

Retraction

Retracted: Emission Measurement Analysis of Sapodilla Seed Oil Blending Fueled IC Engine

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

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- [1] P. M. Prabu, P. Sivaprakasam, V. Perumal, S. C. Kim, P. Balasubramani, and S. S. Kumar, "Emission Measurement Analysis of Sapodilla Seed Oil Blending Fueled IC Engine," *Journal of Nanomaterials*, vol. 2021, Article ID 2385356, 8 pages, 2021.

Research Article

Emission Measurement Analysis of Sapodilla Seed Oil Blending Fueled IC Engine

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This present work focused on investigating the thermal behavior and emission level of sapodilla oil mixed with diesel to an internal combustion (IC) engine. The behavior of the engine is measured via brake thermal efficiency (BTE), brake-specific energy consumption (BSEC), heat release rate (HRR), cylinder pressure, and cumulative heat release rate (CHRR). The test results were evaluated with diesel fuel. Carbon deposits were low in sapodilla seed oil with slight variation of calorific value than standard diesel fuel. BTE value for case B20 is found to equal diesel fuel. For lower and higher blends, the cylinder pressures are lower than the diesel fuel. HRR decreased as increased of the blend ratio. Inferior blends of sapodilla are emitted lower HC and CO. The BTE of B100 works 88.13% efficiently, similar to diesel for low load conditions. When compared to diesel, a maximum NO_x reduction of up to 30% was achieved while using the sapodilla blend. It is found that the oil derived from the sapodilla seed kernels will be the promising additive for fossil fuels for a greener environment.

1. Introduction

The world towards the substitute renewable ecological resource fuels from natural resources due to global oil supply production will be attained [1]. Researchers from several countries have conducted numerous experiments in an internal combustion (IC) engine using vegetable oils. They found the thermal efficiency of different oil cerates is considerably experienced with the mineral diesel. In vegetable oil, the particulate emissions are higher, and the CO, NO_x, PAH, and SO_x values are lesser when compared with diesel. The minor variation in the fuel system, vegetable oil is suitable as a substitute for conventional fuel. On the other side, the imperfect combustion effect, the minor atomization, and the lower vol-

atility lead to higher emission formation and the gum deposit in the cylinder cavity. As a result, pure vegetable oil has inefficient effectiveness while using fuel in IC engines [2].

Animal fats and vegetable oils are renewable sources from nature, which are low emission properties and ecological. It has better probability to reduce the pollution [3]. Numerical and experimental methods examined the fuel injection angle on the delivery system for diesel [4]. Low bioethanol fraction mbwazirume used as fuel in the engine [5] and found E15 gives low CO and CO₂ emission. The soya bean blend performance with emission behavior was analyzed on diesel engine (DE) by numerical and experimental technique [6]. The engine performance results significantly increased when the mahua was used as the additive [7]. The



(a) (b)

FIGURE 1: (a, b) Sapodilla broken seeds and seed kernel.



FIGURE 2: Oil extraction machine with sapodilla inner seed kernels.

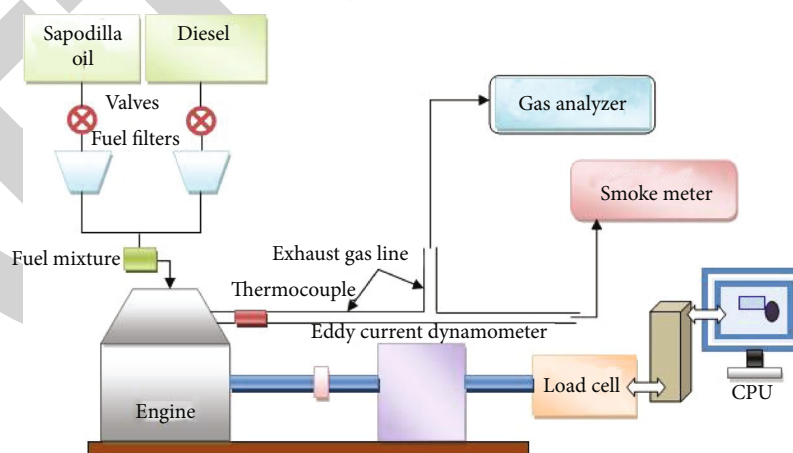


FIGURE 3: Experimental setup—schematic diagram.

energy level and emission outcome of *Moringa oleifera* and palm oils utilized as fuel for diesel engines with percentages of MB5, MB10, PB5, and PB10 were compared to diesel [8]. In addition, the DE (single cylinder) behavior and smoke level of karanja oil [9], free fatty acid neem oil [10], *Jatropha* oil [2, 3], and mixes were investigated. The detailed energy

production from various waste biomass and biochar are given [11, 12]. *Camelina sativa* oil performed effectively in an IC engine with minor fuel system modifications [1]. Food and fuel are the most important factors and raises even for the next-generation biofuel when cultivation pattern may have direct and indirect effects on fuel supply cost [13].

TABLE 1: Types of blends (sapodilla oil with diesel).

Sl.No	Sapodilla oil-diesel percentage	Name
1	0% + 100%	Mineral diesel only
2	10% + 90%	B10
3	20% + 80%	B20
4	50% + 50%	B50
5	75% + 25%	B75
6	100% + 0%	B100 (pure sapodilla oil)

Jaikumar et al. [14] studied about the performance of Niger seed oil with methyl ester on diesel engine and reported the smoke opacity decreased by 5.09%. The lesser ignition delay for neat rapeseed oil with its blend on DE and the combustion character closely followed the diesel [15]. Properties of soap nut oil blend (SNO) 10% were given better IC engine performance [16]. The CO, HC, and smoke emissions were deduced, and then, the NO_x emission somewhat increased when the load at partial and higher condition on IC engine using diesel bioethanol as fuel [17]. The jojoba oil (B20) and sunflower oil (S100) were found to be the promising substitute fuel for DE with no engine alteration [18].

The methyl esters and the apricot seed-kernel oil with lesser concentration significantly accelerated engine performance with exhaust emissions [19]. The analysis carried about emission behavior by preheated raw rapeseed oil with the diesel mix at IC engine [20]. The highest engine performance was observed at the injection pressure 250 bar, BTHE enhanced in 8.9%, and the BFSC improved in 10% [1]. The brake thermal efficiency was determined to be 2.4% percent when the brakes were fully loaded, and the combustion character was comparatively similar with diesel fuel for Eu50 (eucalyptus oil blends) with Me50 mix (methyl ester of paradise oil) [21]. The relatively estimated performance characteristics of the karanja, polanga, and Jatropha using the tractor engine [22]. The turpentine diesel blend is used as alternate fuel in the dual fuel engine with slight modification [23]. The Jatropha oil was used as fuel and found that the fuels 97.4%/2.6% mix given the highest cetane number [24]. The slight alters in DE for raw vegetable oil and the higher emission induced [25] when NO_x reduced. Recently, researchers concentrate on biofuel extraction from various natural resources such as Jatropha seeds [26], cashew nut [27], and deoxygenated vegetable oils [28]. Also, the researchers used several vegetable seeds for producing biodiesel and carried out their research experiments on that fuel. Based on the comprehensive literature survey, it is found that less concentration focused on the sapodilla oil. This work deals with sapodilla oil's thermal energy and emission levels among its blends in DE.

2. Experimental Procedure

2.1. Extraction of Sapodilla Oil. From the fruit, the seeds are removed, and the seeds are dried for one or two days at room temperature. The hard outer cover of seeds is broken (Figure 1(a)), and the inner seed kernels (Figure 1(b)) are

separated manually. These seed kernels are then grounded in the electric-driven oil expeller, and pure brown, clear high viscous sapodilla oil is extracted (Figure 2).

2.2. Engine Setup. Experimental work is conducted at the 4-stroke diesel engine (single cylinder) combined with an eddy current dynamometer. The experimental setup is illustrated schematically in Figure 3.

The data acquisition system is coupled with the engine via an interface, and signals are recorded in the connected computer. The signals from the engine, a slight engine warm-up is needed for few cases of blends. The Kirloskar, TV-1, single cylinder, 4-stroke, DE is utilized for analysis, and it is a water-cooled system. DE have a rated power of 5.2 kW (7 hp) with 1500 rpm of speed, and the compression ratio is 17.5:1. Nozzle opening pressure is between 200 and 205 bar, and the brake mean effective pressure (BMEP) value is 6.34 kg/cm³ for the bore and stroke length 102 and 116 mm. The displacement volume is 0.9481.

2.3. Emission Measurements. The exhaust gas is passed through the portable multigas analyzer (AVL) to the exhaust pipeline. The AVL is used to measure CO, HC, CO₂, and NO_x. The experiments are conducted for several blends of varying concentrations of sapodilla oil (Table 1).

3. Results and Discussions

3.1. Physical and Chemical Concentration. A physical and chemical concentration of raw sapodilla oil with ASTM standard is specified in Table 2. From the results, the cloud point, density, and pour point of the sapodilla oil are high compared to mineral diesel. Therefore, sapodilla oil is unsuitable for colder climates. Sapodilla oil has high flash and fire points, and it is safe to handle. It is found that the ash content is higher for sapodilla oil when compared to diesel fuel.

From the results, the calorific values of diesel and sapodilla oils are 41.536 kcal/kg and 45.343 kcal/kg, respectively. It is visible that new sapodilla oil has 90.16% of calorific energy when compared to diesel. The combustion delay of sapodilla oil (48.1) was found to be lesser as evaluated with diesel, according to cetane number measurements (diesel, 47). The sulfur level is lower for sapodilla oil. The blends of sapodilla oil-diesel considered for the present investigation are B10, B20, B50, B75, and B100, and it is subject to the following rated load variations such as 20%, 40%, 60%, 80%, and 100%.

3.2. Combustion Characteristics

3.2.1. BSEC Value of Sapodilla Blends. Figure 4 depicts the BSEC value of diesel, B100, B75, B50, B20, and B10 for different load conditions. As two different fuels with different density properties are used as fuel in the IC engine, the BSEC may be suitable for brake-specific fuel consumption [21]. From the results, the BSEC value decreased with load increases for all the blends. B100 pure sapodilla oil is having the highest BSEC than diesel.

It occurs because of higher volatility, dense, and density along with lower heat content capability. These natures are

TABLE 2: Raw sapodilla properties.

Properties	Raw sapodilla oil	Mineral diesel
API gravity	22.9	36.95
Density @ 15°C	915.5 kg/m ³	840 kg/m ³
Kinematic viscosity @ 40°C	42.3 C St	2.44 C St
Flash point	295° ± 1°C	71° ± 3
Fire point	310° ± 3°C	103° ± 3
Cloud point	14° ± 1°C	3° ± 1°C
Pour point	Bel + 2°C	-6° ± 1°C
Ash point	0.43 wt%	0.01 wt%
Total sulfur	0.023% S wt%	0.25
Specific gravity @ 15/15°C	0.9163	0.838
Total acid number	0.087 mg of KOH/gm	0.2 mg of KOH/gm
Cross calorific value	41.536 kcal/kg	45.343 kcal/kg
Cetane no.	48.1	47
Carbon (%w/w)	84.37	80.33
Hydrogen (%w/w)	13.52	12.36
Nitrogen (%w/w)	0.21	1.76
Oxygen (%w/w)	1.88	1.19
Sulfur (%w/w)	0.018	0.25
Conradson carbon residue	0.71%	0.1 ± 0.0%

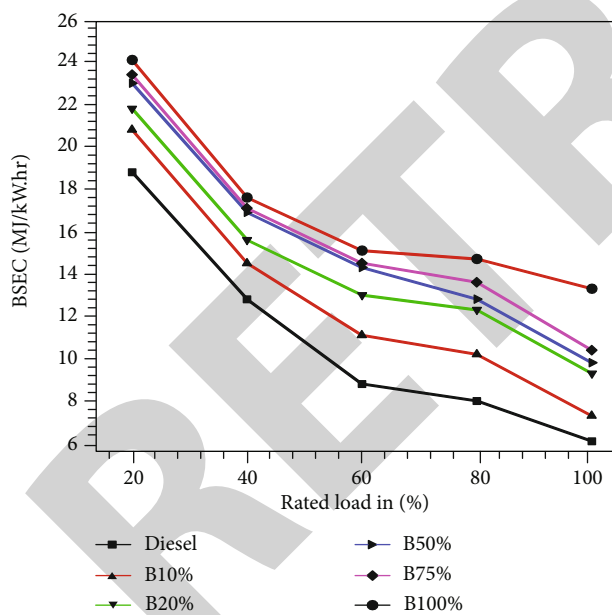


FIGURE 4: BSEC of sapodilla oil and diesel.

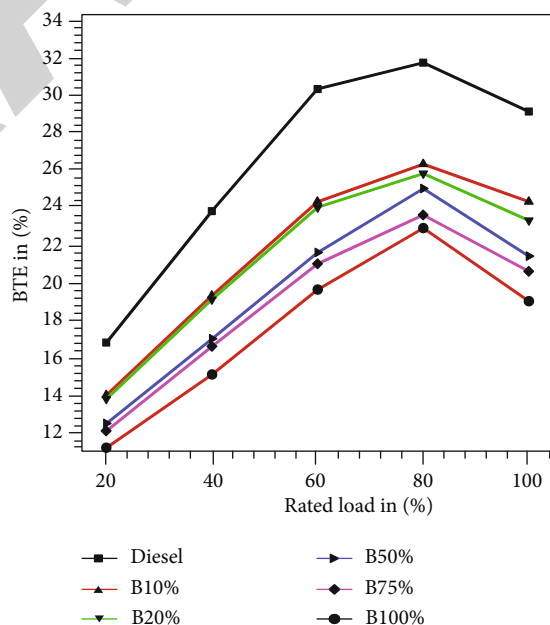


FIGURE 5: BTE of sapodilla oil and diesel.

lead to incomplete combustion and results in unburnt fuel. Hence, the usage of pure sapodilla oil leads to additional fuel to meet the engine's requirement for the same load. For any particular load, when blend decreases, the BSEC approaches towards convectional mineral diesel. However, this trend follows a nonlinear trend.

3.2.2. BTE of Sapodilla Blends. Figure 5 denotes the influence of rated load in connection with BTE for sapodilla and diesel.

BTE is increased with the rated load up to 80% and further decreased gradually with an increase in load. When adding sapodilla oil to diesel as a blend, the BTE decreases for all the cases. Similar BTE trends are noticed for B10 and B20 BTE up to 60% load, and it denotes the lesser effect on BTE when incrementing the blend by 10%. Due to the calorific value effect, the BTE value decreases for the remaining cases. The maximum BTE of 27.05% is noticed for B10 with the

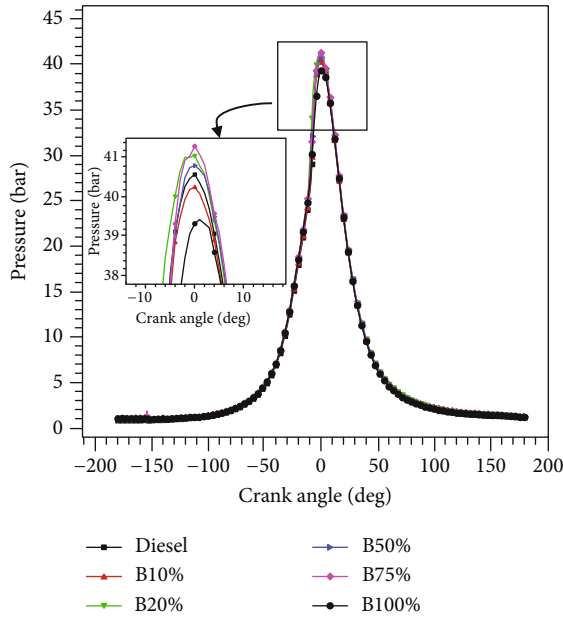


FIGURE 6: Cylinder pressure of sapodilla oil, diesel, and various blends.

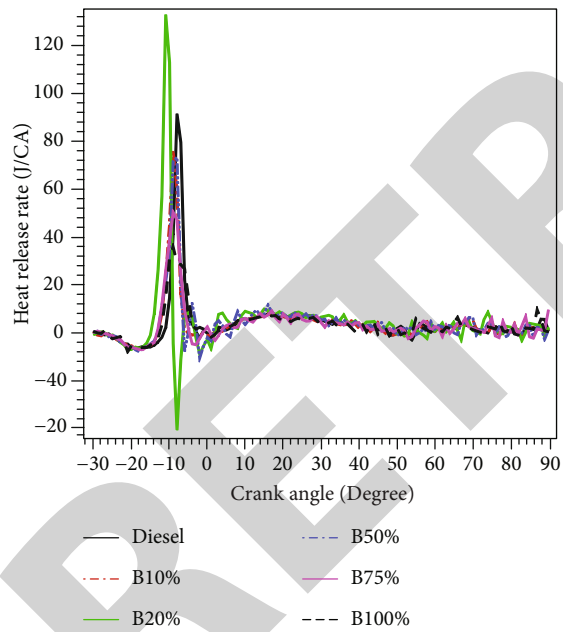


FIGURE 7: HRR of sapodilla oil and diesel.

rated load of 80%, and also, the 80% rated load gives the maximum BTE for all the cases considered. The BTE of B100 works 88.13% efficiently, similar to diesel for low load conditions.

3.2.3. Variations of Cylinder Pressure with Crank Angles. Figure 6 depicts the cylinder pressure for sapodilla oil mixes and diesel at various crank angles. First, the peak pressure 41.3 bar occurs, corresponding to B75. Then, the peak pressure is 40.5, 40.24, 41.06, 40.80, 41.25, and 39.43, corresponding to diesel, B10, B20, B50, B75, and B100, respectively, and

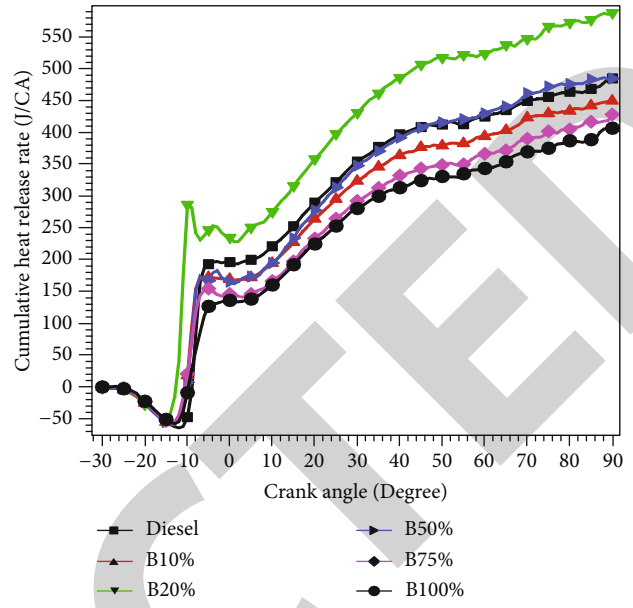


FIGURE 8: CHRR of sapodilla oil and diesel.

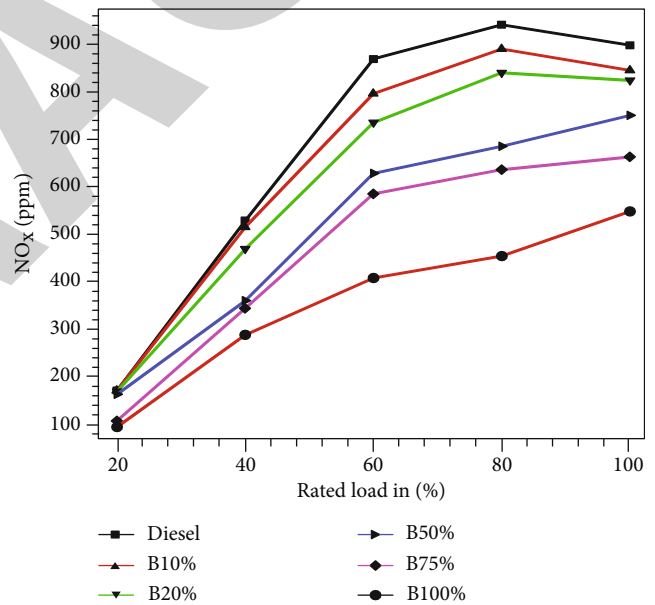


FIGURE 9: NO_x emission of sapodilla oil, diesel, and various blends (biodiesel) with respect to loads.

it happens by the consequence of cetane number, which is higher and very close to diesel, so that the blends B20, B50, and B75 showed higher cylinder pressure. Devan and Mahalakshmi [21] and Gad et al. [26] noticed a similar kind of cylinder pressure behavior.

3.2.4. HRR of Sapodilla Blends. The changes in HRR with crank angle higher rated load, 100% (maximum load), are shown in Figure 7. The fluctuations in HRR of sapodilla blends with crank angle are observed from the diagram, and the B20 sapodilla blend provides high heat releases. When the blending ratio increases, the HRR tends to

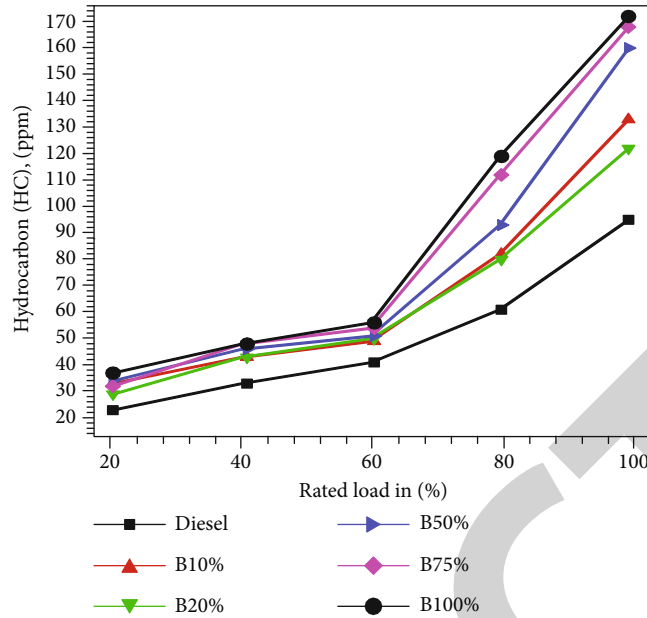


FIGURE 10: Hydrocarbon emissions of sapodilla oil and blends and diesel with respect to loads.

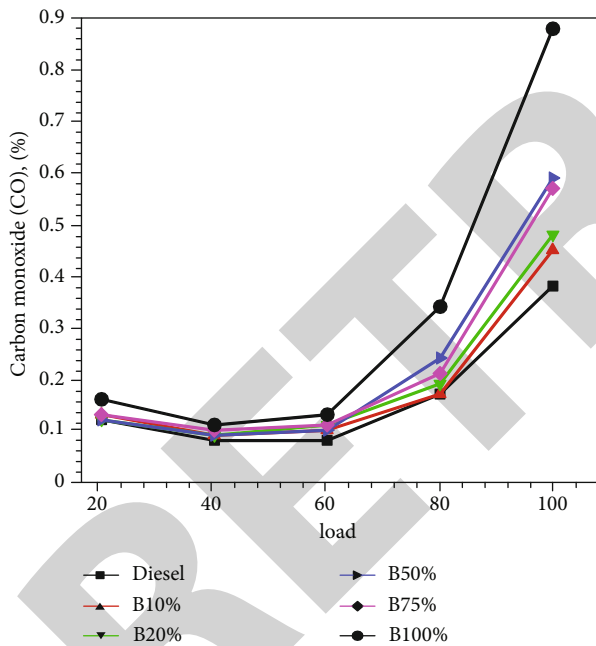


FIGURE 11: CO emission of sapodilla oil, diesel, and various blends (biodiesel) with respect to loads.

decrease. The atomization is affected when the blend quantity is increased, which results in a decrease in HRR.

3.2.5. Fluctuations in Cumulative HRR with Different Crank Angle. Figure 8 shows the CHRR in connection through crank angle for various blends. Initially, CHRR is negative because of ignition delay, which affects fuel evaporation accumulation, and afterward, the CHRR value increased with a nonlinear trend. B20 produces the higher CHRR for all the crank angles. This occurring due to more oxygen particles in the blended oil results higher CHRR value than diesel [29].

3.3. Emission Characteristics. Emission characteristics such as NO_x , HC, CO, and CO_2 are observed (Figures 9–12) for sapodilla oil and its blends.

3.3.1. Oxides of Nitrogen (NO_x). In general, due to absolute and higher burning temperatures, NO_x emissions are high. This can be oxygen content present in sapodilla fuel and mixtures, and it helps the better combustion process. The maximum combustion temperature is targeted by this efficient combustion. When the higher temperature occurs in the burning, the NO_x reaches its maximum [17]. The NO_x emission for various blends of sapodilla oil and diesel used for different load conditions is presented in Figure 9. NO_x emission for B10 acts similar to diesel for the corresponding load of 20%. Reduction in NO_x has been identified when adding sapodilla oil to diesel from B10 to B100 for all rated loads. B100 blends for the 20% rated load resulted in 44.8% less NO_x emission than diesel. Shi et al. [30] observed the same trends on their analysis. When compared to diesel, the maximum NO_x reduction up to 30% was achieved while using sapodilla blend.

3.3.2. Hydrocarbon Emissions (HC). Figure 10 depicts the HC values for various sapodilla blends and diesel for various load conditions. At 40% of the rated load, the hydrocarbon emissions of B50 and B75 are almost equal to diesel. However, for all rated loads, the HC emissions are higher for various blends due to sapodilla oil present when evaluating with diesel. Occurring of this incident, perhaps, the influence of higher viscosity and carbon content value is present in sapodilla. Hence, these properties react to the lower dispersion at the combustion chamber. Also, similar behavior was noticed by Barabas et al. [17]. In all the blends and loads, HC values were lower than the diesel value and the same tendency was noticed by Balakumar et al. [31].

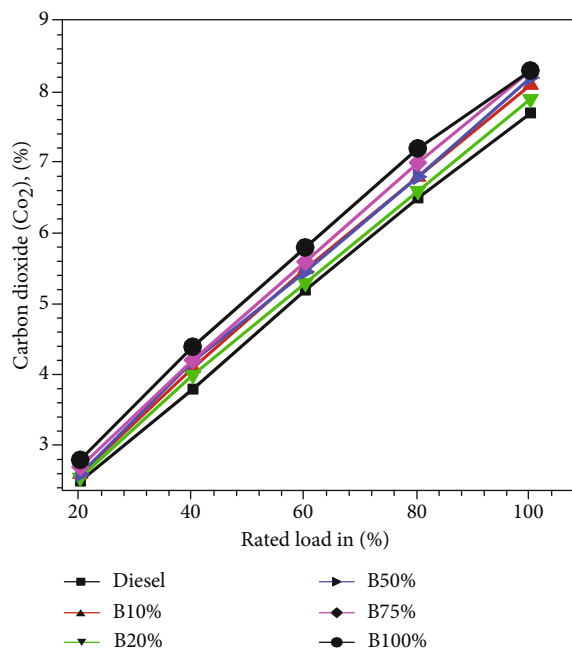


FIGURE 12: CO₂ emission of sapodilla oil, diesel, and various blends (biodiesel) with respect to loads.

3.3.3. *Carbon Monoxide Emissions (CO)*. The CO emissions for various sapodilla blends are compared with mineral diesel, shown in Figure 11. The CO emission value of sapodilla oil blends at lesser load condition is close to the mineral diesel. For example, the B20 and B50 CO emissions are equal to diesel emission for a rated load of 20% [32]. For a rated load of 80%, the B10 blend showed a closer CO emission than that of mineral diesel. A similar trend is observed by [10, 33]. The CO emissions of B10, B20, and B50 at the rated load of 40% increased, and CO values little higher than diesel. CO will be higher for blended oil due to reduced oxygen during ignition delay inside the cylinder at full load conditions.

3.3.4. *Carbon Dioxide Emissions (CO₂)*. Figure 12 describes the CO₂ for various sapodilla blends. The rated load of 80%, B20, and B50 blend shows lesser CO₂ emissions, and for the rated load of 20%, B20, B50, B75, and B100, the CO₂ emissions are comparatively equal as evaluated with diesel fuel. The B75 is given the exact value of the CO₂ emission of diesel for a rated load of 80%. The CO₂ emissions are gradually increased with the increase of load from 20% to 100%. Lower emission of CO₂ is noticed caused by the higher viscosity of the sapodilla blend. Here, the complete combustion is indicated the more emission of CO₂. Hence, higher CO₂ emissions in all mixes indicate efficient combustion due to oxygen, resulting in complete fuel combustion. The CO₂ values were increased from 1% to 11% when evaluated with diesel. From the properties of fuel, sapodilla is having an oxygen value of 1.88 and diesel is having an oxygen value of 1.19; based on this variation, it acts a virtual role on CO₂ emission.

4. Conclusions

The thermal behavior and emission levels of sapodilla blends with a diesel mix are studied in unmodified DE. The viscosity of the mixture is lowered in this test by combining it with diesel. The properties of sapodilla oil and diesel are investigated in terms of their physical, chemical, and thermal properties. The BSEC decreases with increasing loads for all the blends, and BTE increased with load up to 80% rated load and after that decreased gradually with an increase in loads.

- (i) The BTE of B100 works 88.13% efficiently, similar to diesel for low load conditions
- (ii) The variations in-cylinder pressures are nearer to diesel, and as the blend ratio increased, the heat release rate decreased
- (iii) The sapodilla oil blends showed lower NO_x emission than diesel
- (iv) The higher percentage of sapodilla blends had given the higher level of HC emissions in every load condition
- (v) The emission level of CO for the sapodilla is close to diesel at lower and medium load conditions
- (vi) The CO₂ emissions increase when the load increases. When compared to diesel, the maximum NO_x reduction up to 30% was achieved while using sapodilla blend

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding the publication of this paper.

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