Open Access Research Journal of
Science and Technology
Journals home page: https://oarjst.com/
ISSN: 2782-9960 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(Research Article)

Check for updates

# Experimental investigation on brake performance and efficiency of CI engine using algae biodiesel blends

Ganesh Nagane [1,]*, Prashant Singh [2] and Manish Deshmukh [3]

[1] *Research Scholar, Bir Tikendrajit University, Manipur, India & Lecturer, AISSMS Polytechnic, Pune, India.*
[2] *Department of Mechanical Engineering, Bir Tikendrajit University, Manipur, India.*
[3] *Department of Mechanical Engineering, AISSMS College of Engineering, Pune, Maharashtra, India.*

Open Access Research Journal of Science and Technology, 2026, 17(01), 007-013

Publication history: Received on 01 April 2026; revised on 09 May 2026; accepted on 12 May 2026

Article DOI: https://doi.org/10.53022/oarjst.2026.17.1.0051

## Abstract

The rising global consumption of petroleum fuels, coupled with limitations in their extraction, has resulted in a noticeable increase in fuel prices per liter. In addition, concerns about their environmental impact are restricting their continued use. This situation highlights the need for an alternative fuel source that can offer a comprehensive solution. Biodiesel is one such alternative that has been widely researched. However, producing biodiesel from oilseeds is constrained by the displacement of agricultural land. In contrast, biodiesel derived from algae presents a promising option. Since algae can be cultivated in ponds, it does not require cropland, and its yield is higher than that of conventional oilseeds.

The present study focuses on evaluating the performance of a diesel engine using algae oil as fuel. To make the oil suitable for engine application, blends of algae oil with petroleum diesel were prepared. The properties of algae oil and its blends were tested and compared with those of neat diesel. It was observed that the properties of neat algae oil and its blends are very similar to those of neat diesel. Moreover, the calorific value of the algae oil blends is also comparable to that of neat diesel. The test results are encouraging and align with the objectives of this study.

This work further proposes to investigate the performance of algae oil and its blends in a diesel engine by studying various performance parameters and comparing the results with those obtained using neat diesel.

**Keywords:** Algae Biodiesel,;Biodiesel Blends; Brake Power; Emissions; Specific Fuel Consumption

## 1. Introduction

India is one of the fastest-growing markets in the world, and the country's economic development is driving increased energy consumption across all major sectors. This growth has made India the fourth-largest consumer of primary energy and petroleum. Since the nation has limited conventional energy resources, there is a strong need to explore indigenous alternatives. Biodiesel has long been studied as a promising substitute for conventional fuels.

Being an agricultural country, India has adequate raw materials to produce biodiesel from both edible and non-edible oilseeds. However, concerns related to food security may limit biodiesel production to non-edible sources. Oils such as jatropha, rapeseed, soybean, palm, and sunflower are commonly used for biodiesel production. In addition to oilseeds, animal fats can also serve as feedstock for biodiesel.

Although oilseeds are a common source for biodiesel production, their cultivation is associated with the issue of cropland displacement. The land used for growing these oilseeds may otherwise be used for cultivating edible crops. As a result, the availability of land for food production could decrease, leading to reduced edible oil output and higher

* Corresponding author: Ganesh Nagane

prices. Producing biodiesel from microalgae offers a comprehensive solution to this problem. Since microalgae can be cultivated in ponds or bioreactors, the displacement of cropland can be avoided. Furthermore, microalgae provide higher yields compared to traditional oilseeds, making them an attractive alternative source for biodiesel production.

## 2. Overview of algae biodiesel

Algae are unicellular or multicellular organisms that photosynthesize, but lack the features such as leaves, roots, seeds and flowers. They can commonly be found in aquatic—both freshwater and marine—environments. The microalgae can be grown in both open-culture systems such as ponds, lakes and raceways, or in highly controlled closed- culture systems like photo bioreactors, similar to those used in commercial fermentation processes. The photosynthetic growth of micro algal biomass requires light, carbon dioxide, water, organic salts and temperature of 20- 30 °C. Cultivating algae in an open system is most economical, as it requires least expenses. But the biomass produced in such an open system is limited and to increase the yield, a closed culture system can be used.

The algal oil is found inside plant cells, linked with proteins and a wide range of carbohydrates like starch, cellulose, hemi-cellulose and pectin. The cell content is surrounded by a rather thick wall which has to be opened so the protein and oil can be released. Various methods are available for the extraction of algal oil, such as mechanical extraction with hydraulic or screw, enzymatic extraction, chemical extraction through different organic solvents, Ultrasonic extraction and supercritical extraction using carbon dioxide.

Biodiesel can be produced by transesterification of algal oil. Transesterification is the reversible reaction of fat or oil (which is composed of triglyceride) with an alcohol to form fatty acid alkyl ester and glycerol. The reaction occurs stepwise: triglycerides are first converted to diglycerides, then to monoglycerides and finally to glycerol [18].

Microalgae are capable of synthesizing more oil per acre than the terrestrial plants as they can double their biomass within 24 hrs [19]. Hence using microalgae to produce biodiesel will not compromise production of food, fodder and other products derived from crops.

## 3. Experimental setup

In the present work, the performance of different blends of diesel-biodiesel is studied in diesel engine. For this purpose, different blends of petroleum diesel and biodiesel were prepared and named B00, B10, B20 and B30. Here, B00 is neat diesel and is used to compare the performance of biodiesel. B10, B20 and B30 are the blends of diesel and algae biodiesel where algae biodiesel is mixed with diesel in proportion of 10%, 20% and 30% respectively by volume. In order to characterize, the properties of bends were studied and compared with diesel. It is found that the properties of algae biodiesel-diesel blend are very close to the properties of petroleum diesel.

The engine used for the experimentation is Kirloskar single cylinder diesel engine. Being a VCR engine, the compression ratio can be varied between 12 and 18. The hydraulic dynamometer is used to apply the load on the engine output shaft. A data acquisition system is used to collect various parameters of the engine.

The experimental investigation was carried out using a Kirloskar TV1 single-cylinder diesel engine. A hydraulic dynamometer was employed to apply load to the engine output shaft. Various engine parameters were recorded using a data acquisition system, and the collected data were analyzed with the help of “Engine Soft” software. Exhaust emissions were measured using an AVL Digas 444 five-gas analyzer.

**Table 1** Engine Specifications

| **Parameter** | **Specification** |
|---|---|
| Engine Make | Kirloskar TV1 VCR Engine |
| Number of Cylinders | 1 |
| Cycle | 4 Stroke |
| Rated Power | 3.5 kW at 1500 rpm |
| Cylinder Diameter | 87.5 mm |

| | |
|---|---|
| Stroke Length | 110 mm |
| Connecting Rod Length | 234 mm |
| Compression Ratio | 12 to 18 |
| Cooling Medium | Water Cooling |

## 4. Results and discussion

### 4.1. Effect of Biodiesel Properties

**Table 2** Properties of diesel-biodiesel blends

| Sr. | Test parameter | B00 | B10 | B20 | B30 |
|---|---|---|---|---|---|
| 1 | Density (gm/cc) | 0.834 | 0.801 | 0.803 | 0.807 |
| 2 | Viscosity (Cst) | 2-4.5 | 2.70 | 2.90 | 3.10 |
| 3 | Calorific value(MJ/Kg) | 45.20 | 42.40 | 42.00 | 41.70 |
| 4 | Cetane Number | 46 (min.) | 47 | 49 | 52 |
| 5 | Flash Point ($^oC$) | 55 (min.) | 78 | 86 | 94 |

*4.1.1. Density*

Density is the measure of mass per unit volume of a material. Biodiesels, in general, are characterized by higher densities than conventional petroleum diesel. This means, volumetrically operating fuel pumps will inject greater mass of fuel. This will affect the air fuel ratio of the engine [14].In present study, density of biodiesel blends is found to be increasing with the increase in blend ratio.

*4.1.2. Viscosity*

It is a measure of internal resistance to flow of a fluid. Higher viscosity of fuel enhances fuel spray penetration and thus improves air fuel mixing [38]. However fuel with higher viscosities cannot be used safely in compression ignition engines [14]. It is seen that the viscosity of the blend increases with an increase in the blending ratio. This limits the blending ratio of diesel and biodiesel.

*4.1.3. Calorific Value*

Calorific value is the measure of heat content of fluid or fuel. It is very well established that, calorific value of biodiesel is lower than petroleum diesel. The same is observed in the study. This also reduces the calorific value of biodiesel blends. This, in turn, means that more fuel will have to be consumed for getting the same work output from an engine which is using petroleum diesel. This will increase the specific heat consumption and may lower the torque and power output of the engine.

*4.1.4. Cetane Number*

Cetane number is one of the most important characteristics of fuel. It is a dimensionless number and indicates the ignitability of the fuel [14]. Higher cetane number of fuel promotes faster auto ignition of fuel and reduces the emissions of nitrogen oxides [14]. Cetane number of biodiesel blends in present study is found to be higher than diesel, which creates a possibility of better combustion and knock free working of the engine.

### 4.2. Torque

The Engine was tested for different compression ratios and different loads. The result shows minimal variation in torque for different biodiesel blends as compared to diesel. At lower loads, torque produced by biodiesel blends is closely similar to the torque produced by diesel. Whereas at higher loads, biodiesel blends show improvement in torque. Fig. 3 shows the torque variation for diesel and biodiesel blends.

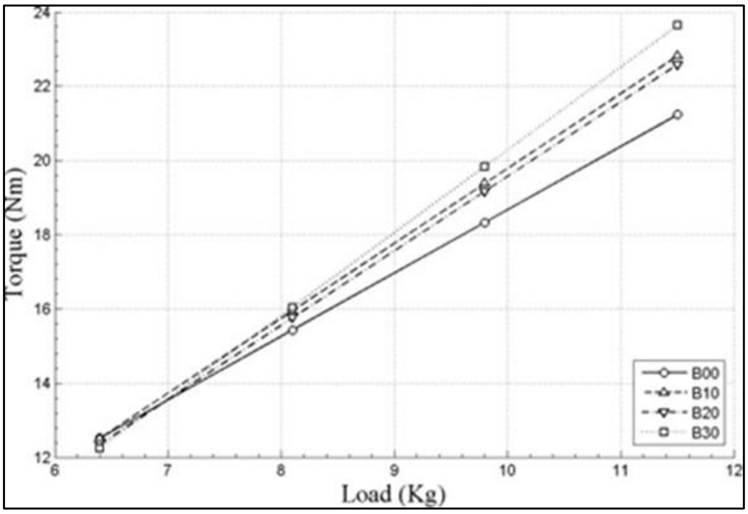


**Figure 3** Torque Vs Load

### 4.3. Brake Power

It can be seen that there is a minor effect of blending on brake power as compared to diesel. The variation lies within 6%.This may be because of lower calorific value of biodiesel. Brake power slightly decreases for biodiesel blends at lower loads, but shows improvement at higher loads. Biodiesel blends show better performance than diesel at higher loads. Fig. 4 shows variation in brake power with increasing load. It can be observed, at higher load and higher compression ratio, biodiesel blends show better performance.

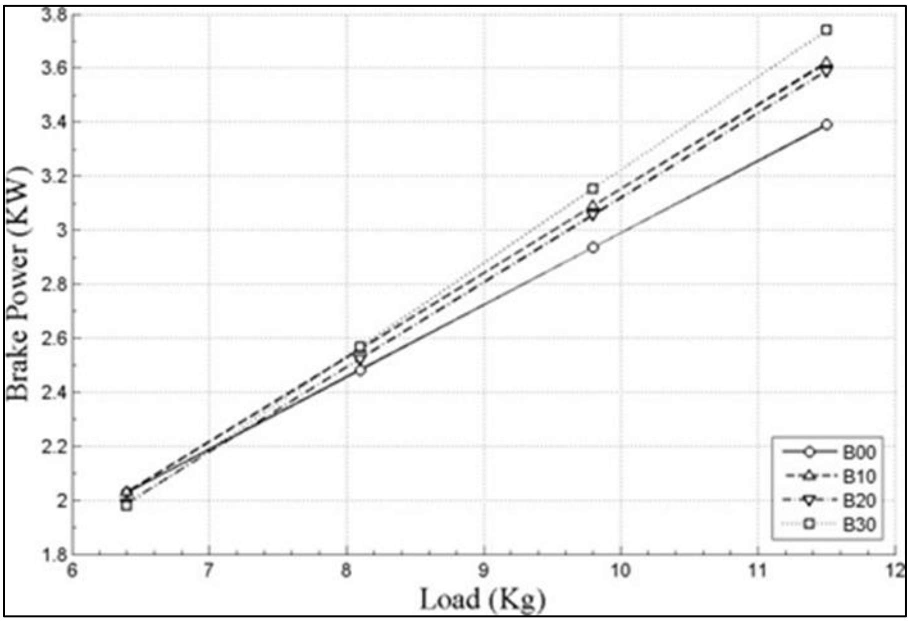


**Figure 4** Brake Power Vs Load

### 4.4. Brake Thermal Efficiency

Brake Thermal Efficiency is a function of heating value. With the increase in blend proportion, Brake Thermal Efficiency decreases for lower loads and lower compression ratio. This decrease is minimal and lies within 6.18% as compared to neat diesel. This could be because of lower heating value of biodiesel. Slight improvement is observed with increase in load. It can be observed from Fig. 5 that, B10 blend shows better results for all loads at higher compression ratio. At lower load and compression ratio, it shows a minor decrease of 3.52%. At higher load and compression ratio, all biodiesel blends show better performance.

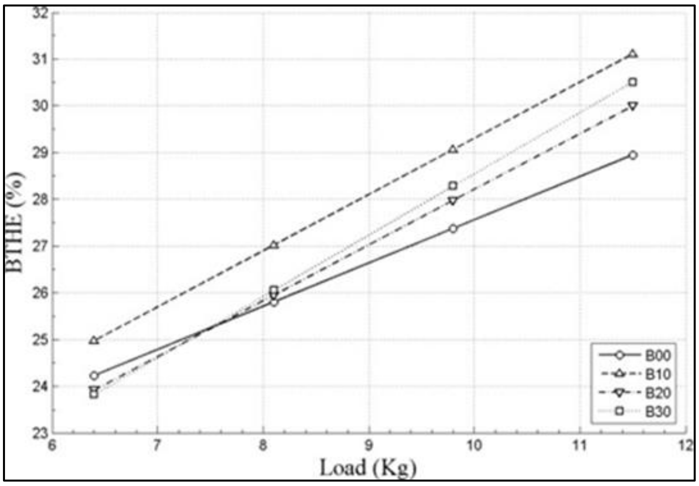


**Figure 5** Brake Thermal Efficiency Vs Load

### 4.5. Cylinder Pressure

A minor decrement is observed in cylinder pressure for blends of biodiesel as compared to diesel. Fig. 6 shows the variation in cylinder pressure with crank angle for diesel and biodiesel blends. It can be seen that B10, B20 and B30 blend shows a decrement of 3.55%, 6.65% and 4.41% respectively as compared to diesel. This could be because of slower heat release rate of biodiesel.

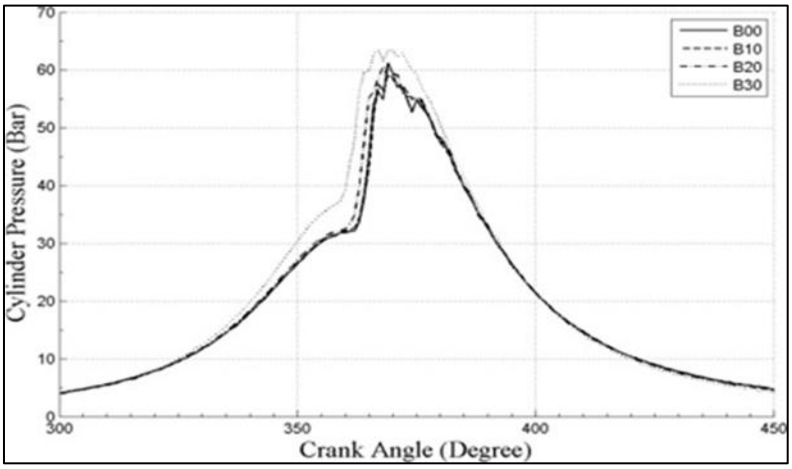


**Figure 6** Cylinder Pressure Vs Crank Angle

### 4.6. Specific Fuel Consumption

Fig. 7 shows the variation in specific fuel consumption for diesel and biodiesel blends. Specific fuel consumption is slightly higher at lower loads, but shows moderate improvement at higher loads. It increases with an increase in blending ratio. This could be because of the lower calorific value of biodiesel. It is seen that the B10 blend shows better fuel efficiency than other blends, except that it shows an increase of 2.78% at 60% load and compression ratio of 15. All blends have better fuel efficiency at higher compression ratio and higher loads.

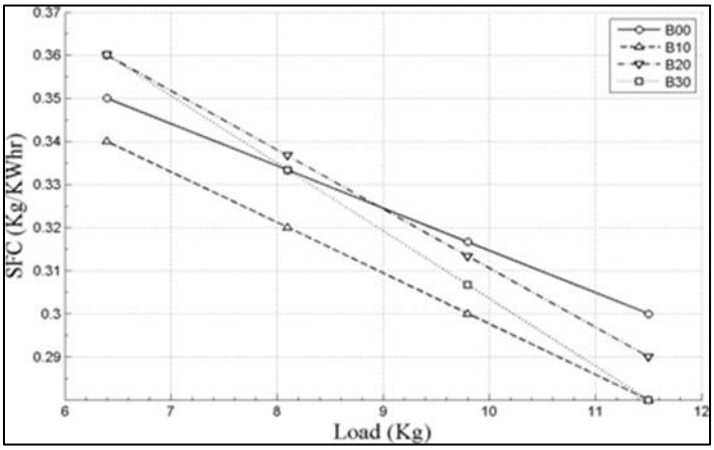


**Figure 7** Specific Fuel Consumption Vs Load

### 4.7. Exhaust Emissions

Study shows a minor decrease in emissions of CO and HC for lower loads. At higher loads emissions of HC are almost similar to that of diesel. B20 blend shows better results for emissions of CO and HC. Emissions of nitrogen oxides are increased with increase in blend ratio. This may be due to improved automation of biodiesel blends and higher peak temperatures.

## 5. Conclusion

The present study evaluates the suitability of algae biodiesel–diesel blends for use in a diesel engine. The following observations were made:

- The cylinder pressure for biodiesel blends varied by up to 6.65% compared with neat diesel.
- Torque and brake power were only marginally affected by the blending of biodiesel.
- The thermal efficiency of the engine showed a slight reduction at lower loads but improved at higher loads and higher compression ratios.
- Specific fuel consumption increased slightly with an increase in the blending ratio.
- Emissions of CO, $CO_2$, and HC showed minimal variation, whereas nitrogen oxide emissions increased with higher biodiesel content.

Based on these findings, it can be concluded that algae biodiesel can be blended with diesel and used in existing diesel engines without requiring any engine modifications.

## Compliance with ethical standards

*Disclosure of conflict of interest*

No conflict of interest to be disclosed.

## References

[1] Niraj s. Topare, V.C. Renge, Satish V. Khedkar, Y.P. Chavan& S.L. Bhagat, ―Biodiesel from algae oil as an alternative fuel for diesel engine,‖ ijCEPr, Vol.2, No. 2- 3, 116-120, May-December 2011.

[2] Biodiesel in India : Value chain organisation and policy options for rural development / Tilman Altenburg, Bonn : DIE, 2009. ISBN 978-3-88985-379-0

[3] National policy on biofuels‖, Ministry of New & Renewable Energy, Government of India.

[4] Hariram V., G.Mohan Kumar, ―Combustion analysis of algal oil methyl ester in a direct injection compression ignition engine‖, Journal of Engineering Science and Technology, Vol. 8, No. 1 (2013) 77 – 92.

[5] J.A..Kinsat, ―Production of biodiesel from multiple feedstocksand properties of biodiesels and biodiesel- diesel blends‖, NREL/SR-510-31460.

[6] Evangelos G. Giakoumis, ―A statistical investigation of biodiesel physical and chemical properties, and their correlation with the degree of unsaturation‖, Renewable Energy, Vol. 50, pp. 858-878, 2013

[7] Mustafa Balat, HavvaBalat, ―A critical review of bio- diesel as a vehicular fuel‖, Energy Conversion and Management 49 (2008) 2727–2741.

[8] Yusuf Chisti, ―review paper on biodiesel from microalgae‖, Biotechnology Advances 25 (2007) 294– 306

[9] Bryan R. Moser, ―Biodiesel production, properties, and feedstocks‖, In Vitro Cell.Dev.Biol.—Plant (2009) 45:229–266

[10] John R. Benemann, ―Opportunities and challenges in algae biofuels production‖, algae world 2008

[11] Teresa M. Mata, Antonio A. Martins, Nidia. S. Caetano, ―Microalgae for biodiesel production and other applications: A review‖, Renewable and Sustainable Energy Reviews 14 (2010) 217–232.

[12] [22] R.MuraliManohar, M.Prabhahar, Dr.S.Sendilvelan, ―Bio-Diesel production and Effect of Catalytic Converter on Emission performance with Bio-Diesel Blends‖, International Journal of Engineering Science and Technology Vol. 2(6), 2010, 2133-2139

[13] S. Jaichandar and K. Annamalai, ―The Status of Biodiesel as an Alternative Fuel for Diesel Engine – An Overview‖, Journal of Sustainable Energy & Environment 2 (2011) 71-75

[14] JinlinXue, Tony E. Grift, Alan C. Hansen, ―Effect of biodiesel on engine performances and emissions‖, Renewable and Sustainable Energy Reviews 15 (2011) 1098–1116

[15] Xiaohu Fan and Rachel Burton, ―Recent Development of Biodiesel Feedstocks and the Applications of Glycerol: A Review‖, The Open Fuels & Energy Science Journal, 2009, 2, 100-109

[16] Ala'aAlsoudy, MetteHedeggardThomsen &IsamJanajreh, ―Influence on process parameters in transesterification of vegetable and waste oil – a review‖, IJRRAS 10 (1), January 2012

[17] Jerry Johnson, Nicolas Enjalbert, Joel Schneekloth, Alan Helm, Ravi Malhotra, Daren Coonrod,

[18] KaziMostafijurRahman, Mohammad Mashud, Md. Roknuzzaman and Asadullah Al Galib, ―Biodiesel from jatropha oil as an alternative fuel for diesel engine‖, International Journal of Mechanical & Mechatronics IJMME-IJENS Vol: 10 No: 03

[19] Avinash Kumar Agarwal, AtulDhar, ―Experimental investigations of performance, emission and combustion characteristics of Karanja oil blends fuelled DICI engine‖, Renewable Energy 52 (2013) 283-291

[20] M.Harinathareddy, P.Nageswara Reddy and K.Vijayakumar Reddy, ―Performance and Emission Characteristics of a Diesel Engine Operated on Mahua Oil Methyl Ester‖, Elixir Mech. Engg. 55 (2013) 12978-12982

[21] Alp Tekinergenc, Leventyuksek, Orkunozener, ―Performance, emission, and heat release analyses of a direct injection diesel engine running on diesel and soybean ester blends‖, Turkish J EngEnvSci (2013) 37: 23 – 32

[22] AhmetNecatiOzsezen, Mustafa Canakci, ―Determination of performance and combustion characteristics of a diesel engine fueled with canola and waste palm oil methyl esters‖, Energy Conversion and Management 52 (2011) 108–116

[23] JawadNagi, Syed Khaleel Ahmed, FarrukhNagi, ―Palm Biodiesel an Alternative Green Renewable Energy for the Energy Demands of the Future‖, ICCBT2008

[24] D. Subramaniam, A. Murugesan, A. Avinash, ―A comparative estimation of C.I. engine fuelled with methyl esters of punnai, neem and waste cooking oil‖, international journal of energy and environment, Volume 4, Issue 5, 2013 pp.859-870