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# Experimental investigation of a diesel engine with methyl ester of mango seed oil and diesel blends

**K. Vijayaraj *, A.P. Sathiyagnanam**

*Department of Mechanical Engineering, Annamalai University, Tamil Nadu, India*

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**Abstract** Petroleum based fuels worldwide have not only resulted in the rapid depletion of conventional energy sources, but have also caused severe air pollution. The search for an alternate fuel has led to many findings due to which a wide variety of alternative fuels are available at our disposal now. The existing studies have revealed the use of vegetable oils for engines as an alternative for diesel fuel. However, there is a limitation in using straight vegetable oils in diesel engines due to their high viscosity and low volatility. In the present work, neat mango seed oil is converted into their respective methyl ester through transesterification process. Experiments are conducted using various blends of methyl ester of mango seed oil with diesel in a single cylinder, four stroke vertical and air cooled Kirloskar diesel engine. The experimental results of this study showed that the MEMSO biodiesel has similar characteristics to those of diesel. The brake thermal efficiency, unburned hydrocarbon and smoke density are observed to be lower in case of MEMSO biodiesel blends than diesel. The CO emission for B25, B50 and B75 is observed to be lower than diesel at full load, whereas for B100 it is higher at all loads. On the other hand, BSFC and $NO_x$ of MEMSO biodiesel blends are found to be higher than diesel. It is found that the combustion characteristics of all blends of methyl ester of mango seed oil showed similar trends with those of the baseline diesel. From this study, it is concluded that optimized blend is B25 and could be used as a viable alternative fuel in a single cylinder direct injection diesel engine without any modifications.



## 1. Introduction

India is importing crude petroleum and petroleum products from Gulf countries. Indian scientists searched for an alternate to diesel fuel to preserve the global environment and to withstand the economic crisis. As far as India is concerned because of its vast agro forestry base, fuels of bio origin can be considered to be ideal alternative renewable fuels to run the internal combustion engines. Vegetable oils from plants both edible and non-edible and methyl esters (Biodiesel) are used as an alternate source for diesel fuel. Biodiesel was found to be the best alternate fuel, technically, environmentally acceptable, economically competitive and easily available. There are more than 350 oil bearing crops that have been identified, among which only sunflower, soyabean, cottonseed, mango seed, rapeseed and peanut oils are considered as potential alternative fuels for diesel engines. Apart from the renewability, the advantages of biofuel are as follows: High oxygen content,

* Corresponding author.

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higher flash point and higher lubricity that produce complete combustion in comparison with conventional diesel fuel [1]. Further, the environmental benefit is another investigation factor due to lesser greenhouse effect, less air pollution, less contamination of water, soil and reduced health risk [2]. Traditional oilseed feedstock for biodiesel production predominantly includes soyabean, rapeseed/canola, palm, corn, sunflower, cottonseed, peanut and coconut oil [3]. The long chain hydrocarbon structure, vegetable oils have good ignition characteristics, however they cause serious problems such as carbon deposits buildup, poor durability, high density, high viscosity, lower calorific value, more molecular weight and poor combustion. These problems lead to poor thermal efficiency, while using vegetable oil in the engine. These problems can be rectified by different methods that are used to reduce the viscosity of vegetable oils. The methods are transesterification, dilution and cracking method [4]. The transesterification of vegetable oil gives better performance when compared to straight vegetable oil [5]. Many researches are focused on non-edible oils which are not suitable for human consumption due to the presence of toxic components present in the oil. Moreover, the non-edible oil crops grow in wastelands which are not suitable to use as food [6,7]. The increase in brake thermal efficiency and lower in specific fuel consumption were observed in a diesel engine fueled with Calophyllum Inophyllum (punnai) biodiesel and additives [8]. The diesel engine performance parameters were higher and lower in emissions while operating with B20 blend biodiesel [9]. Rakopoulos et al. [10] studied the use of four straight vegetable oils such as sunflower, cotton seed, olive and corn oils on mini-bus engine and reported that olive oil has very high content of the unsaturated oleic acid (one double carbon bond) and very low content of the unsaturated linoleic acid (two double carbon bonds), in contrast to the other three vegetable linoleic acids. Further, the cotton seed oil has the highest content of palmitic acid (saturated). These may play some role in the soot formation and oxidation mechanism. Saravanan et al. [11] reported that pure Mahua oil methyl ester (B100) gives the lower emissions as compared with neat diesel (B0) in a DI diesel engine. The performance of diesel engine with rice bran oil methyl ester and its diesel blends resulted in increase of CO, HC and soot emissions and slight increase of NOx with increase in blends compared to diesel. Also the ignition delay and peak heat release rate for RBME were lower for biodiesel and it was increased with increase in RBME blends [12]. Rajan and Kumar [13] have investigated the performance of a diesel engine with internal jet piston using biodiesel and observed increase in brake thermal efficiency and decrease in CO and smoke emissions at full load, whereas $NO_x$ emission is increased at full load compared to diesel fuel. Godiganur et al. [14] investigated the use of Mahua oil methyl ester and its diesel blends as an alternative fuel in a heavy duty diesel engine and observed that B20 blend gives better performance and lower emissions. The methyl ester of Thevetia peruviana seed oil (METPSO) results in lower emission of CO, HC and higher $NO_x$ as compared to that of diesel [15]. The cylinder peak Pressure of soyabean biodiesel is close to that of diesel and also the peak rate of pressure rise and peak heat release rate during premixed combustion are lower for biodiesel [16].

Implementation of biodiesel in India will lead to many advantages such as green cover to wasteland, support to agriculture, rural economy, reduction in dependence on imported crude oil and reduction in air pollution [17]. Currently, India is spending about Rs. 80,000 million per year for importing 70% of petroleum fuels and produces only 30% of the total fuel requirements. It is estimated that mixing of 5% of biodiesel fuel to the present diesel fuel can save Rs. 40,000 million per year. The objective of the present study is the preparation of biodiesel from mango seed oil; the performance, emission and combustion characteristics of a diesel engine using biodiesel and its various blends are analyzed and compared with neat diesel.

## 2. Biodiesel production and characterization

### 2.1. Biodiesel production

The production of biodiesel from mango seed oil is done by transesterification process. It is the process of reacting the mango seed oil with methanol in the presence of catalyst (KOH). During the process, the molecule of mango seed oil is chemically broken to form methyl ester of mango seed oil (biodiesel). The biodiesel is filtered to separate from glycerol. A maximum of 850 ml methyl ester of mango seed oil production is observed for 1 l of raw mango seed oil, 250 ml of methanol and 12 gm of potassium hydroxide at 60 °C.

### 2.2. Biodiesel properties

A series of tests are conducted to characterize the properties and fatty acid composition of the produced biodiesel. The properties and compositions of biodiesel and its blends with diesel fuel are shown in Tables 1 and 2 respectively.

It is shown that the viscosity of biodiesel is evidently higher than that of diesel fuel. The density of the biodiesel is approximately 8% higher than that of diesel fuel. The gross calorific value is approximately 8.5% lower than that of diesel. Therefore, it is necessary to increase the fuel amount to be injected into the combustion chamber to produce the same amount of power. Fuels with flash point 52 °C are regarded as safe. Thus, biodiesel is an extremely safe fuel to handle when compared to diesel. B25 has a flash point much above than that of diesel, making biodiesel a preferable choice as far as safety is concerned.

The fatty acid composition of the oils seems to have an important role in the performance of the biodiesel in diesel engines [18]. The higher level of unsaturated fatty acid reduces fuel quality, because of its easy oxidation [19]. The saturated

**Table 1** Properties of biodiesel in comparison with diesel and best blend (Source: Laboratory evaluation at Eta-lab, Chennai).

| Property | Diesel | B 25 | B 100 |
|---|---|---|---|
| Specific gravity @ 15 °C | 0.829 | 0.846 | 0.895 |
| Kinematic viscosity @ 40 °C in cSt | 2.57 | 3.33 | 5.6 |
| Density @ 15 °C (kg/m$^3$) | 828 | 845 | 894 |
| Flash point (°C) | 53 | 82 | 168 |
| Fire point (°C) | 59 | 88 | 174 |
| Gross calorific value (kJ/kg) | 44,680 | 43,729 | 40,874 |
| Cetane number | 51 | 51.3 | 52 |

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