Experimental Investigation of Diesel Engine with Novel Juliflora Biodiesel

Dasari Akhil, K. Appa Rao

***Abstract:** Biodiesels which have been derived from non-edible vegetable oils are bagging the interest of researchers. These have been recognized as the potential alternatives of regular petroleum fuels. In this work, oil extracted from Juliflora seeds is converted as biodiesel by the transesterification process and used as alternative fuel in diesel engines. The tests are conducted by using diesel, B10, B20, B30 and B40. The experimental results of this study have disclosed that the Juliflora biodiesel blends have shown similar characteristics as diesel fuel. The BTE, CO, HC and smoke emissions are low for biodiesel blends while BSFC and NO_x emissions are slightly higher. Taking all results into account it can be clinched that B10 blend of Juliflora biodiesel has viable option for diesel engine applications.*

***Keywords:** Juliflora Biodiesel; performance; emissions; HC emissions.*

I. INTRODUCTION

In a search of promising alternative fuel for diesel engines, various fuels are introduced and used for different applications. In this context biodiesel is largely used in CI engines along with diesel. Biodiesel has some limitations to use in large proportions as they produce more NO_x emissions. Vijayraj and Sathiyagnanam [1] investigated the performance of CI engine with different blends of mango seed biodiesel. The experimental results demonstrated that the BTE of lower blends was high due to improved atomization, vaporization and combustion of biodiesel, in other hand BSFC and NO_X emissions were increased slightly. Nanthagopal et al. [2] reported that BTE and, CO, HC and smoke emissions were detected to be lower in the case of Waste cooking oil (WCO) biodiesel blends than diesel.And also, the BSEC and NO_x had increased slightly when engine is running with WCO blends. Aydin and Bayindir [3] conducted tests on performance and emission analysis of cotton seed oil methyl ester in a diesel engine. The results exposed that the usage of the low volume of biodiesel increases the torque at intermediate and higher speeds. When volume of biodiesel increases the exhaust, emissions were decreased. Devan and Mahalakshmi [4] explored the diesel engine with dual biodiesel blend by mixing paradise oil and eucalyptus. Significant drop in smoke by 49%, HC by 34.5% and CO emissions by 37 % had recorded owing to improved combustion for the ME50-EU50 blend. Devan and Mahalakshmi [5] explained that the brake thermal efficiency of methyl ester poon oil (MEPO 40] blend is slightly higher than that of standard diesel and other blends due to the additional lubricity provided by the biodiesel.

Godiganur et al. [6] reported, Asrise of biodiesel size in fuel blend the emissions of CO, HC reduced and NOx had increased compared with diesel fuel due to more complete oxidation flue gas, more complete is combustion of the fuel and increased exhaust gas temperatures respectively.

Saravanan et al. [7] stated that while using Madhuca Indica methyl ester as a biodiesel the specific energy consumption and fuel consumption has increased owingto lowenergy content (39 MJ/ kg) and high viscosity of 4.39 mm^2/s in CIengine. Qi et al. [8]studied combustion and performance evaluation of soybean biodiesel. The results exposed that at all engine loads, ignitionof fuel started earlier in caseof biodiesel than for diesel because of short ignition delay and lower volatility of biodiesel. Gumus and kasifoglu [9] reported that as increasing the portion of apricot seed kernel oil methyl ester in diesel the engine power and torque increases up toblend B20biodiesel contains additional 10% (in weight) oxygen can be enhanced combustion, especially in the fuel rich zone causing more complete combustion.

Dhar and Agarwal [10] examined the appearances of Karanja biodiesel (Karanja oil methyl ester; KOME) on CI engine at different engine speeds and load. For 10% and 20% KOME blends the torque has increased 0.7% and 0.3% respectively when compared with baseline diesel due more availability of oxygen in biodiesel which boost the combustion efficiency and heat release rate.

Prasanth et al.[11] conducted the experiments with mango seed methyl ester (MSME) blends. Mango seed biodiesel was blended with diesel in 10, 20, 40,50 and 100 % by volume. BTE and BSFC MSME20 recorded to be very close to standard diesel fuel. MSME100 blend publicized tiniest carbon monoxide (CO) emissions among all tested biodiesel blends but MSME10 blend showed more identical emissions of CO as diesel. All fuel blends of MSME except MSME20 displayed lower CO_2 emissions than diesel. This may be due to more Oxygen content of MSME which enhances the air-fuel mixture. MSME100 blend exposed minimised NO_X emissions among all tested fuel blends which owing to less temperature generation through combustion phase. HC and smoke emissions of MSME20 blend exposed the same trend as diesel.

Reddy et al. [12] explored the various characteristics of cotton seed methyl ester (CSME) when fuelled with diesel engine. CSME biodiesel blended with diesel in 10, 15,20 and 25 % ratios on volume basis. Authors had reported that B50 biodiesel blends exhibited better results. At full load condition, engine emission namely HC and CO were raised than diesel data due improper combustion.

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Dasari Akhil, M. Tech student, Department of Mechanical Engineering, Lakireddy Bali Reddy College of Engineering, Mylavaram, AP, India. Email: akhildasari1996@gmail.com.

Dr. K. Appa Rao, Professor, Department of Mechanical Engineering, Lakireddy Bali Reddy College of Engineering, Mylavaram, AP, India. Email: apparaokadimalla@gmail.com

Nanthagopal et al. [13] took waste cooking oil as asubstitute fuel for diesel engine. When operating with WCO a drop in BTE and rise in BSEC was observed than diesel due to lower calorific value and higher viscosity of WCO. Emission results demonstrated that the carbon monoxide, unburned hydrocarbon and smoke opacity were lessen while Nitrogen emissions enlarged than diesel readings due to enhanced combustion and more oxygen availability.

Venu et al. [14] did experimental evolution of regulated and unregulated emissions of diesel engine with fuelled with different blends of *Chlorella emersonii* methyl ester (CSME). Fuel blends were prepared by blending CSME with diesel at 10,20,30,40 and 100 by volume. From the test results, CEME 20 blend showed the better characteristics in terms of brake thermal efficiency. In terms of regulated emissions, drop in HC, CO and smoke; and rise in CO_2 and NO_x were noticed. In terms of unregulated emissions lower toluene and acetaldehyde; and higher acetone and formaldehyde were observed.

II. MATERIALS AND METHODS

A. Juliflora trees

Juliflora, scientifically known as *Prosopis Juliflora*belongs to Fabaceae family. This is a crude plant able to grow in hot and humid climates and also, doesn't depend on water for survival. It is a local tree in Asia and Caribbean regions. This tree can produce tonnes for seed every year independent of any season. These seeds consist of high oil source. Fig. 1 shows the juliflora tree with fruit.

Fig 1. Picture of Juliflora tree

B. Biodiesel preparation

The Juliflora seeds were collected from the surroundings of the institute. The seeds are washed by water to remove dirt and dried in an open area for two weeks. The dry seeds were taken and put in an oven to bake for 24 hours and maintained about 50 ^{0}C. This process removes the moisture content from seeds. By using a mechanical expeller, the oil is extracted. The biodiesel is prepared by using a transesterification process. By taking volume faction fuels blends are prepared. The physical and chemical properties of biodiesel blends are experimentally found by ASTM standards and listed in **Table 1.**

(a) Diesel (b) Juliflora fuel blends

Fig 2. Fuel samples

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Properties	**Diesel**	**Juliflora**	**B10**	**B20**	**B30**	**B40**
Density 40 ^{0}C (kg/m^3)	835	880	839.5	844	848.5	853
Calorific value (MJ/kg)	42.5	37.6	42.01	41.52	41.03	40.54
kinematic viscosity at 40 ^{0}C in (mm^2/sec)	2.2	6.2	2.6	3	3.4	3.8
Flash point ^{0}C	45	128	53.3	61.6	69.9	78.2
Cetane number	50	52	50.2	50.4	50.6	50.8

Table 1 Properties of fuel blends

III. EXPERIMENTAL SETUP

This investigation is done by using Kirloskar make TV1 model water cooled, single cylinder diesel engine. The technical specifications of the TV1 engine have been listed in **Table 2**. **Fig 3** represents the graphical representation of the engine. To put the load on the engine a rope dynamometer is used. The experiment is conducted by diesel to generate the baseline readings. Again, the same test is repeated with B10, B20, B30 and B40. For each fuel blend the test is conducted at 0, 25, 50, 75 and 100% load at constant speed of 1500 rpm. The exhaust emissions i.e. CO, CO_2, HC, NOx, and O_2 are measured by using AVLfive-gas analyser. AVL smoke meter isemployed to measure the concentration of smoke opacity.

Make	Kirloskar
Model	TV1
Power output	3.5 kW
Number of Cylinders	1
Bore & stroke	87.5 & 110
Compression ratio	18.5:1
Cooling type	Water cooling
Fuel injection timing	23^0 bTDC
Fuel injection pressure	210 bar

Table 2 Technical specifications of engine

Fig 3 Engine

Fig 4 Emission measuring devices

IV. RESULTS AND DISCUSSIONS

A. *Performance characteristics*

Important engine performance characteristics i.e. Brake thermal efficiency and Brake specific fuel consumption are evaluated for JFSME and compared with diesel. The BSFC is an ideal parameter for comparing the engine performance when fuelled with different fuels.

Brake thermal efficiency (BTE) can be defined as the ratio of Brake power of engine to the product of mass flow rate and calorific value of given fuel sample. The BTE of the engine for diesel is higher among the all tested fuel blends. In **Fig 4**. the variation of BTE vs load for all fuel samples has shown. Blends of B10 and B20 are shown close to BTE values to diesel. This is because of reduced viscosity which results in amended atomizationof fuel particles. Due to the enhanced combustion of fuel blend the BTE has improved. The highest values of BTE are 32.64, 31.93, 30.63, 28.4 and 26.15 % for diesel, B10, B20, B30 and B40, respectively.

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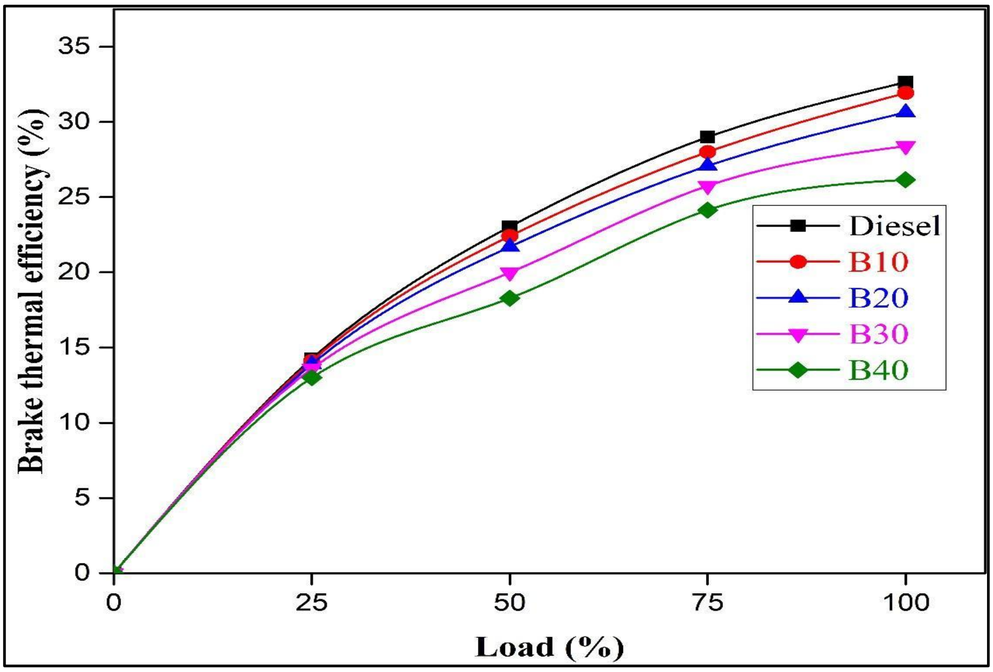

Fig 4 Load Vs Brake thermal efficiency

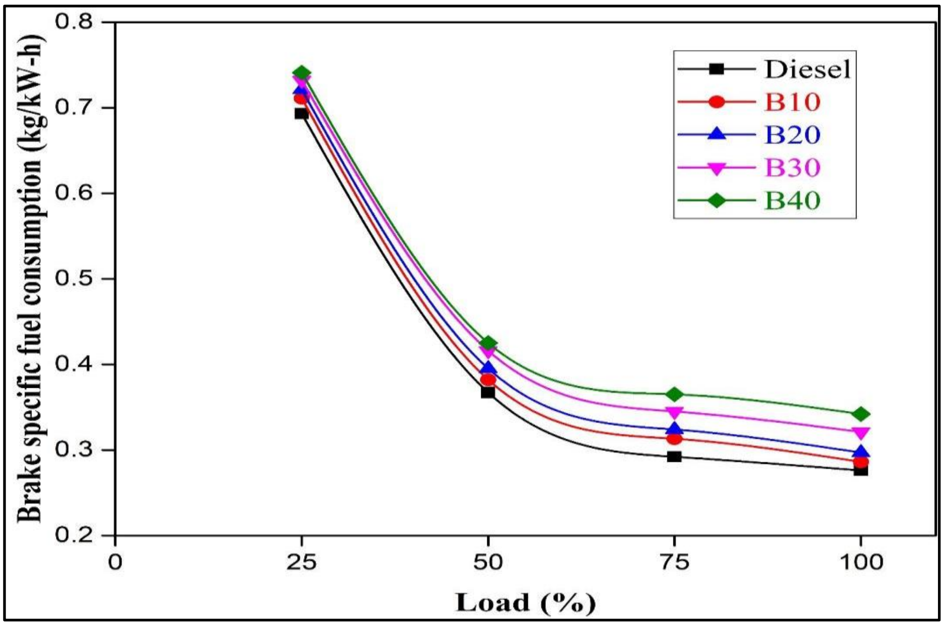

Fig 5 Load vs Brake specific fuel consumption

Brake specific fuel consumption specifies the amount of fuel taken to produce unit brake power. The variation of with load for different blends of Juliflora was depicted in **Fig 5**. The BSFC is slightly higher Juliflora blends than diesel. B10 and B20 blends have shown similar BSFC values to diesel. The BSFC of fuel samples at full load are 0.276 for diesel, 0.286 for B10, 0.297 for B20, 0.321 for B30 and 0.342 for B40 blends. From the figure, it is noted that as load on the engine rises the BSFC is dropped. At part loads the BSFC is maximum and at full load the BSFC is minimum.

B. Emission characteristics

Shortage of Oxygen inside the cylinder during the combustion of fuel is the main cause of Carbon emissions. Emissions of CO has to be depressed to a substantial level for a good environment. **Fig. 6** indicates the variation of CO emissions of a diesel engine working with various Juliflora blends and diesel. At medium loads the CO emissions are minimum for all tested fuels. B10 blend of juliflora has showed lowest Carbon emissions and B40 blends shows maximum concentration of CO emissions. At full load, CO emissions for diesel, B10, B20, B30 and B40 are notices as 0.9, 0.08, 0.098, 0.11 and 0.12% respectively.The emissions are low for B10 due to complete combustion of fuel.

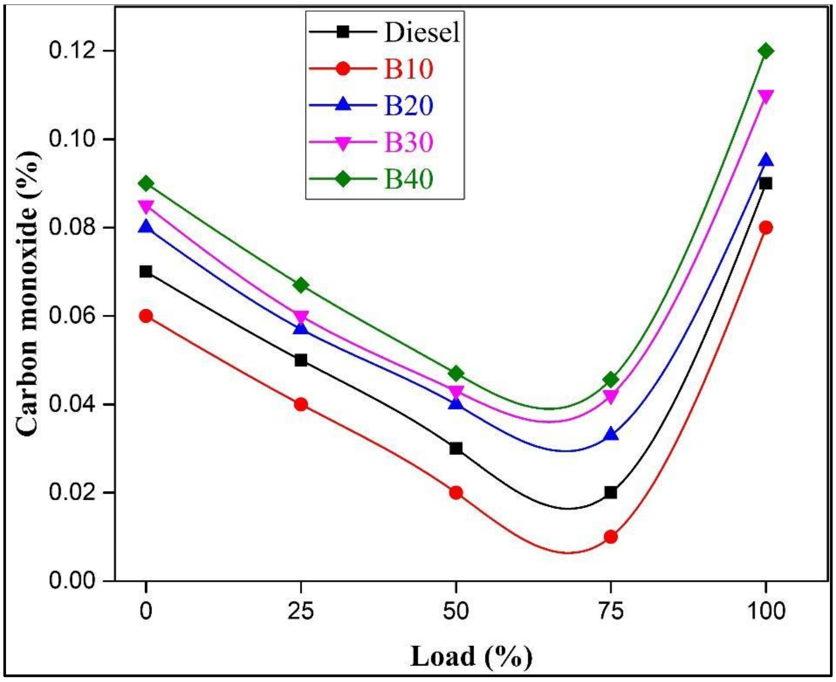

Fig 6 Load vs Carbon monoxide emissions

The variation of HC emissions with respect to load has displayed in **Fig 7.** Liberation of HC emissions mainly due to improper burning of fuel inside the combustion chamber. At full load, HC emissions for diesel, B10, B20, B30 and B40 blends are noticed as 70, 86, 112, 153 and 191 ppm, respectively. The 10% blend of Juliflora blend has exposed near to baseline readings. B10 blend has shown lowest Carbon monoxide emissions among the all tested fuel blends. Low cetane number of JMSE has resulted in shorter ignition delay. This will enhance the combustion phenomenon which results in lower CO emissions.

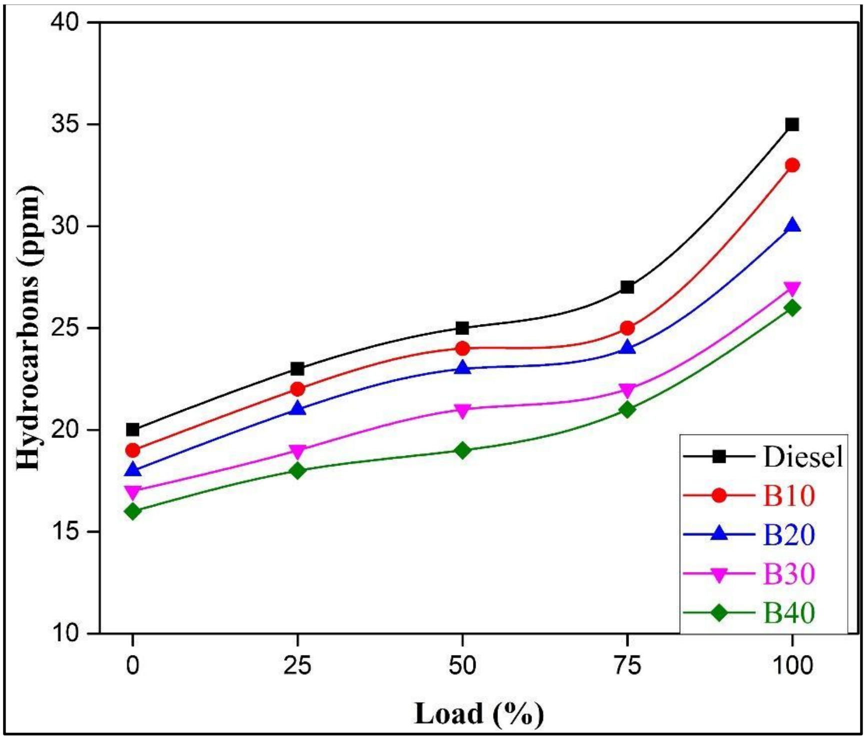

Fig 8 Load vs Hydrocarbon emissions

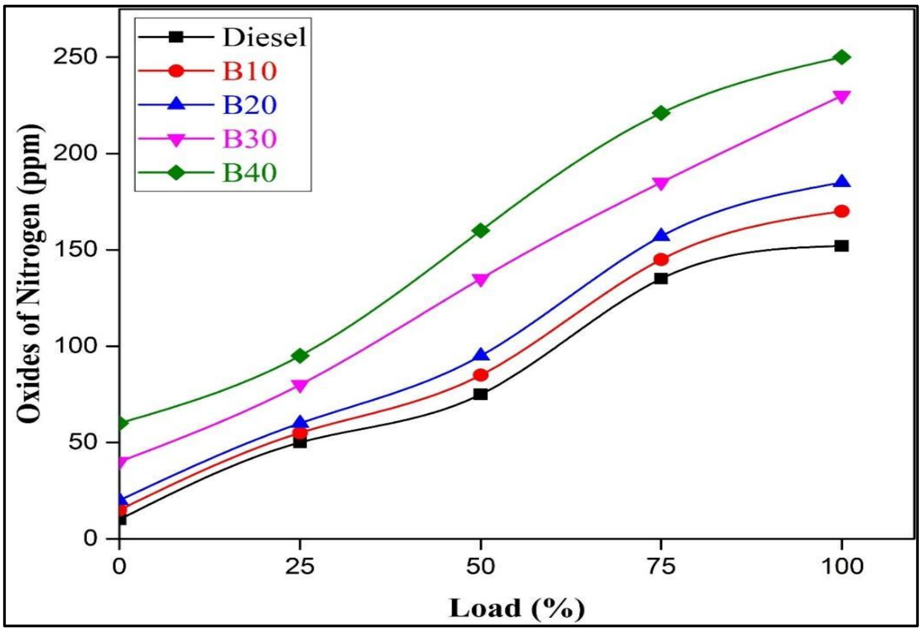

Fig 9 Load vs Oxide of Nitrogen emissions

High temperature and excess Oxygen inside the cylinder are the main reasons for production of NO_x emissions in CI engines. Biodiesel blends of JFME have generated slightly higher NO_x emissions than diesel at all loads. The variation of NO_x emissions with load is presented in **Fig 9**. The NO_x emissions are 152, 170, 185, 230 and 250 ppm for diesel, B10, B20, B30 and B40, respectively. At maximum load, emissions of NO_x are highest and 64.4% higher for B100 blend compared to diesel whileblend B10 showed 13.5% higher. This was mainly due to high flame temperature and inherent Oxygen content of JFME. The reduction of NOx emission is highly desired for best emission performance.

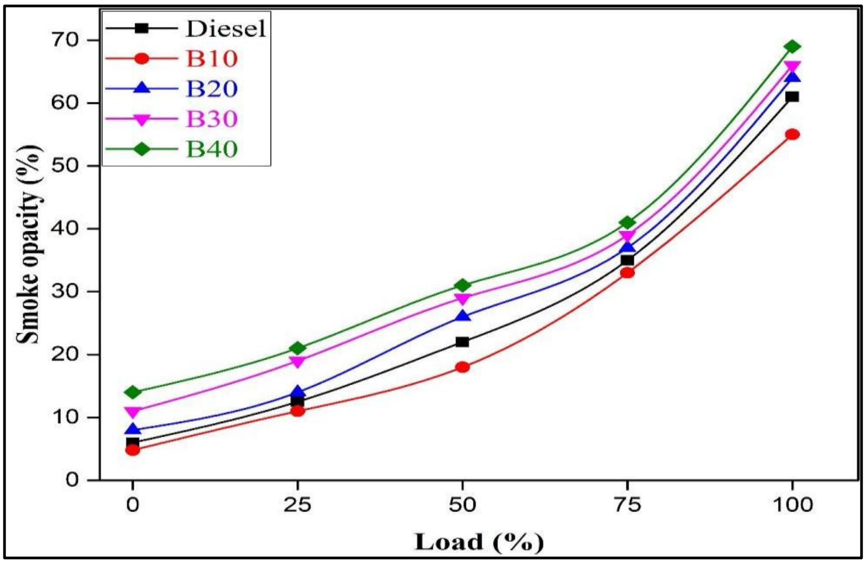

Fig 10 Load vs Smoke Opacity

Fig 10 depicts the change of Smoke opacity with respect to engine load. A significant reduction of smoke opacity by 9.83 % is observed when engine run at B10 fuel blend. This is because of Oxygenated nature of JFME biodiesel. Another reason for low smoke emission of B10 blends is low Carbon content of JFME. At full load smoke emissions are noticed as 61, 55, 64, 66 and 69 % for diesel, B10, B20, B30 and B40 respectively. B20, B30 and B40 blends of Juliflora biodiesel blends showed higher amounts of smoke emissions. This may be owing to high density and viscosity of JFME which leads to poor atomization of fuel.

Table2 Final results of Experiment at full load

Parameters	Diesel	B10	B20	B30	B40
BTE (%)	32.64	31.93	30.63	28.4	26.152
BSFC (kg/kW-h)	0.276	0.286	0.297	0.321	0.342

V. CONCLUSIONS

CO (%)	0.09	0.08	0.095	0.11	0.12
HC (ppm)	35	33	30	27	26
NO_x (ppm)	152	170	185	230	250
SO (%)	61	55	64	66	69

After doing a series of experiments on diesel engine, the major conclusions are drawn as follows.

- It is noticed that B10 blend of Juliflora biodiesel has exhibited highest BTE among all the blends. At full load BTE for Diesel and B10 are 32.64 and 31.93%.
- B10 blend shown lowest BSFC among all Blends of Juliflora biodiesel and it is slightly higher than diesel value.
- CO emissions are low in case of B10 blend among the all tested fuels.
- All blends of Juliflora biodiesel have shown lower HC emissions than diesel. B40 blend of Juliflora biodiesel has shown lowest HC emissions.
- NO_x emissions are high in case of Juliflora biodiesel blends. B10 blend showed low emissions while B40 Blend disclosed highest NOx emissions.
- Smoke opacity was low when the enginewas running with B1O blend of Juliflora.

From the major findings of the experiment, it can be concluded that the B10 blend of Juliflora biodiesel has explored promising alternative fuel in diesel engine without modifications.

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AUTHORS PROFILE

Dasari Akhil, M. Tech student,Department of Mechanical Engineering, Lakireddy Bali Reddy College of Engineering, Mylavaram, AP, India.
Email: akhildasari1996@gmail.com.

Dr. K. Appa Rao, Professor, Department of Mechanical Engineering, Lakireddy Bali Reddy College of Engineering, Mylavaram, AP, India.
Email: apparaokadimalla@gmail.com