IJEES

International Journal of Electrical Engineering and Sustainability (IJEES)

ISSN (online): 2959-9229

https://ijees.org/index.php/ijees/index

Volume 2 | Number 2 | April-June 2024 | Pages 36-45

Research Article

The Effect of Biodiesel on the Diesel Engine

Nabil M. Muhaisen[1], Mustafa M. Graisa [2]*

[1] Department of Aeronautical Engineering, College of Civil Aviation, Misrata, Libya

[2] School of Mechanical Engineering, Libyan Academy for Postgraduate Studies, Misrata, Libya

*Corresponding author: mustafagraisa@gmail.com

DOI: 10.5281/zenodo.11213302

Received: February 02, 2024 Accepted: April 20, 2024 Published: May 16, 2024

Abstract: Biodiesel has a significant impact on the performance and durability of diesel engines. Biodiesel, a renewable and cleaner-burning fuel derived from biological sources such as vegetable oils and animal fats, is increasingly being adopted as an alternative to traditional petroleum diesel. This shift is driven by the need for reducing the environmental impact of fossil fuels and enhancing energy security. The integration of biodiesel into the diesel fuel market comes with a variety of effects on engine performance, emissions, and durability. Understanding these impacts is crucial for optimizing engine design, ensuring operational efficiency, and complying with environmental regulations. This article undertakes a systematic experimental analysis to evaluate the impact of various vegetable oil-diesel blends on the performance characteristics of a single-cylinder compression ignition engine. The investigation incorporated four distinct fuel mixtures: 10% sunflower oil with 90% diesel, 10% olive oil with 90% diesel, 10% corn oil with 90% diesel, and a control sample of pure diesel. Performance testing was conducted using a four-stroke single-cylinder engine (Model GR0306/000/038A) with a compression ratio of 21:1. Experimental results indicate a decrement in engine performance parameters when utilizing vegetable oil fuel blends. Specifically, the brake power exhibited reductions of 9.7%, 5.14%, and 1.7% for the 10% olive oil-diesel blend, 10% sunflower oil-diesel blend, and 10% corn oil-diesel blend respectively, when compared to the baseline of pure diesel at an engine speed of 2000 rpm. Similarly, thermal efficiency (η_{bth}) was observed to decrease by 9.4%, 7.25%, and 6.04% for the same respective blends. Concurrently, the brake specific fuel consumption (BSFC) demonstrated increases of 7.9%, 5.7%, and 2.4% when operating with the aforementioned blends compared to pure diesel. These findings highlight the nuanced interplay between fuel composition and engine performance, providing critical insights into the viability of integrating renewable energy sources within existing diesel engine frameworks.

Keywords: Performance, Biodiesel, Blends, Vegetable fuel, Compression ratio

1. Introduction

Fuel type significantly influences engine performance, particularly within the domain of diesel engines, which predominate in sectors such as transportation, power generation, and maritime and industrial applications [1]. Despite diesel engines being more fuel-efficient than their spark-ignited counterparts, they are often criticized for higher emissions and elevated noise levels. The pervasive use of diesel, coupled with the gradual depletion of fossil fuel reserves and escalating environmental concerns related to exhaust emissions, underscores the imperative for viable alternative fuels for compression ignition engines. Vegetable oil, commonly referred to as biodiesel, emerges as a promising alternative due to its physicochemical properties closely mirroring those of diesel fuel [2]. In this context, the cetane number and calorific value of biodiesel align closely with conventional diesel, facilitating the operation of diesel engines on vegetable oil without necessitating modifications. This compatibility is crucial as many alternative fuels struggle to gain acceptance due to performance discrepancies compared to their petroleum-based counterparts [3].

In terms of performance metrics such as horsepower, torque, and fuel efficiency, biodiesel and its blends with petroleum diesel are comparable to traditional diesel. Pure biodiesel typically exhibits an energy content that is 5%-10% lower than that of standard petroleum diesel, which can vary by up to 15% between suppliers [4]. The marginal reduction in energy content with 100% biodiesel usage translates into slightly diminished engine performance, though many users report negligible impact on mileage or overall performance. When blended with petroleum diesel at B20 levels (20% biodiesel, 80% petroleum diesel), the change in fuel energy content is less than 2%, with most users observing no noticeable effect on vehicle economy. The lubrication quality of fuel, known as lubricity, is critical for the longevity and efficiency of diesel engine injection systems [5]. Low lubricity in petroleum diesel can precipitate premature wear and failure of injection components. Biodiesel excels in enhancing the lubricity of fuel, especially important in the era of low sulfur and ultra-low sulfur diesel fuels, which lack the lubricating properties previously provided by certain compounds. Blending as little as 5% biodiesel can significantly improve the lubricity of these fuels, extending the durability of the engine's fuel injection system [6].

Moreover, biodiesel is the only alternative fuel to have completed the Environmental Protection Agency's (EPA) stringent emissions and health effects studies under the Clean Air Act, demonstrating substantial reductions in emissions of carbon monoxide, particulate matter, unburned hydrocarbons, and sulfates compared to petroleum diesel. In this point, biodiesel cuts emissions of carcinogenic compounds by up to 85% relative to petroleum diesel. These emission reductions are generally proportional to the biodiesel content in the fuel blend, enhancing air quality particularly in close-quarter environments such as public transportation, mining, and construction. The use of biodiesel not only contributes to environmental sustainability but also adds value to waste products [7]. Waste cooking oil and other low-value fats, once relegated to disposal or animal feed, are now increasingly utilized as biodiesel feedstocks, enhancing their economic worth and promoting effective recycling practices. This approach is exemplified by initiatives like those undertaken by Pacific Biodiesel Technologies, which have significantly mitigated waste oil contributions to landfills by transforming these substances into high-quality biodiesel [8]. The adoption of biodiesel offers a multifaceted solution to the challenges posed by conventional diesel, aligning with both environmental stewardship and energy security objectives, thereby supporting the transition towards more sustainable energy paradigms in the diesel engine sector.

Numerous studies have explored the impact of biodiesel on diesel engine performance. The primary objective of this research [9] is to synergize response surface methodology (RSM) and life cycle assessment (LCA) to mitigate environmental impacts associated with mechanical power generation in a diesel engine using diesel-biodiesel blends. The study assessed the environmental consequences of operating an OM 314 diesel engine with biodiesel through a comprehensive life cycle analysis. Utilizing response surface methodology, the research aimed to determine the optimal proportion of algae-derived biodiesel in the fuel blends, taking into account various engine loads and speeds. The findings indicated reductions in abiotic depletion, fossil fuel depletion, and ozone layer depletion indicators by 16.09–44.09% relative to pure diesel. Similarly, improvements were noted in several other environmental indicators, which decreased by 16.74–131.84% compared to pure biodiesel. The normalization process revealed that marine aquatic ecotoxicity was the predominant environmental impact across all fuels studied. This article [10] investigates the emissions regulation of a 3.5 kW single cylinder, direct injection, diesel engine powered by biogas and Mahua biodiesel. The study systematically varies the compression ratio from 17 to 18 in increments of 0.5, the pilot fuel injection timing from 23° before top dead center (BTDC) to 32° BTDC, and the engine load from 20% to 100% in increments of 20%. Using response surface methodology, the study identifies the optimal operating conditions that result in minimized emissions. At these optimal settings—namely, a compression ratio of 17.73, pilot fuel injection timing of 26.71° BTDC, and an engine load of 58.96%—the emissions were recorded at 42.89 ppm for nitrogen oxides, 80.36 ppm for unburned hydrocarbons, 4.23% volume for CO_2, and 77.72 ppm for carbon monoxide.

In [11], the study delineates the outcomes of experimental research on the application of biodiesel blends in maritime fuel systems. This research was conducted on specialized sea vessels with deadweights of 10,820 tons and 29,420 tons navigating the waters of South America, the Caribbean, and the Sulphur Emission Control Areas (SECAs) of Northern Europe. The vessels were powered by a combination of marine fuel derived from petroleum and blends that incorporated biodiesel. Operational trials were conducted using marine medium-speed diesel engines, specifically the 5DC-17A Daihatsu Diesel, the 16V32 Wärtsilä-Sulzer, and the Volvo Penta TWD1645GE. The fuel varieties utilized included traditional marine fuels and biodiesel types such as Fatty Acid Methyl Esters (FAME) B99.9 and B99.6.

This article provides a detailed experimental evaluation of how various vegetable oil-diesel blends affect the performance of a single-cylinder compression ignition engine. The article tested blends containing 10% sunflower, olive, and corn oil mixed with 90% diesel, alongside a control group using pure diesel. Results showed that all vegetable oil blends reduced engine performance compared to pure diesel, specifically in terms of brake power, thermal efficiency, and increased fuel consumption. These findings help understand the impact of renewable fuel sources on diesel engine performance, highlighting the complex interplay between fuel type and engine efficiency. This contributes to ongoing discussions on the viability of integrating alternative fuels into existing engine technologies.

2. Methodology

This article adopted a systematic experimental approach to explore the impact of various vegetable oil-diesel blends on the performance characteristics of a single-cylinder compression ignition engine. The experimental design focused on isolating the effects of different biofuel compositions on engine efficiency and emissions. For the experiments, a four-stroke, single-cylinder engine (Model GR0306/000/038A) with a compression ratio of 21:1 was utilized. This engine type was selected for its commonality in research environments where control over test conditions and simplicity are paramount. The investigation tested four distinct fuel blends: 10% sunflower oil with 90% diesel, 10% olive oil with 90% diesel, 10% corn oil with 90% diesel, and a control sample of 100% pure diesel. These concentrations were chosen to examine the potential of different vegetable oils in replacing or supplementing diesel fuel in practical applications.

Performance testing was conducted at a constant engine speed of 2000 rpm to maintain consistent conditions across all tests. The primary performance metrics evaluated were brake power, thermal efficiency (η_{bth}), and brake specific fuel consumption (BSFC) power measurements provided data on power output decreases, thermal efficiency gauged the engine's ability to convert fuel energy into mechanical energy, and specific fuel consumption assessed the fuel efficiency of each blend. Data collection was integrated with systems that measured fuel consumption, exhaust emissions, and engine output. Analysis focused on comparing the performance of each blend against the pure diesel control. Specific attention was given to quantifying reductions in brake power and thermal efficiency, as well as increases in specific fuel consumption. The experimental setup was carefully structured to ensure the repeatability and reliability of results. Each fuel blend underwent identical testing conditions to isolate fuel composition effects from other variables. Multiple tests run for each fuel type were conducted to verify the consistency of the findings. Through this methodology, the study aims to provide valuable insights into the viability of integrating renewable energy sources into existing diesel engine frameworks, focusing on performance impacts and potential environmental benefits. The results contribute to the broader discussion on sustainable alternatives to conventional diesel fuel.

Experiments were conducted on an Italian-made internal combustion engine, specifically the Prodit GR0306/000/038A model. This single-cylinder, four-stroke engine was coupled with a hydraulic dynamometer mounted on a steel frame to measure engine torque and facilitate load control. The main characteristics of the engine are detailed in Table 1. The engine setup was integrated with several systems, including cooling, fuel, and an instrumentation unit (model GR0306/000/019R), which was positioned adjacent to the engine under test.

Table 1. Specific information and characteristics of the engine.

Engine Type	Prodit SA
Number Of Stroke	Four-Stroke
Cylinders Number	Single-cylinder
Diameter Of Piston	70mm
Length Of Stroke	75mm
Swept volume	541mm3
Compression Ratio	21:1
Cooling System	cooling water
Mechanical efficiency	85%
Max. speed	3500r.p.m

This unit not only housed the instruments necessary for measuring engine performance but also featured a front view displayed in Figure 1. Airflow through the engine was measured using a viscous flow meter located in the GR0329/000/040 instrumentation unit. The fuel mass flow rate was determined by timing the consumption of a preset volume of fuel using a stopwatch and a calibrated 50ml glass tube within the GR0306/000/019R unit. Additionally, the instrumentation setup included gauges for monitoring engine speed, plucks, and the temperatures of cooling water both internally and externally. It also measured the compression ratio and the pressure differential across the intake air nozzle.

Figure 1. A photographic view of the engine.

For the experimental study, fuel samples were meticulously prepared in the laboratory, culminating in four distinct types. The first type was pure diesel, serving as the control with a composition of 100% diesel fuel. The second type was a blend comprising 10% corn oil mixed with 90% diesel. The third type consisted of a 10% sunflower oil and 90% diesel blend. Finally, the fourth type was formulated with 10% olive oil combined with 90% diesel. These fuel models were crucial for evaluating the performance and environmental impacts of biofuel blends compared to traditional diesel. The experiments were conducted using these specially prepared fuel samples, which were also tested and validated. Table 2 presents the properties of the fourth sample, the 10% olive oil and 90% diesel blend, detailing specific characteristics such as viscosity, calorific value, and density which are essential for assessing its suitability and performance as a diesel engine fuel.

Table 2. The characteristics of the fourth sample of diesel fuel.

Test	10% corn oil - 90% diesel blends	10%sunflower oil-90% diesel blends	10% olive Oil-90%diesel blends	Pure diesel fuel
Specific gravity @ 15.6 0C	0.8513	0.8513	0.8513	0.8433
A.P.I	34.6	34.6	34.6	36.3
Flash point 0C	70	77	75	71
Pour point	-9	-9	-9	-9
Viscosity (CST) @40 0C	3.8	3.7	3.8	3.5
Cetane	51.132	50.606	50.606	53

The article encompassed a series of experiments focusing on the operation of four distinct fuel models. The experimental methodology involved initially manually rotating the engine and then gradually increasing its speed. The engine was allowed to warm up by running at a low load until it reached a stable operating condition. This preparatory phase ensured the engine was adequately heated, stabilizing both the fuel temperature and exhaust gas conditions. Experiments were structured to assess engine performance across a variable speed range from 500 to 3000 revolutions per minute (rpm), with increments of 500 rpm. Engine load was regulated using a hydraulic dynamometer, which was critical for maintaining the required operational conditions. Before introducing a new fuel blend, the engine was run for a sufficient period to consume any residual fuel from previous experiments, thereby ensuring clean test conditions.

To accurately determine the engine performance parameters such as brake power, brake specific fuel consumption (BSFC), and thermal brake efficiency, specific mathematical equations are utilized. There are the standard equations used in engine testing for calculating these parameters. In this direction, brake power (BP) is a measure of the actual power output of the engine, accessible at the output shaft. It is calculated using the Eq. (1). Moreover, BSFC is a measure of the fuel efficiency of an engine at producing work. It is defined as the rate of fuel consumption divided by the power produced. BSFC is calculated using the Eq. (2). In thermal brake efficiency (η_{th}). This parameter measures the efficiency with which the engine converts the energy contained in the fuel into mechanical energy at the crankshaft. It is expressed as following Eq. (3). In term of Equation for Heat Release ($\dot{Q}f$). The rate of heat release from the fuel is critical for calculating thermal efficiency and is given by Eq. (4):

$$\text{BP}=\frac{2\pi NT}{60} \quad (1)$$

where N is the engine speed in revolutions per minute (rpm), and T is the torque in Newton meters (Nm).

$$\text{BSFC}=\frac{\dot{m}f}{BP} \quad (2)$$

where $\dot{m}f$ is the mass flow rate of fuel in kilograms per hour (kg/hr), and BP is the brake power in kilowatts (kW).

$$\eta_{\text{th}}=\frac{BP}{\dot{Q}f} \quad (3)$$

where BP is the brake power in kilowatts (kW), and $\dot{Q}f$ is the rate of heat release from the fuel in kilowatts (kW), which can be calculated from the lower heating value of the fuel and the rate of fuel consumption.

$$\dot{Q}f = \dot{m}f * \text{LHV} \quad (4)$$

where $\dot{m}f$ is the mass flow rate of the fuel in kilograms per hour (kg/hr), and LHV is the lower heating value of the fuel in kilojoules per kilogram (kJ/kg).

Baseline tests were performed using 100% diesel to establish a control for comparative analysis. Subsequent tests incorporated various biofuel blends: 10% sunflower oil with 90% diesel, 10% olive oil with 90% diesel, and 10% corn oil with 90% diesel. These blends were tested under identical operating conditions to those of the baseline to facilitate direct comparison. During the experiments, operational conditions were carefully stabilized, and several variables were continuously monitored and recorded. These included the speed and torque of the dynamometer, the time required to consume specific volumes of fuel, pressure drops across the engine system, and the temperature of the exhaust gases. The results from these measurements were meticulously documented, as described in the subsequent tables, providing a comprehensive overview of the performance differentials between the fuel blends and the standard diesel under comparable conditions. In Table 3, the speed of rotation for pure gasoline was altered, resulting in changes to all values of T and $\dot{m}_f$. Table 4 rotated at a different pace, causing a variation in the flow rate of the mixture of 10% corn oil and 90% diesel. Table 5 altered the properties of the T and $\dot{m}_f$. by varying the rotational speed by 10% using a blend of 90% diesel and 10% sunflower oil. Table 6 rotated at a speed of 6 revolutions per minute and underwent a change in rotation speed of 10% when 90% of the olive oil was updated.

Table 3. Changes all of T,$\dot{m}_f$ with the change in rotation speed for pure gasoline.

$\dot{m}$f	T	N
107.844	6.57	500
177078	6.687	1000
253.24	7.571	1500
324.47	8.1	2000
431.45	8.9	2500
. 618.7	10.1	3000

Table 4. Changes all of T,$\dot{m}_f$ with change speed of rotation for10% corn oil -90% diesel.

$\dot{m}$f	T	N
102.217	6.15	500
167.7	6.23	1000
248	7.23	1500
319	7.92	2000
437	8.77	2500
622.2	9.98	3000

Table 5. Changed all of T,$\dot{m}_f$ with change speed of rotation for10% sunflower oil -90% diesel blends.

$\dot{m}_f$	T	N
99.95	52.37	500
145.64	58.59	1000
232.398	65.65	1500
311.96	73.59	2000
391.405	75.84	2500
597.86	92.77	3000

Table 6. Changed all of T,$\dot{m}_f$ with change speed of rotation for10% olive oil -90%.

$\dot{m}_f$	T	N
7.78	41.82	500
137.27	48.616	1000
229.7	63.49	1500
315.4	72.76	2000
383.19	73.3	2500
563	85.40	3000

3. Results and Discussions

Based on the equations previously outlined (Eq. 1 to 4), performance indicators were calculated, taking into account an assumed combustion efficiency of 97%. These calculations facilitated the generation of performance curves that illustrate the relationship between various operational parameters and engine output. The results of these calculations are meticulously compiled in the tables provided. Specifically, Table 7 details the variations in brake power (BP), brake specific fuel consumption (BSFC), and thermal brake efficiency (η_{bth}) in response to changes in the engine's rotational speed when operating on pure diesel. This table allows for a clear visualization of how each performance indicator is affected by the engine speed, providing critical insights into the efficiency and operational characteristics of the engine under different load conditions. This data is essential for optimizing engine performance and making informed decisions about potential adjustments to engine settings or fuel formulations. Moreover, Table 8 indicates the change in each of the BP, BS_{fc}, η_{bth} with change the speed of rotation for 10% corn oil-90% diesel blends. Table 9 presents the change in each of the BP, BSFC, η_{bth} with change the speed of rotation for10% sunflower oil-90% diesel blends. Table 10 demonstrates the change in each of the BP, BSFC, η_{bth} with change the speed of rotation for10% olive oil-90% diesel blends.

Table 7. The variations in brake power, brake specific fuel consumption, and thermal brake efficiency.

BP	BSFC	η_{bth}	N
0.500	1128.6	7.625	500
0.800	914.311	9.828	1000
1.225	771.44	11.501	1500
1.750	675.5	12.4122	2000
2.350	663.5	12.875	2500
3.200	700	12.751	3000

Table 8. The change in each of the BP, BSFC, η_{bth} with change the speed of rotation for10% corn oil-90% diesel blends.

BP	BSFC	η_{bth}	N
0.4112	1142.8	7.500	500
0.750	928.80	9.875	1000
1.200	785.94	11.360	1500
1.720	696.00	11.375	2000
2.3175	685.70	12.800	2500
3.115	714.28	12.740	3000

Table 9. The change in each of the BP, BS_{fc}, η_{bth} with change the speed of rotation for10% sunflower oil -90% diesel blends.

BP	BSFC	η_{bth}	N
0.311	1157.08	7.375	500
0.700	943.08	9.312	1000
1.100	800.20	10.625	1500
1.66	718.71	11.523	2000
2.2425	699.98	11.875	2500
3.015	730.72	11.751	3000

Table 10. The change in each of the BP, BSFC, η_{bth} with change the speed of rotation for10%olive oil -90% diesel blends.

BP	BSFC	η_{bth}	N
0.222	1172.20	7.000	500
0.600	957.52	8.754	1000
1.060	815.71	10.251	1500
1.5800	734.98	11.211	2000
2.2125	714.26	11.275	2500
2.990	744.98	11.911	3000

The experimental studies on the GR0306/000/038A engine, utilizing unaltered configurations and fueled with four distinct blends, analyzed key performance metrics such as brake power, brake thermal efficiency, and brake fuel consumption across various engine speeds. Figure 2 illustrates the relationship between brake power and engine speed for the four tested fuel samples: 10% olive oil-90% diesel blend, 10% sunflower oil-90% diesel blend, 10% corn oil-90% diesel blend, and pure diesel. The graph unequivocally shows that for all fuel types, brake power tends to increase as the engine speed rises. However, it also highlights a decline in brake power at an engine speed of 2000 r.p.m, where the blends show reductions of 7.4%, 5.2%, and 1.3% for the olive oil, sunflower oil, and corn oil blends, respectively, compared to pure diesel.

This decrease in brake power is attributed primarily to the lowered air-fuel mixture temperature at the start of the combustion stroke, which is a consequence of the reduced lower heating value of the vegetable oil-diesel blends. This results in a decrease in the combustion temperature. Additionally, the higher viscosity of the oil-diesel blends adversely affects the fuel spray characteristics during injection, potentially delaying the combustion process. Furthermore, the lower cetane number of the blends contributes to increased ignition delay, further reducing brake power for all vegetable oil-diesel blends.

Figure 3 presents the brake thermal efficiency (η_{bth}) for the same fuel blends at varying engine speeds. This figure provides a comparative view of how each fuel's efficiency behaves in response to changes in engine speed, offering insights into the thermal performance dynamics under different operational conditions. This data is crucial for understanding the energy conversion efficiency of each blend, highlighting the trade-offs between environmental benefits and performance drawbacks associated with using alternative fuels in diesel engines.

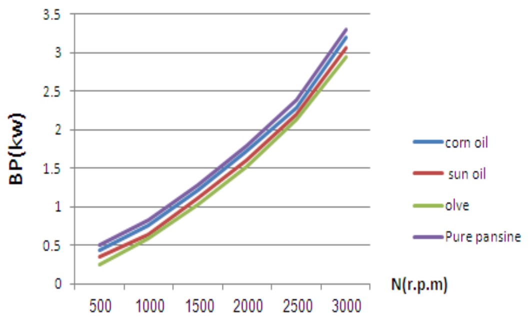

Figure 2. The relationship between the break power with the rotational speed of the pure fuel.

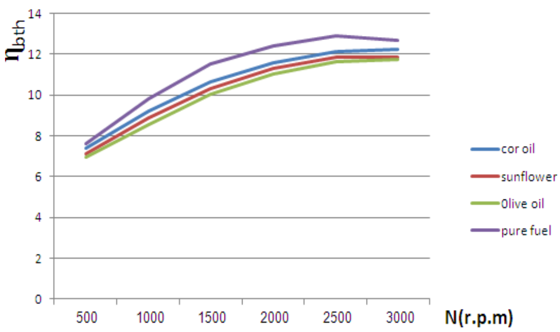

Figure 3. The effect of fuel blends types on the brake thermal efficiency at difference speeds.

The analysis unequivocally demonstrates that brake thermal efficiency η_{bth} escalates concomitantly with an increase in engine speed across all tested fuels. Conversely, there is a discernible decrement in ηbth when employing vegetable oil-diesel blends compared to pure diesel at an engine velocity of 2500 r.p.m. The decrements are quantified as 10.9% for 10% olive oil-90% diesel blends, 7.5% for 10% sunflower oil-90% diesel blends, and 5.8% for 10% corn oil-90% diesel blends. This decline in η_{bth} for the blends can be primarily ascribed to the diminished brake power output observed in these vegetable oil-diesel combinations. Such reduction in power efficacy is further attributable to a marginal elevation in BSFC, suggesting a lower conversion efficiency of fuel to usable power. Figure 4 delineates BSFC as a function of speed, examining four sample fuels: 10% olive oil-90% diesel, 10% sunflower oil-90% diesel, 10% corn oil-90% diesel blends, and pure diesel.

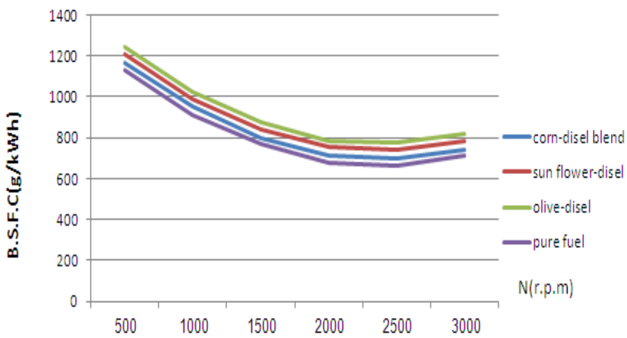

Figure 4. The effect of fuel blends types on the BSFC at difference speeds.

The depicted data reveals that brake specific fuel consumption (BSFC) escalates as engine speed diminishes, reaching a nadir at 2000 revolutions per minute (r.p.m.) before increasing with further speed augmentation across all fuel blends. Concurrently, BSFC exhibits increment of 7.9%, 5.7%, and 2.4% for 10% olive oil-90% diesel blends, 10% sunflower oil-90% diesel blends, and 10% corn oil-90% diesel blends, respectively, when compared to pure diesel fuel. This observed trend is rationalized by the fact that engines require greater fuel volumes to generate equivalent power outputs with fuel blends than with pure diesel. This increased consumption is attributable to the lower heating value of the fuel blends, which in turn escalates BSFC. At these particular operational conditions, the viscosity differential between the vegetable oil-diesel blends and pure diesel is notable, with the blends exhibiting approximately ten times the viscosity of standard diesel fuel. Consequently, diesel demonstrates a lower BSFC relative to the raw vegetable oil-diesel blends. The results suggest that the overall combustion rate of the vegetable oils is moderately slower compared to that of diesel fuel, which further contributes to the observed differences in BS_{fc} and efficiency across the tested fuel types.

4. Conclusion

The article of diesel engine performance utilizing different vegetable oil-diesel blends reveals key insights into their efficiency and effectiveness as alternative fuels. The results indicate notable differences in engine performance metrics such as brake power, brake specific fuel consumption (BSFC), and brake thermal efficiency when using these blends compared to pure diesel.

- Brake Power Reduction:

The inclusion of vegetable oils (10% olive oil, 10% sunflower oil, and 10% corn oil blended with 90% diesel) results in a decrease in brake power. This reduction is attributed to the higher heat of vaporization and the lower cetane number of the blends, which increases the ignition delay. Among the blends, the 10% corn oil-90% diesel blend exhibits relatively better performance than the sunflower oil blend, while the olive oil blend shows the least brake power and exhaust temperature.

- Increase in Brake Specific Fuel Consumption:

BSFC is observed to increase across all oil-diesel blends due to the reduced lower heating value of the blends. This necessitates higher fuel consumption to achieve similar power outputs as pure diesel, effectively increasing the BSFC. Here again, the 10% corn oil-90% diesel blend performs better in comparison to the sunflower oil blend, with the olive oil blend showing the highest BSFC.

- Decline in Brake Thermal Efficiency:

The blends also show a decrease in brake thermal efficiency, which can be linked to the elevated BSFC and reduced combustion temperatures. Consistently, the 10% corn oil-90% diesel blend outperforms the sunflower blend in thermal efficiency, whereas the olive oil blend ranks lowest, compounded by its lower brake power and slight increases in BSFC and reductions in exhaust temperature and air-fuel ratio.

- Overall Engine Performance:

Comparatively, the 10% corn oil-90% diesel blend shows a better overall engine performance than the sunflower and olive oil blends. Although pure vegetable oils have potential as alternative energy sources, their high viscosity at room temperature poses challenges for direct use in diesel engines. This study highlights the corn oil blend as the most viable among the tested options, combining relatively better efficiency and performance metrics.

In conclusion, while vegetable oil-diesel blends can serve as feasible alternatives to pure diesel, variations in their compositions impact engine performance differently. The corn oil blend, in particular, demonstrates a superior balance of reduced BSFC and preserved power and efficiency, suggesting its potential viability for broader use in diesel engines. The findings underscore the importance of optimizing blend compositions to enhance overall engine performance while considering environmental and economic impacts.

ORCID
Nabil M. Muhaisen https://orcid.org/0009-0003-3008-7338
Mustafa M. Graisa https://orcid.org/0000-0002-5767-4378

References

[1] S. Sagin, S. Karianskyi, V. Madey, A. Sagin, T. Stoliaryk, and I. Tkachenko, "Impact of biofuel on the environmental and economic performance of marine diesel engines," *J. Mar. Sci. Eng.*, vol. 11, no. 1, p. 120, 2023. [Google Scholar]

[2] C. Jin *et al.*, "Effect of nanoparticles on diesel engines driven by biodiesel and its blends: A review of 10 years of research," *Energy Convers. Manag.*, vol. 291, no. 117276, p. 117276, 2023. [Google Scholar]

[3] A. M. Ansari, L. A. Memon, M. T. Ghannam, and M. Y. E. Selim, “Impact of biodiesel blended fuel with nanoparticles on performance and noise emission in compression ignition engine,” *International Journal of Thermofluids*, vol. 19, no. 100390, p. 100390, 2023. [Google Scholar]

[4] J. Liu, X. Zhang, C. Tang, L. Wang, P. Sun, and P. Wang, “Effects of palm oil biodiesel addition on exhaust emissions and particle physicochemical characteristics of a common-rail diesel engine,” *Fuel Process. Technol.*, vol. 241, no. 107606, p. 107606, 2023. [Google Scholar]

[5] A. Ashfaque *et al.*, “Impact of biodiesel on engine performance and emission,” *Mater. Today*, 2023. [Google Scholar]

[6] H. A. Allami, H. Nayebzadeh, and S. Motamedi, “The effect of biodiesel production method on its combustion behavior in an agricultural tractor engine,” *Environ. Sci. Pollut. Res. Int.*, vol. 30, no. 3, pp. 5955–5972, 2023. [Google Scholar]

[7] A. S. Mohammed, S. M. Atnaw, A. V. Ramaya, and G. Alemayehu, “A comprehensive review on the effect of ethers, antioxidants, and cetane improver additives on biodiesel-diesel blend in CI engine performance and emission characteristics,” *J. Energy Inst.*, vol. 108, no. 101227, p. 101227, 2023. [Google Scholar]

[8] M. El-Adawy, “Effects of diesel-biodiesel fuel blends doped with zinc oxide nanoparticles on performance and combustion attributes of a diesel engine,” *Alex. Eng. J.*, vol. 80, pp. 269–281, 2023. [Google Scholar]

[9] K. Kheiralipour, M. Khoobbakht, and M. Karimi, “Effect of biodiesel on environmental impacts of diesel mechanical power generation by life cycle assessment,” *Energy (Oxf.)*, vol. 289, no. 129948, p. 129948, 2024. [Google Scholar]

[10] A. Mohite *et al.*, “Performance enhancement and emission control through adjustment of operating parameters of a biogas-biodiesel dual fuel diesel engine: An experimental and statistical study with biogas as a hydrogen carrier,” *Int. J. Hydrogen Energy*, vol. 52, pp. 752–764, 2024. [Google Scholar]

[11] S. V. Sagin *et al.*, “Use of biofuels in marine diesel engines for sustainable and safe maritime transport,” *Renew. Energy*, vol. 224, no. 120221, p. 120221, 2024. [Google Scholar]