



## Research article

# Experimental investigation of performance characteristics of compression-ignition engine with biodiesel blends of Jatropha oil & coconut oil at fixed compression ratio



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## ABSTRACT

The present research investigates raw oil (Jatropha and coconut oil Fuel), which lies in the edible and non-edible vegetable oils category. We have a set opinion to be taken as potential alternative fuels for C.I. engines and are choosing to search out their quality being employed as a future fuel. The most effective distinction between these two varieties of oils and diesel fuel is viscosity. The blends of the above oils prepared along with pure diesel. Each oil was separately blended in variable proportion (20%–50%) with pure diesel. We have experimented to monitor and analyze the performance of pure diesel fuel against various blends (B20 to B50) of Jatropha-biodiesel & Coconut-biodiesel at a fixed compression ratio i.e. eighteen. The performance limits that were under study and compared are the variation of brake specific fuel consumption & brake thermal efficiency with various loads for many fuel blends.

## 1. Introduction

A century before, Rudolf diesel first came with the idea of diesel engine, used peanut oil (oil) for experimental analysis that point solely it indicated that vegetable oils are applicable to cater to the requirements of the future. Nearly a century back, Rudolf diesel introduced a plan of diesel engine along with oil (which could be a vegetable oil) as fuel for experimental purposes. At that point, this experiment indicated that vegetable oils are potential fuels to meet the requirements of the coming century. In the current century, it's believed that crude oil and petroleum products can become terribly scarce and overpriced to find and manufacture, though researchers have found a variety of the way to increase the fuel economy, however, population of countries has raised several folds and additionally energy is the backbone of any nation's economy. Employing excessive extraction of crude reserves by a variety of applications, simply because of sudden exploding of the population around the globe. Standard lubricants ready from the mineral oils and additives are probably toxic to water & soil due to their rich composition and lesser biodegradability. There's continually a frightening scenario as a way as surroundings are concern that pulls our attention towards natural counter components simply because of rising crude costs, inappropriate

disposal strategies and absence of stuff usage across the world [1, 2, 3]. The properties like high oiliness, viscosity and indices, higher flash points, less evaporative loss, and low full accounting price (includes working and nature filling cost) are technical in nature which provides competitive edge, and therefore, they're most popular even once some inferior traits like reduced oxidation and thermal stabilities, poor cold flow properties, lower time period, however researches are working on these limits and might be improved by applying some change in techniques and systematized research [4, 5, 6, 7, 8]. There are massive numbers of types of oil (Edible & Non-Edible), just some are shortlisted as their potential is a concern. Edible oils carry good properties to cater to it as a good option for alternative fuel but could not recommend due to the food dependency of the nation. Non-edible oil carries quite the same properties to become an option as an alternative fuel and has very little tradition of usage in food; also it requires wasteland to grow a hence dependency of food quite low in non-edible oil and wasteland usage increases. It has untapped potential and also enhances the economy of rural areas [9, 10, 11, 12, 13].

Jindal [14] took Jatropha methyl ester as fuel and reported its emission and performance characteristics. CR noted as one of the important parameters, as compression ration increase to 18, BTE has

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**Table 1**

Property of diesel, Jatropha biodiesel blends and coconut biodiesel blends.

Properties	Diesel	Jatropha oil blends				Coconut oil blends			
		B20	B30	B40	B50	B20	B30	B40	B50
Density (Kg/m <sup>3</sup> )	849	853	857	859	864	835.7	838.5	841.7	845.8
Kinematic Viscosity (mm <sup>2</sup> /sec)	4.7	4.83	4.95	5.07	5.2	3.31	3.49	3.68	3.74
Calorific Value (KJ/Kg)	43210	42147	41626	41116	40833	48224	47454	46952	43842

shown climbed by 8.9%. However, the emission characteristics shown an increase in temperature (EGT) but shown a decline in smoke and emissions of CO. Chauhan et al. [15] have done an investigation on pure diesel and biodiesel of Jatropha. The investigation has shown an increase in load elevates BTE and an increase in the blend ratio elevates the emission of HC and NO<sub>x</sub> compared with pure diesel. Raheman [16] reported with Mahua biodiesel blends and pure diesel showed elevation of BTE by 1% with a B20 20% blend ratio, also a reduction in BTE when B100 100% blend ratio used. It has shown a decline in CO emission, but increases in HC and NO<sub>x</sub> emission as blend ratio increases towards the higher end. Prem Kumar Chaurasiya et al [17] investigated the raw oil of jatropha, soybean, and waste cooking fuel and its blends with diesel with CR 16.5. Experimental analysis shows that all loads, B20 blends of each oil show very close values of BTE and the exhaust emission indicate CO emissions decrease with 80% of the load and then curve sharply moves up for all the biodiesel blends but B20 shows the least NO<sub>x</sub> emissions at all load conditions. A.K. El Morsi [18] investigated the biodiesel made from Jatropha, palm, algae and waste cooking oils blended as B10 and B20 using single-cylinder combustion engine. Results indicate the exhaust emissions CO, CO<sub>2</sub>, NO<sub>x</sub>, HC, and smoke is lesser for the mixtures of biodiesel, but biodiesel blends of waste cooking oil are having and NO<sub>x</sub> emissions increases for all biodiesel blends as compared to diesel fuel.

Many researchers have done their comparative study of either non-edible oil or edible oils. The experimental study aims to figure out the performance characteristics of both edible and nonedible together (raw Jatropha oil and raw Coconut Oil) against pure diesel at a fixed compression ratio [18]. By varying the blend ratio from B20 to B50 performance parameters of biodiesel blends of Jatropha oil, Coconut oil has been studied and compared with pure diesel.

## 2. Materials and method

Experimental work carried out on a variable compression ratio (VCR)

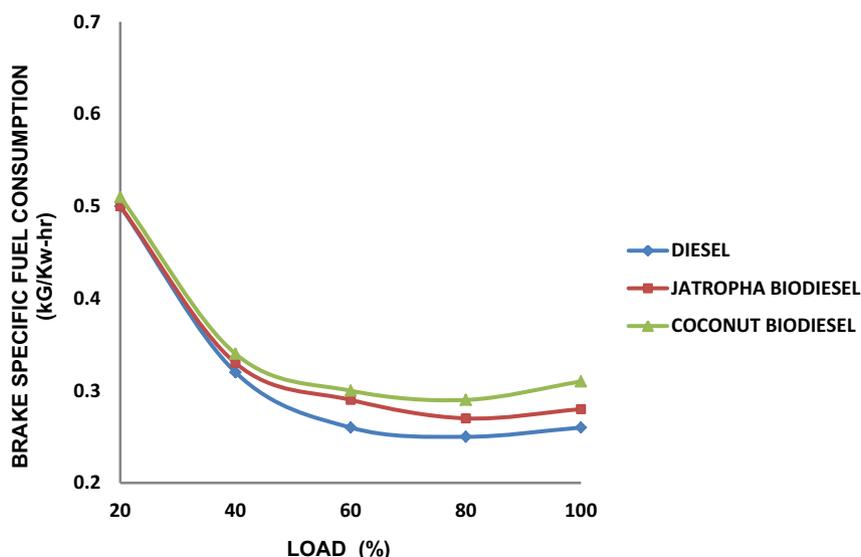


Fig. 1. Variation of BSFC with Engine Load for B20 at Constant Speed 1500 rpm & CR 18.

diesel engine with a single-cylinder, Power 3.5 kW @ 1500 revolutions per minute (constant speed). We found the overview after conduction of the test which says the performance on engine with fixed compression ratio (CR 18) at variable loads (20%, 40%, 60%, 80% & 100%) by using the diesel blends (B2B – B50) with jatropha and coconut oil biodiesel thus on realize BSFC, BTE.

### 2.1. Experimental setup

We have conducted the experimental work with a fixed compression ratio of 18 at variable load values. The load measuring instrument used for this experimental work carrying a dynamometer of eddy current type, a load cell of strain gauge type and a loading unit. We will complete the load application by supplying the current to dynamometer employing a loading unit. By using a load cell to quantify the load applied on the engine.

### 2.2. Biodiesel

In this study, biodiesel obtained from jatropha oil, coconut oil and its blends with pure diesel. The oils and pure diesel have been purchased from local commercial suppliers. Biodiesel blends carry certain properties are shown in Table 1.

## 3. Result & discussions

### 3.1. Engine performance

#### 3.1.1. Brake specific fuel consumption

The brake specific fuel consumption is the fuel flow rate per unit power output. It is a quantity of the efficiency of the engine in using the fuel supplied to produce work. With various oils with the same blends, the variations of BSFC concerning load are in Figs. 1, 2, 3, and 4 at the compression ratio of 18 and constant speed of 1500 rpm.

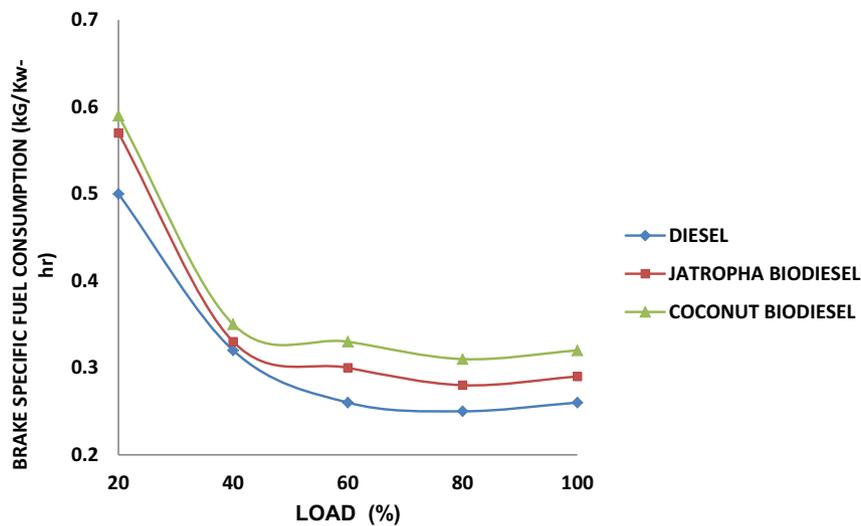


Fig. 2. Variation of BSFC with Engine Load for B30 at Constant Speed 1500 rpm & CR 18.

It tells that the specific fuel consumption of the diesel with respective blends seen a decrease with an increase in load. Also, fuel consumption shows an increase along with a high proportion of biodiesel in the blend. The BSFC of all fuels with a load of 80% & B20 were as the following 0.25 kg/kW-hr for Diesel fuel, 0.27 kg/kW-hr for Jatropa and 0.29 kg/kW-hr for coconut. Blend ratio increase with specific fuel consumption, observations has indicated that the BSFC of Jatropa with a load of 80%, B20 is 0.27 kg/kW-hr which indicates the least and for B-50 is 0.36 kg/kW-hr which indicates the highest and similarly with coconut B20 is 0.29 kg/kW-hr which indicates the least and for B-50 is 0.37 kg/kW-hr which indicates the highest. Comparing the BSFC parameter with higher blends of biodiesel against pure diesel; biodiesel has a higher viscosity and combustion took place at lower loads which indicates high mass consumption per unit power output. As the load increases the increase of temperature has been observed, which turns down the consequence of the high viscosity of the blends of biodiesel and thus BSFC of blends of biodiesel arrives quite closer to pure diesel.

3.1.2. Brake thermal efficiency

BTE shows the relation between the output in power and input energy in the form of fuel. It can also be stated as the product of the flow rate of

the mass of fuel injected and the lower heating value. With the Jatropa biodiesel, Coconut biodiesel and its blends, BTE show variation with change in load percentage at a fixed compression ratio of 18 and constant speed of 1500 rpm in Figs. 5, 6, 7, and 8.

It is reported that BTE shows an increase due to an increase in load tested for pure diesel and all the biodiesel blends of Jatropa and Coconut. Investigation indicated that the BTE of Jatropa and Coconut was 31.54 % and 29.75 % compared with pure diesel (33.15 %) at a load of 80% and B20 blend. At higher blends of biodiesel, it is observed that BTE slides down a little due to the higher viscosity and lower heating values of biodiesel. BTE for Jatropa (B20) is 31.54% indicated maximum and Coconut (B50) is 23.87% indicated minimum for 80% load.

4. Conclusion

- The in-depth investigation of the performance limits of the VCR C.I. engine has coincided with two varieties of blends of biodiesel.
- The test carries on the VCR test rig to check the performance at CR 18. Blends of biodiesel B00, B20, B30, B40 and B50 for Coconut Oil and Jatropa Oil.

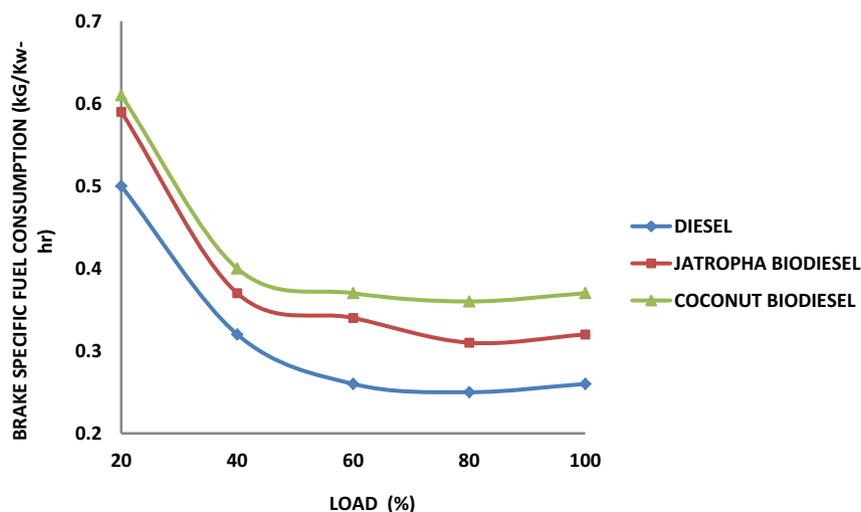


Fig. 3. Variation of BSFC with Engine Load for B40 at Constant Speed 1500 rpm & CR 18.

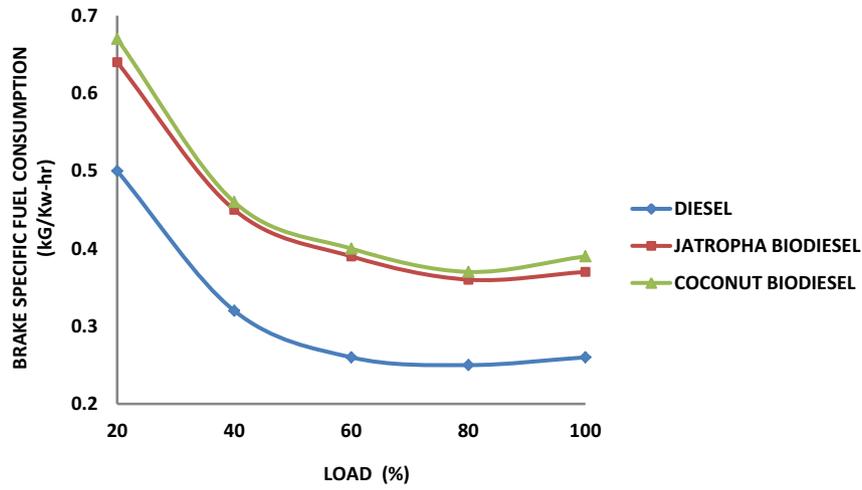


Fig. 4. Variation of BSFC with Engine Load for B50 at Constant Speed 1500 rpm & CR 18.

- During the test B-20 biodiesel blend indicates quite close values of BTE at all the load conditions in comparison with diesel fuel and for rest all the blend of biodiesel at all loads, BTE is slightly lower in comparison with pure diesel oil.
- With constant speed and fix compression ratio 18, blends of biodiesel showed a similar kind of performance in comparison with pure diesel oil. At all loads, the BSFC of Jatropha blends reveals least among all the blends. With the same load conditions. A B-20 blend of Jatropha

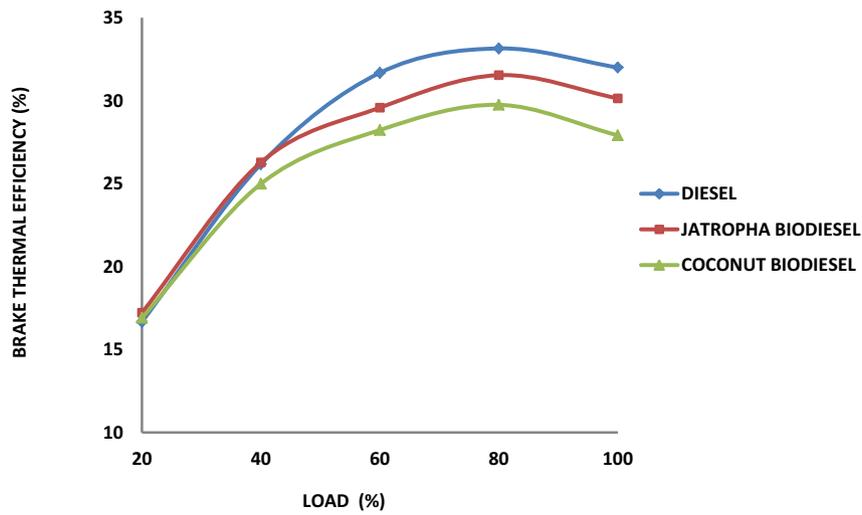


Fig. 5. Variation of BTE with Engine Load for B20 at Constant Speed 1500 rpm & CR 18.

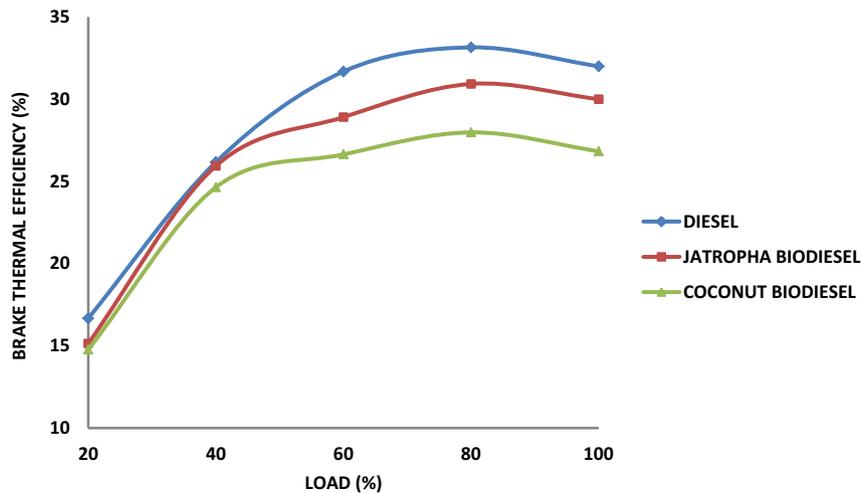


Fig. 6. Variation of BTE with Engine Load for B30 at Constant Speed 1500 rpm & CR 18.

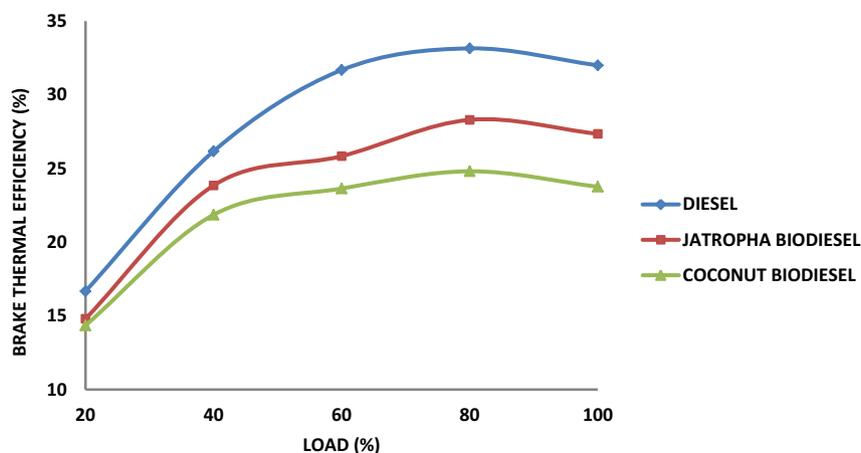


Fig. 7. Variation of BTE with Engine Load for B40 at Constant Speed 1500 rpm & CR 18.

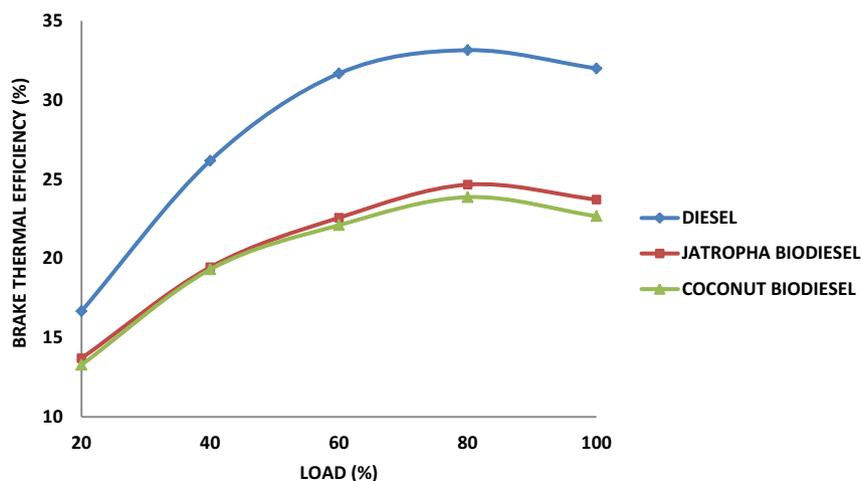


Fig. 8. Variation of BTE with Engine Load for B50 at Constant Speed 1500 rpm & CR 18.

biodiesel shows BSFC quite close to pure diesel oil followed Coconut Oil.

## Declarations

### Author contribution statement

Yogendra Rathore: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Dinesh Ramchandani & R K Pandey: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

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### Competing interest statement

The authors declare no conflict of interest.

### Additional information

No additional information is available for this paper.

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