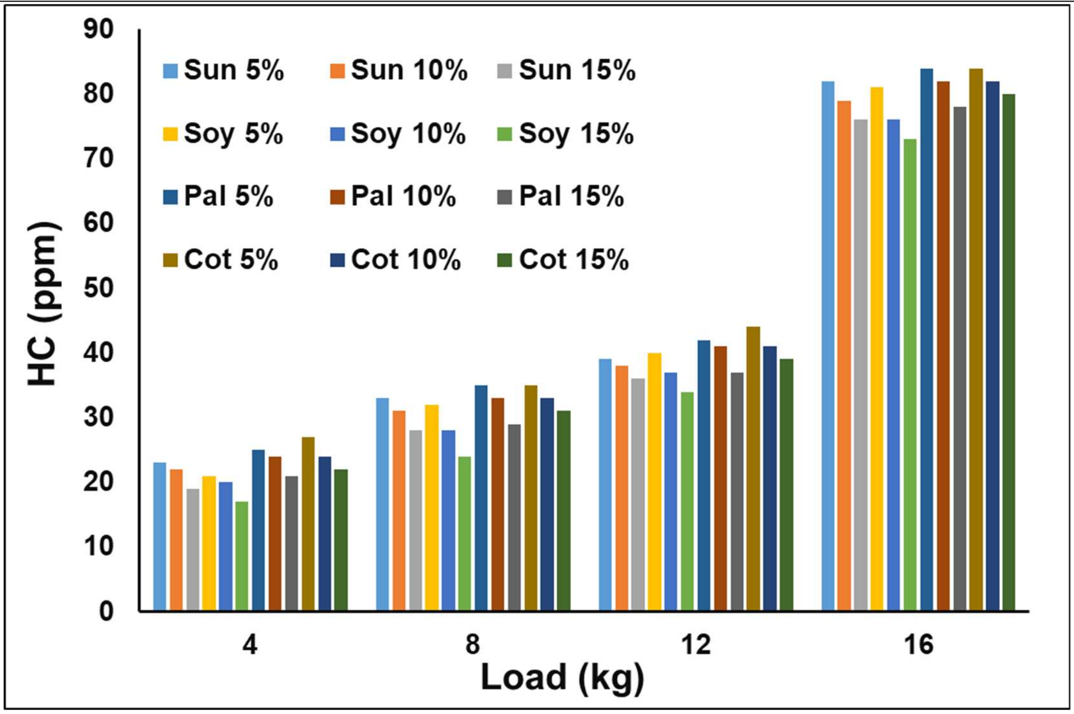

Figure 9. Comparison of the value of HC for different biodiesel

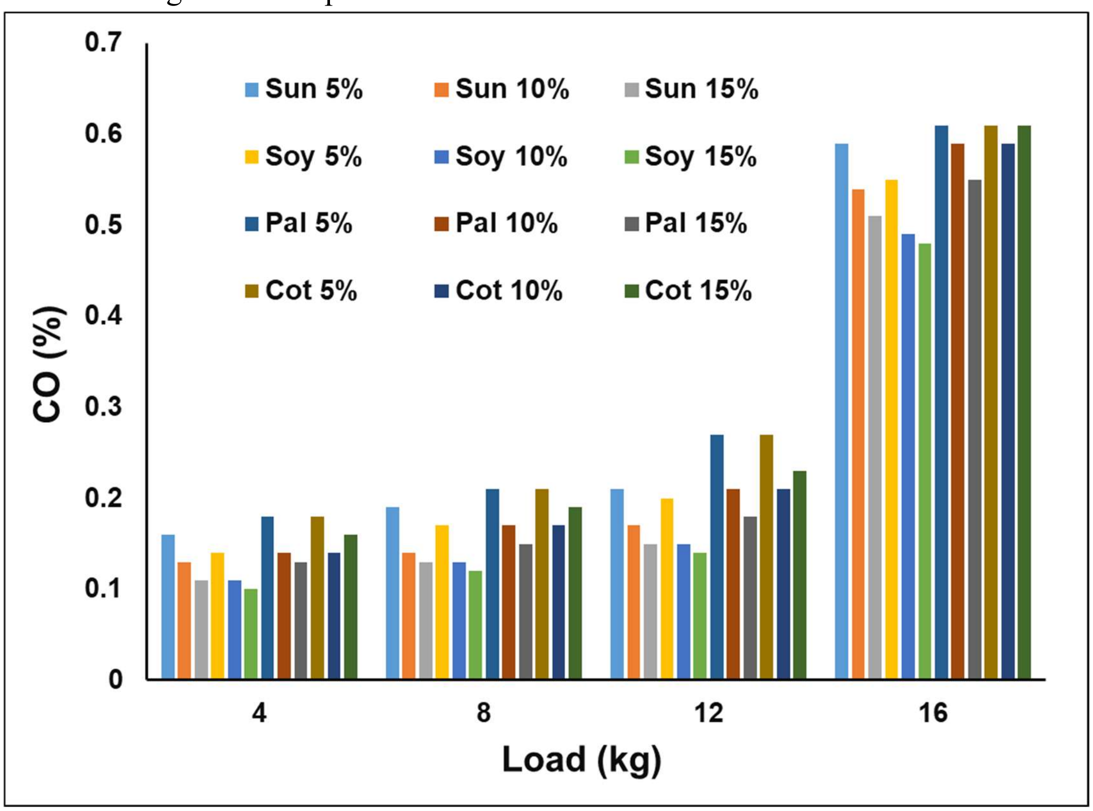

Figure 10. Comparison of the value of CO_2 for different biodiesel at different loading conditions

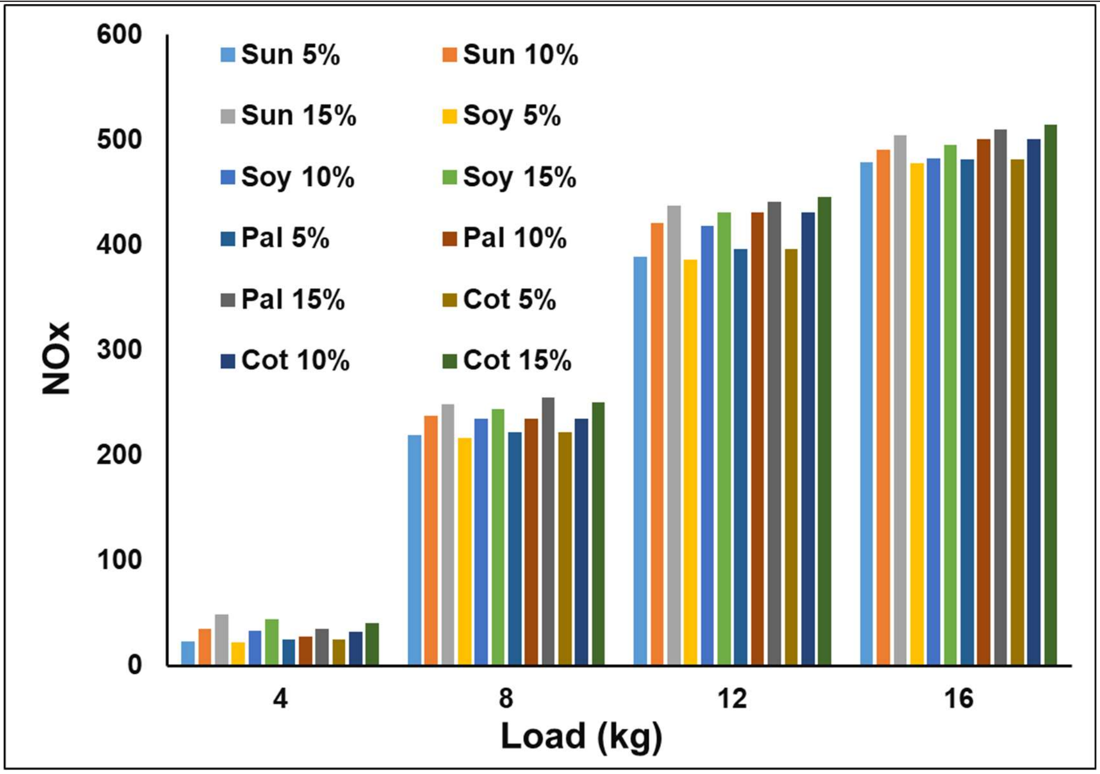

Figure 11. Comparison of the value of NOx for different biodiesel at different loading conditions

5. Conclusion

Edible oil-based biodiesel (Soybean, sunflower, palm, and cottonseed) was evaluated experimentally and measured engine performance and emission gases. Through comparison of various performance parameters, it is found that soybean biodiesel shows higher performance in terms of all parameters (BP, BthE, and SFC) as compared to other biodiesels. Their BP is significantly higher than the others whereas the exhaust emission of different elements and gases is also less as compared to other biodiesels. Through experiment results, it is also found that with B10 blending, each biodiesel shows better performance and less emission content as compared to B5 and B15. Therefore, it is concluded that B10 is the optimized blending percentage for all the four biofuels in diesel. Overall Soybean with B10 blending is the most efficient edible oil biodiesel composition for the CI engine.

References

[1] M.M. Gui, K.T. Lee, S.J.E. Bhatia, Feasibility of edible oil vs. non-edible oil vs. waste edible oil as biodiesel feedstock, 33 (2008) 1646-1653.

[2] A. Atabani, T. Mahlia, H. Masjuki, I.A. Badruddin, H.W. Yussof, W. Chong, K.T.J.E. Lee, A comparative evaluation of physical and chemical properties of biodiesel synthesized from edible and non-edible oils and study on the effect of biodiesel blending, 58 (2013) 296-304.

[3] L. Caspeta, N.A. Buijs, J.J.E. Nielsen, E. Science, The role of biofuels in the future energy supply, 6 (2013) 1077-1082.

[4] A. Callegari, S. Bolognesi, D. Cecconet, A.G.J.C.R.i.E.S. Capodaglio, Technology, Production technologies, current role, and future prospects of biofuels feedstocks: A state-of-the-art review, 50 (2020) 384-436.

[5] W.-R. Chang, J.-J. Hwang, W.J.R. Wu, S.E. Reviews, Environmental impact and sustainability study on biofuels for transportation applications, 67 (2017) 277-288.

[6] L.A.H. Nogueira, G.M. Souza, L.A.B. Cortez, C.H. de Brito Cruz, Biofuels for transport, in: Future Energy, Elsevier, 2020, pp. 173-197.

[7] M. Raboni, P. Viotti, A.G.J.R.a. Capodaglio, agua, A comprehensive analysis of the current and future role of biofuels for transport in the European Union (EU), 10 (2015) 9-21.

[8] W.T.J.A.W.T.E.o.F. Coyle, Farming, Natural Resources,, R. America, The future of biofuels: a global perspective, (2007) 24-29.

[9] M.F. Demirbas, M.J.E.C. Balat, Management, Recent advances on the production and utilization trends of bio-fuels: a global perspective, 47 (2006) 2371-2381.

[10] M. Balat, H.J.E.c. Balat, management, A critical review of bio-diesel as a vehicular fuel, 49 (2008) 2727-2741.

[11] A.B. Chhetri, K.C. Watts, M.R.J.E. Islam, Waste cooking oil as an alternate feedstock for biodiesel production, 1 (2008) 3-18.

[12] P. Verma, M.J.R. Sharma, s.e. reviews, Review of process parameters for biodiesel production from different feedstocks, 62 (2016) 1063-1071.

[13] C.-Y. Lin, X.-E.J.P. Wu, Determination of cetane number from fatty acid compositions and structures of biodiesel, 10 (2022) 1502.

[14] D.O. Onukwuli, L.N. Emembolu, C.N. Ude, S.O. Aliozo, M.C.J.E.J.o.P. Menkiti, Optimization of biodiesel production from refined cotton seed oil and its characterization, 26 (2017) 103-110.

[15] A. Nomgboye, A.J.I.A. Hansen, Prediction of cetane number of biodiesel fuel from the fatty acid methyl ester [FAME] composition, 22 (2008) 21-29.

[16] L. Tao, A.J.I.V.C. Aden, D. Biology-Plant, The economics of current and future biofuels, 45 (2009) 199-217.

[17] A. Kumar, S.J.R. Sharma, S.E. Reviews, Potential non-edible oil resources as biodiesel feedstock: an Indian perspective, 15 (2011) 1791-1800.

[18] D. Kour, K.L. Rana, N. Yadav, A.N. Yadav, A.A. Rastegari, C. Singh, P. Negi, K. Singh, A.K.J.P.o.r.b.i.f.e.s. Saxena, Technologies for biofuel production: current development, challenges, and future prospects, (2019) 1-50.

[19] S. Saraf, B.J.P.s. Thomas, e. protection, Influence of feedstock and process chemistry on biodiesel quality, 85 (2007) 360-364.

[20] L. Lin, Z. Cunshan, S. Vittayapadung, S. Xiangqian, D.J.A.e. Mingdong, Opportunities and challenges for biodiesel fuel, 88 (2011) 1020-1031.

[21] P.T. Vasudevan, M.J.J.o.I.M. Briggs, Biotechnology, Biodiesel production—current state of the art and challenges, 35 (2008) 421.

[22] M.J.E.c. Balat, management, Potential alternatives to edible oils for biodiesel production–A review of current work, 52 (2011) 1479-1492.

[23] P.D. Patil, S.J.F. Deng, Optimization of biodiesel production from edible and non-edible vegetable oils, 88 (2009) 1302-1306.

[24] L.S. Oliveira, A.S. Franca, R.R. Camargos, V.P.J.B.T. Ferraz, Coffee oil as a potential feedstock for biodiesel production, 99 (2008) 3244-3250.

[25] I. Ambat, V. Srivastava, M.J.R. Sillanpää, s.e. reviews, Recent advancement in biodiesel production methodologies using various feedstock: A review, 90 (2018) 356-369.

[26] M.P.J.R. Sharma, S.E. Reviews, Selection of potential oils for biodiesel production, 56 (2016) 1129-1138.

[27] J. Pullen, K.J.E. Saeed, Factors affecting biodiesel engine performance and exhaust emissions–Part I, 72 (2014) 1-16.

[28] G.A. Ewunie, J. Morken, O.I. Lekang, Z.D.J.R. Yigezu, S.E. Reviews, Factors affecting the potential of Jatropha curcas for sustainable biodiesel production: A critical review, 137 (2021) 110500.

[29] B. Salvi, N.J.R. Panwar, s.e. reviews, Biodiesel resources and production technologies–A review, 16 (2012) 3680-3689.

[30] A.K. Agarwal, J.G. Gupta, A.J.P.i.E. Dhar, C. Science, Potential and challenges for large-scale application of biodiesel in automotive sector, 61 (2017) 113-149.

[31] G. Lindsay, A. Macmillan, A.J.A. Woodward, N.Z.j.o.p. health, Moving urban trips from cars to bicycles: impact on health and emissions, 35 (2011) 54-60.

[32] J. Bünger, J. Krahl, K. Baum, O. Schröder, M. Müller, G. Westphal, P. Ruhnau, T.G. Schulz, E.J.A.o.t. Hallier, Cytotoxic and mutagenic effects, particle size and concentration analysis of diesel engine emissions using biodiesel and petrol diesel as fuel, 74 (2000) 490-498.

[33] A.C. Lloyd, T.A.J.J.o.t.A. Cackette, W.M. Association, Diesel engines: environmental impact and control, 51 (2001) 809-847.

[34] K.J. Swanson, M.C. Madden, A.J.J.E.h.p. Ghio, Biodiesel exhaust: the need for health effects research, 115 (2007) 496-499.

[35] A.A. Yusuf, J.D. Ampah, M.E.M. Soudagar, I. Veza, U. Kingsley, S. Afrane, C. Jin, H. Liu, A. Elfasakhany, K.A.J.E.C. Buyondo, Management, Effects of hybrid nanoparticle additives in n-butanol/waste plastic oil/diesel blends on combustion, particulate and gaseous emissions from diesel engine evaluated with entropy-weighted PROMETHEE II and TOPSIS: Environmental and health risks of plastic waste, 264 (2022) 115758.

[36] J. Krahl, A. Munack, O. Schröder, H. Stein, J.J.S.t. Bünger, Influence of biodiesel and different designed diesel fuels on the exhaust gas emissions and health effects, (2003) 2447-2455.

[37] R.L.J.I.T. McCormick, The impact of biodiesel on pollutant emissions and public health, 19 (2007) 1033-1039.

[38] K. Sivaramakrishnan, P.J.A.j.o.e. Ravikumar, a. sciences, Determination of cetane number of biodiesel and its influence on physical properties, 7 (2012) 205-211.

[39] C. Rocabruno-Valdés, L. Ramírez-Verduzco, J.J.F. Hernández, Artificial neural network models to predict density, dynamic viscosity, and cetane number of biodiesel, 147 (2015) 9-17.

[40] K. Araújo, D. Mahajan, R. Kerr, M.J.A. da Silva, Global biofuels at the crossroads: an overview of technical, policy, and investment complexities in the sustainability of biofuel development, 7 (2017) 32.

[41] A. Markevičius, V. Katinas, E. Perednis, M.J.R. Tamašauskienė, S.E. Reviews, Trends and sustainability criteria of the production and use of liquid biofuels, 14 (2010) 3226-3231.

[42] T.M. Mata, A.A. Martins, S.K. Sikdar, C.A.J.C.T. Costa, E. Policy, Sustainability considerations of biodiesel based on supply chain analysis, 13 (2011) 655-671.