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* **Corresponding author**.

raju@chaitanya.edu.in

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Experimental Investigation on Performance Characteristics o f Diesel Engine Using Various Blended Biodiesels

B Mohan[1], S Raju[2]*, M Srinivasnaik[3]

1 Professor, Department of Mechanical Engineering,, Chaitanya Deemed to be University, Hyderabad, Telangana, India
2 Research scholars, Department of Mechanical Engineering, Chaitanya Deemed to be university, Hyderabad, Telangana, India
3 Associate professor, Department of Mechanical Engineering, Jawaharlal Nehru University, New Delhi, New Delhi, India

Abstract

Objectives: To evaluate the performance characteristics of diesel engines through experimental research with various biodiesel blends. **Method:** Three types of oils were chosen for this study: waste cooking oil, waste chicken oil, and palm oil. The methyl esters were produced from waste chicken oil (COME), waste cooking oil (WCOME), and palm oil (POME). The test runs were done on a 4.5 kW direct injection, air-cooled, four-stroke, single-cylinder, and constant-speed diesel engine using varied fuel at maximum load. **Findings:** This study finds performance analysis for a variety of methyl esters and diesel. The Brake Thermal Efficiency (BTE) was found to be: for Diesel (33.36%), POME (30.53%), WCOME (27.5%), COME (25.0%) at rated power (4.5) K.W. The brake thermal efficiency for palm oil methyl esters is similar to the diesel compared to the other methyl esters. **Novelty:** This research study provides a comparison between the diesel and methyl esters of break thermal efficiency for diesel engines.

Keywords: Diesel Engine; Trans esterification; Biodiesels; Performance characteristics

1 Introduction

Biodiesel is a renewable fuel that can be used to reduce the consumption of petroleum-based fuels and perhaps lessen the overall greenhouse gas emissions of internal combustion engines. In an attempt to lower emissions, researchers that are looking into vegetable oils as a fuel substitute for diesel engines have focused their efforts in this area[(1)],[(2)]. The use of vegetable oils and their derivatives as substitute fuels for diesel engines has been extensively studied. Vegetable oils are often investigated for their potential as diesel engine fuels. The majority of vegetable oils have demonstrated encouraging results in short-term engine performance tests[(3)]. However, longer endurance tests reveal the existence of some problems, such as gum formation, ring sticking, injector cocking, and lubricant thickening. Certain problems have been connected to vegetable oils because of their high viscosity and non-volatility [4]. High fuel viscosity and inadequate atomization patterns lead to low combustion quality. The lubricating oil may get contaminated with unburned fuel as a result, and deposits in the combustion chamber may grow. In an experiment to improve the efficiency of dual engines running on natural gas/LPG. [5] Used pilot fuel derived from jojoba seeds. Increased knocking limit, reduced cyclic variability of combustion, reduced noise during combustion, and improved performance of dual fuel engines were determined to be the benefits of jojoba fuel's enhanced attributes. In order to evaluate and compare the use of soybean oil, sunflower oil, cottonseed oil, and the corresponding methyl esters. [6,7]. The result states that all assessed vegetable oil or biodiesel blends can be used in a safe manner. [8] Carried out an experimental study to assess the properties, effectiveness, and emissions of several blends (B20, B40, B60, B80, and B40) of methyl ester of palm oil (POME), waste cooking (WCOME), and waste chicken (CME) with pure diesel. The results indicated that pure diesel mixes had reduced reasonable efficiency. Conducted an experiment utilizing mixes of methyl esters of palm oil and diesel fuel to examine the performance of diesel engines. Blends of methyl esters up to 100% were able to obtain acceptable brake thermal efficiency.

Objectives

1. Preparing biodiesel from waste cocking oil, chicken oil and palm oil.
2. Testing the chemical properties of prepared biodiesels.
3. Comparison of BTE between diesel and blended biodiesels.

Advant ages of Biodiesel

1. Reduced Emissions
2. Improved Lubricity
3. Renewable and Sustainable
4. Compatibility with Existing Engines
5. Flexibility in Fuel Blending

2 Methodology

The experimental setup consists of four-stroke, single-cylinder diesel engines. Measuring the in-cylinder combustion pressure in relation to the crank angle, the pressure sensor is fixed to the cylinder head, which is exposed to the combustion chamber. On the crank shaft, an encoder was mounted in order to measure the crank angle. The engine was loaded using an eddy current dynamometer. Using the data gathering system, the pressure-crank angle data were gathered and then examined. Static injection time and engine speed (1500 rpm) were constant throughout the testing.

Fig 1. Four Stroke Single Cylinder Diesel Engine

Table 1. Specification of Diesel Engine

Engine	Kirloskar diesel engine
Speed	1500 rpm
Number Of Cylinders	1
Compression Ratio	16.5:1
Orifice Meter	20mm
Maximum H.P	7 H.P
Stroke	110mm
Bore	80mm
Type	Water cooled
Method of loading	Rope brake

A diesel engine with a single cylinder and four strokes may have different specifications depending on its intended use and design, as shown in Table 1. Knowing these specs makes it easier to choose the right engine for a certain application, ensuring that it satisfies performance standards while taking into account variables like environmental effect, efficiency, and dependability.

Table 2. Properties of Neat Oils

PROPERTY	PALM OIL	WASTE COOKING OIL	WASTE CHICKEN OIL	DIESEL
Density at 15 0 (Kg/M^3)	918	870	926	850
Kinematic viscosity at 40^0(Mm^2 /Sec)	39.6	5.03	38.10	3.5
Calorific Value (KJ/Kg)	36220	36940	35560	42800
Flash point (^{0} C)	267	164	208	56
Fire point (^{0} C)	296	160	220	63

Table 2 is a brief explanation of the properties of oils. By exploiting these properties effectively, industries can optimize combustion processes, improve energy efficiency, reduce emissions, and enhance overall system performance. Advances in combustion technology and fuel formulation continue to offer opportunities for further efficiency gains and environmental benefits.

Table 3. Properties of Oils after Transterification

Property	Palm oil ME	Waste cooking ME	Waste Chicken Oil Me
Density at 15 0 (Kg/M^3)	880	885	874
Kinematic viscosity at 40^0(Mm^2 /Sec)	6.2	5.7	5.27
Calorific Value (KJ/Kg)	38050	38650	39174
Flash point (^{0} C)	164	160	174
Fire point (^{0} C)	171	164	190

Table 3 is a brief explanation of the properties of different methyl ester oils. Methyl esters, also referred to as biodiesel when made from vegetable or animal fats, have unique qualities that can be used to good use in a variety of contexts. Methyl esters can be used in a variety of applications, including power production, transportation, and heating, to meet regulatory criteria and achieve environmental sustainability, energy security, and regulatory compliance. The performance and suitability of methyl esters as a renewable fuel alternative are intended to be further improved by ongoing research and technical developments.

3 Results and Discusssion

3.1Performance and Emission Characteristics

The main factors that determine whether a fuel is appropriate are the characteristics of engine performance. The purpose of this study is to assess the methyl ester-diesel blends' brake thermal efficiency (BTE).

3.1.1 Brake Thermal Efficiency (BTE) For Palm Oil Methyl Esters with Diesel

Figure 2 displays the variances in brake thermal efficiency for the several test fuels used by POME. At all load levels, it was discovered that the braking thermal efficiency of POME blends was inferior to that of diesel. For example, at rated power (4.5 kW), diesel, 20% POME, 40% POME, 60% POME, 80% POME, and 100% POME had brake thermal efficiencies of 34.112%, 32.68% (0.56%), 31.877% (2%), 31.852% (2.14%), 30.87% (2.49%), and 30.53% (3.99), respectively. The mixes of palm oil methyl esters have lower braking thermal efficiency than diesel, as indicated by the figures in brackets. In comparison to diesel, the highest drop for different blends of POME at rated power is only 3.99%. Due to improved combustion chamber spray characteristics that allowed the fuel to burn completely, B20's efficiency is more comparable to that of diesel. Because of their weak spray properties and increased viscosity, brake thermal efficiency decreases as concentration increases. The fuel's lower calorific value contributes to the reduced brake thermal efficiency.

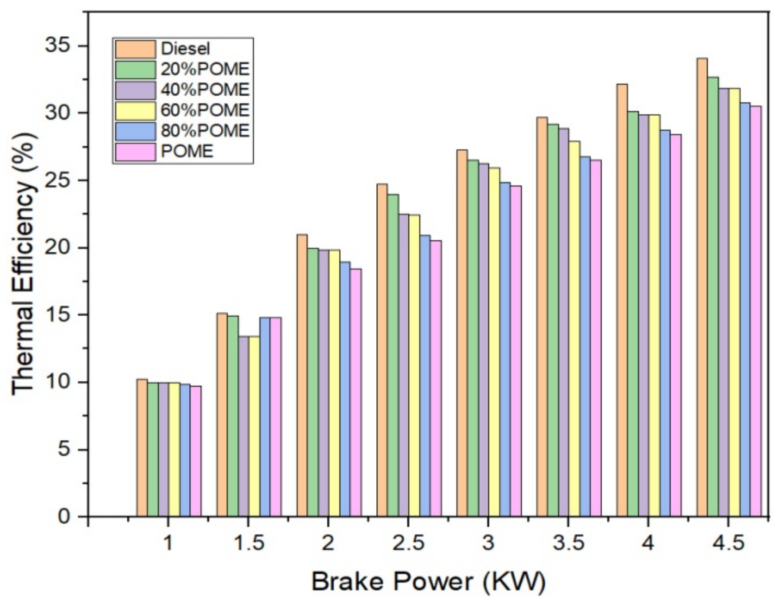

Fig 2. Comparison of brake thermal Efficiency for POME blends/diesel

3.1.2 Brake Thermal Efficiency (BTE) For Chicken Methyl Esters with Diesel

Figure 3 displays the changes in brake thermal efficiency for the several test fuels used in Chicken ME. At all load levels, it was discovered that the brake thermal efficiency of Chicken ME mixes was inferior to that of diesel. Specifically, at rated power (4.5 kW), diesel, 20%, 40%, 60%, 80%, and 100% chicken ME had brake thermal efficiencies of 33.47%, 32.96% (0.56%), 31.64% (2%), 31.26% (2.14%), 30.26% (2.49%), and 28.53% (3.99), respectively. The mixes of chicken methyl esters have lower braking thermal efficiency than diesel, as indicated by the figures in brackets. When comparing several blends of chicken ME at rated power to diesel, the highest drop is only 3.99%. Because of the improved spray characteristics in the combustion chamber that led to full combustion of the B20, the efficiency is more like that of diesel. Because of their weak spray properties and increased viscosity, brake thermal efficiency decreases as concentration increases. The fuel's lower calorific value contributes to the reduced brake thermal efficiency.

3.1.3 Brake Thermal Efficiency (BTE) For Waste Cooking Oil Methyl Esters with Diesel

Figure 4 displays the variances in brake thermal efficiency for the several test fuels used in the WCOME. At all load levels, it was discovered that the braking thermal efficiency of WCOME mixes was inferior to that of diesel. For example, at rated power (4.5 kW), diesel, 20% WCOME, 40% WCOME, 60% WCOME, 80% WCOME, and 100% WCOME had brake thermal efficiencies of 33.47%, 33% (0.56%), 28.07% (2%), 28.05% (2.14%), 29.37% (2.49%), and 27.67% (3.99), respectively. When comparing

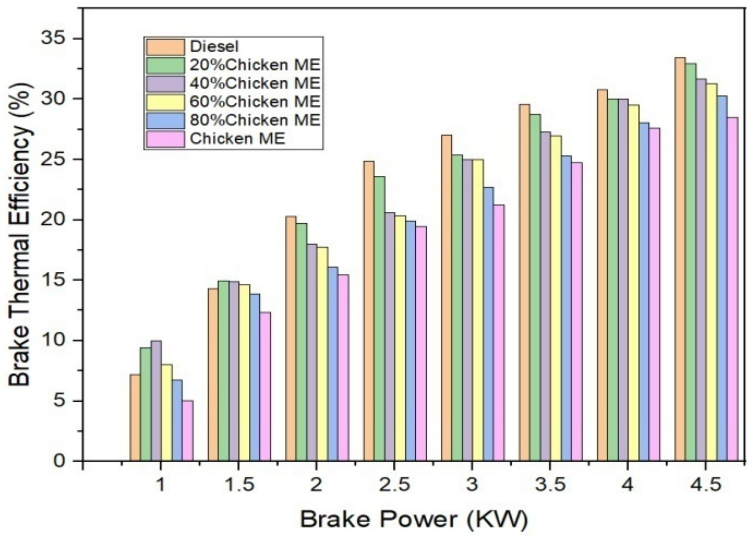

Fig 3. Comparison of brake thermal efficiency for Chicken ME blends/diesel

blends of waste cooking oil methyl esters to diesel, the figures in brackets demonstrate the decrease in brake thermal efficiency. In comparison to diesel, the highest drop for different blends of WCOME at rated power is only 3.99%. Since the fuel was completely burned due to improved spray characteristics in the combustion chamber, B20's efficiency is more comparable to that of diesel. Because of their weak spray properties and increased viscosity, brake thermal efficiency decreases as concentration increases. The fuel's lower calorific value contributes to the reduced brake thermal efficiency.

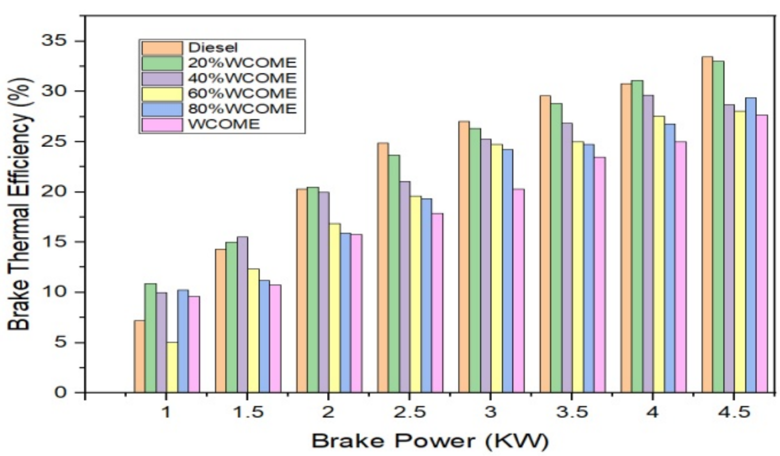

Fig 4. Comparison of brake thermal Efficiency for WCOME blends/diesel

3.1.4 Comparison of Brake Thermal Efficiency (BTE) for All Methyl Esters with Diesel

Figure 5 displays the braking thermal efficiency of the different test fuels. At all load levels, it was discovered that the braking thermal efficiency of different methyl esters was lower than that of diesel. POME's braking thermal efficiency is higher than WCOME's and Chicken ME's at rated power (4.5 kW). POME is similar to the diesel compared to the other methyl esters.

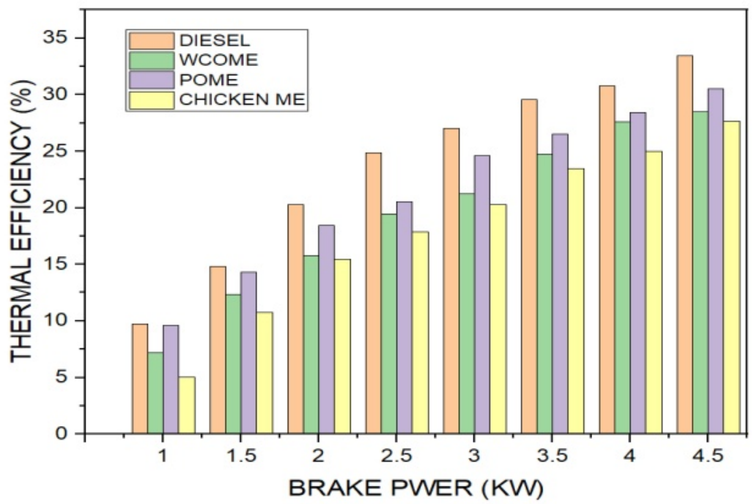

Fig 5. Brake Power Vs Brake Thermal Efficiency for all methyl esters/dies

4 Conclusion

The current study anticipates how well methyl esters would burn, function, and emit when utilized in C.I. engines and outlines the method for producing them from edible oils and non-edible oils. This study looks at using biodiesel and diesel blends made from several types of oil, such as palm, waste chicken oil, and waste cooking oil, as substitute fuel for diesel engines. Without modifying the engine, diesel engines can utilize palm oil, waste chicken, and waste cooking methyl esters. Brake thermal efficiency of B20 is good compared to other blends. In this investigation, diesel (33.36%), waste cooking oil (27.5%), chicken methyl (25.0%), and palm oil (30.53%) were examined. At full braking power, the brake thermal efficiency of the palm oil is similar to diesel.

References

1) Ağbulut Ü. Turkey's electricity generation problem and nuclear energy policy. *Energy sources*. 2019;41:2281–2298. Available from: https://doi.org/10.1080/15567036.2019.1587107.
2) Kesharvani S, Dwivedi G, Nathverma T, Verma P. The Experimental Investigation of a Diesel Engine Using Ternary Blends of Algae Biodiesel. *Ethanol and Diesel Fuels Energies*. 2023;16:229–229. Available from: https://doi.org/10.3390/en16010229.
3) Dugala NS, Goindi GS, Sharma A. Experimental investigations on the performance and emissions characteristics of dual biodiesel blends on a varying compression ratio diesel engine. *SN Applied Science*. 2022;3(662). Available from: https://doi.org/10.1007/s42452-021-04618-0.
4) Magesh N, Pushparaj T, Kannan T, Vinoth V, Thakur, Deepak, et al. Experimental Investigation and Prediction of Performance, Combustion, and Emission Features of a Diesel Engine Fuelled with Pumpkin-Maize Biodiesel using Different Machine Learning Algorithms. *Mathematical Problems in Engineering*. 2022;9505424:1–17. Available from: https://doi.org/10.1155/2022/9505424.
5) Mehta B, Subhedar D, Patel G, Swarnkar A. Experimental investigation of performance and emission characteristics of diesel engine with use of rape seed oil as biodiesel. *IOP Conference Series: Materials Science and Engineering*. 2020. Available from: https://doi.org/10.1088/1757-899X/872/1/012093.
6) Azad AK. Introduction to sustainable and alternative ecofuels. In: and others, editor. Advances in Eco-Fuels for a Sustainable Environment. 2019;p. 211–236. Available from: https://doi.org/10.1016/C2017-0-04211-8.
7) Azad AK, Doppalapudi AT, Khan MMK, Hassan NMS, Gudimetla P. A landscape review on biodiesel combustion strategies to reduce emission. *Energy Reports*. 2023;9:4413–4436. Available from: https://doi.org/10.1016/j.egyr.2023.03.104.
8) Ayoob AK, Fadhil AB. Valorization of waste tires in the synthesis of an effective carbon based catalyst for biodiesel production from a mixture of non-edible oils. *Fuel*. 116754;2020. Available from: https://doi.org/10.1016/j.fuel.2019.116754.