

# Application of *Jatropha (Gossypifolia Linneus)* Seed Oil as Additive for the Reduction Fuel Consumption from Diesel Engine Combustion

Nasir A. U<sup>1,2\*</sup>, Uzoije A. P<sup>3</sup>, Anyanwu J. C<sup>4</sup>, Nwachukwu J. I<sup>5,6</sup>, Rufai Abdul<sup>7,8</sup>, Ameh A. Y<sup>9</sup>

<sup>1,3,4,5,7,9</sup>Department of Environmental Management, School of Environmental Sciences,  
Federal University of Technology, Owerri, Imo State, Nigeria

<sup>2,6,8</sup>Department of Sustainable Environmental Studies, Centre of Excellence in Sustainable Procurement,  
Environmental and Social Standards (CE-sPESS), Federal University of Technology Owerri, Imo State, Nigeria

\*Corresponding Authors: Nasir A. U

## ABSTRACT

*Jatropha Gossypifolia linnues* is also grown in different parts of Nigeria especially the northern parts. It is usually planted to grow as live fences and hedge plants in homesteads and gardens. Its ecological performance in the country is such that it can grow in the semi-arid, arid and tropical climate. The is a robust woody shrub of light gray bark which may reach an average height of 4m in not so favourable environment and a good average of 9 m in good climatic conditions. The burning of fossil diesel fuel is one of the biggest contributors of pollution in the environment. Diverse factors such as global environmental issues, increasing petroleum prices, and the fact that the fossil diesel fuel is finite are some of the reasons why researchers are seeking to cleanly burn diesel engines with other fuels. Biodiesel can also be used as fuel and it can even be blended with diesel in their various proportions. This research is pure quantitative experimental research to determine the effect of the additive on diesel engine fuel consumption. Using Perkins 2200 SERIES 2206A-E13TAG2 diesel engine. It is a 13L, 6-cylinder, turbocharged, aftercooled engine with a direct injection electronic control system, and prime power of 350kVA (280kW). The *Jatropha* seeds were pressed using screw press at 120 rpm. The oil that was extracted was subjected to a thermal chamber at 120<sup>0</sup>C to eliminate the content of moisture. Crude *Jatropha* oil was combined with the conventional diesel in 5%, 10%, 15%, 20% and 25%. Each of the samples was heated with three temperatures (40, 60 and 80<sup>0</sup>C) and

was identified as JD1, JD2, JD3, JD4, JD5, Crude *Jatropha* oil (CJ) and diesel fuel. Results show that two major trends. Firstly, the viscosity of the diesel blends is rising with the concentration of JSO in the diesel. Diesel fuel record viscosity of 3.06mm<sup>2</sup>/s at 40<sup>0</sup>C. The viscosity of JD1 (5% JSO) is 5.55 mm<sup>2</sup>/s which gradually increases to 7.67 mm<sup>2</sup>/s (JD2), 18.4 mm<sup>2</sup>/s (JD4), and 24.98 mm<sup>2</sup>/s (JD5). Crude *Jatropha* oil (CJ) has the highest viscosity of 31.15mm<sup>2</sup>/s at 40<sup>0</sup>C. This pattern is found in all the experimental temperatures (60<sup>0</sup>C and 80<sup>0</sup>C). The 5% JSO mixture (DJ1) and the 10% JSO mixture (DJ2) consume less fuel as compared to standard diesel at all engine loads. DJ1 draws 68.0 L/hr and DJ2 draws 71.0 L/hr at 100% load which are much lower than the 80 L/hr of diesel. At a load of 25%, DJ1 (16.4 L/hr) is significantly lower than diesel (23 L/hr). There is increase in fuel consumption as the ratio percentage of JSO being used in the blend increases between DJ1 and DJ5. To illustrate, FC represents 55.0 L/hr in the case of DJ1, 58.5 L/hr in the case of DJ2, 62.5 L/hr in the case of DJ3, 67.0 L/hr in the case of DJ4 and 72.0 L/hr in the case of DJ5 (75% load).

**KEYWORDS:** *Jatropha seed, Load, Diesel, Fuel, Consumption, Viscosity.*

**How to cite this paper:** Nasir A. U | Uzoije A. P | Anyanwu J. C | Nwachukwu J. I | Rufai Abdul | Ameh A. Y "Application of *Jatropha (Gossypifolia Linneus)* Seed Oil as Additive for the Reduction Fuel Consumption from Diesel Engine Combustion" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-10 | Issue-1, February 2026, pp.136-146, URL: [www.ijtsrd.com/papers/ijtsrd100008.pdf](http://www.ijtsrd.com/papers/ijtsrd100008.pdf)



Copyright © 2026 by author (s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (<http://creativecommons.org/licenses/by/4.0>)



## INTRODUCTION

*Jatropha Curcas* is a drought-resistant shrub or tree that grows wild or in semi-cultivated environments (Kumar & Sharma, 2018). Depending on soil quality and rainfall, the oil from *Jatropha curcas* nuts and seeds may be obtained after 2–5 years after cultivation. *Jatropha Curcas* nuts or seeds are produced in quantities ranging from 0.5 to 12 tonnes per year per hectare. *Jatropha Curcas* farming is effective in the tropics, where annual rainfall ranges from 250 to 3,000 mm. The genus *Jatropha Curcas* belongs to the Euphorbiaceae family's Jatrophaeae tribe, and there are roughly 170 species recognised currently (Carels, 2019). The genus *Jatropha* gets its name from the Greek words “Jatros,” which means “doctor,” and “trophy,” which means “food,” and references to the plant's past medicinal uses (Kumar & Sharma, 2018).

*Jatropha Curcas* is a dense shrub or small tree that may reach a height of 3–5m. Under ideal circumstances, it may reach a height of 10 m. It has 2n - 22 chromosomes and is a diploid species (Carels, 2019). Despite having a native range that spans South and Central America, South-East Asia, Africa, and India the plant now has a pantropical distribution with distinct *Jatropha Curcas* seed provenances (Kumar & Sharma, 2011; Moser, 2011).

*Jatropha Curcas* may thrive in a variety of rainfall conditions, from 250 to over 1,200 mm per year (Divakara, Upadhyaya, Wani & Gowda, 2010).

Plantation areas of 2 m × 2 m, 2.5 m × 2.5 m, and 3 m × 3m, according to Ojiako, are adequate and generate higher fruit harvests (Ojiako, 2014). The second year of operation begins to produce fruit, and by the fourth or fifth year, the economic output has stabilised. It's possible the plant will survive for up to 50 years (Achten, Nielsen, Aerts, Lengkeek, Kjaer, Trabucco, 2010).

Moreover, *Jatropha curcas* is cultivated in various regions of Nigeria, particularly in the northern areas. It is commonly found growing as live fences and hedge plants around homesteads and gardens. The plant thrives in semi-arid, arid, and tropical environments, making it suitable for different ecological zones within the country (Ojiako, 2013). Federal University of Technology, Owerri: Approximately 2 hectares have been established for research and cultivation, with seeds sourced from locations like Ilorin and Lafiagi in Kwara State, and Mokwa in Niger State (Ojiako, 2013). It is a deciduous plant with a morphological discontinuity and an articulated growth habit. A primary taproot and four shallow lateral roots make up the root system (Abdelgadir and Van Staden, 2013). Smooth

greenish-bronze bark and transparent latex cover the glabrous branches. Smooth, 5-lobed, heart shaped leaves, ten to 15 cm long, dark green, cordate or round, acute at the apex, cordate at the base, alternating, and dropping once a year (Nayak & Patel, 2010; Kamal & Sharma, 2011).

*Jatropha curcas* yields substantial quantity of seed oil and is growing in importance as a source of biodiesel. In Nigeria, the plant has traditionally been grown as live fences and hedge plants around homesteads and gardens to screen off unwanted sites or protect crops against roaming animals. Traditionally, growers are not so much concerned with selection, production, dissemination, and access to improved seeds. With increasing interest in renewable energy around the world, it has become necessary for breeders to, in the first instance, identify and characterize the available germplasm in Nigeria. Subsequently, there is need for appropriate production practices relative to the different ecological zones in order to greatly expand cultivation (Ojiako, 2014). The flowers are borne in axillary clusters on a 3–5 cm tall stem with whole, lanceolate, or linear bracts that are highly pubescent and yellowish-green, and enormous glandular discs on the blooms (Perumal & Sanmugam, 2015). 5 ovateelliptic sepals, less than 4 mm long, 5 oblong-ovate petals, 6–7 mm long, densely hairy inside, and eight stamens make up the male flower. Female flowers are 4 mm long, with loose oblong petals and bigger sepals (Raju & Ezradanam, 2002; Abdelgadir et al., 2009). *Jatropha Curcas* oil production is expected to reach 1,590 kg/ha (Vyas and Singh, 2007; Gui et al., 2008; Janaun and Ellis, 2010). Fruits are trilobite ovoid capsules with three cells and a length of 23–30 mm by a width of 28 mm. The seeds of *Jatropha Curcas* have a thin shell and an oblong shape with a dark back colour (Dehgan, 2012).

The mature *Jatropha Curcas* seeds are 212 cm in length and may easily be cracked to extract the oil. Toxins such as phorbol esters, curcin, trypsin inhibitors, lectins, and phytates are present in such high amounts in most provenances' blackish seeds that the seeds, oil, and seed cake are not for human consumption without detoxification (Kumar & Sharma, 2011).

Moreover, the world's agitation and aggression for more energy is alarmingly on its increase. With the circumstantial availability of fossil fuel and its exhaustiveness, so much effort is fast going into its replacement as a major source of energy with another and also complementation. The rigours and time span that characterize the production of fossil fuel from long buried organisms under intense temperature and pressure are not favourable factors to readily assuage

its constant demands. The world at one stage in history had heaved a sigh of relief when it was obvious that this demand could be met by nuclear power plants until the Japanese Fukushima nuclear power plant disaster rewrote the history of energy quest. This singular occurrence has once again brought to the fore the necessity for global warming prevention.

Apart from solar power cells, wind generators, geothermal power sources, energy derivable from biomass and biodiesel have become the focal point of green energy for checkmating global warming, Thanh, Okitsu and Boi (2012).

Biofuel is perceived to be a reliable energy security, a panacea for greenhouse gas emission and environmentally friendly. Biofuel is derived from the edible or non edible oil from plants and animal fats. The biofuel from edible or non edible oil is known to be renewable because of the source reproduction in seasons. Kinney and Clemente T.E (2015). Biofuel could also be obtained from recycled waste vegetable oil and animal fats. The name biodiesel is used to describe environmental friendly and less polluting fuel for combustion and turbine engines because the carbon (IV) oxide (CO<sub>2</sub>) has earlier been absorbed while growth of plant was taking place and therefore CO<sub>2</sub> remains free from variation.

Biodiesel, close in combustion properties to fossil diesel is a methyl or ethyl ester of fatty acid. Developed countries in Europe and United States of America and of the world with little or no deposit of fossil oil have devised means of using biodiesel derivable from surplus edible oils such as rapeseed, sunflower and soybean oils as a source of driving pollution less economy. Africa and other developing nations naturally shy away from the luxury of converting edible oil to biodiesel simply for the purpose of feeding their teeming populace. Parawira W (2010).

In addition to that, countries endowed with fossil fuel and gas deposits are not constrained to look for alternative source of energy except when either the use of green house gas pollution or exhaustion of resource becomes obvious. It is pertinent to note that non-edible oils rather than the edible types have veritable use as biodiesel after appropriately converted for the purpose desired. This accounts for why plants like *Jatropha* readily comes to mind.

Features and climatic condition for cultivation *Jatropha curcas* is a plant that resists severe drought, thrives well on the worst fertile soil and most unfriendly climatic condition for plant cultivation. It grows easily and has the tendency to produce seeds

for far more than five decades. It is adaptable to arid and semi-arid conditions. The least effort is therefore required for good crop yield. A period of five years is enough to produce reasonable quantity oil if cultivated on good soil and with adequate rainfall condition. 35-40% of the seed mass of *Jatropha* contains oil. Datta and Mandal (2014).

### Important Plants in Biofuel Technology

Plants of substantial economic importance in this family include:

1. Roots: *Manihot Esculenta* (cassava)
2. Rubber: *Hevea Brasiliensis*
3. Nuts: *Caryodendron Orinocense* (tacy nut)
4. Vegetables: *Sauropus Androgynous* (katuk)
5. Oils: *Ricinus Communis* Linn (castor bean); *Aleurites* spp. (tung trees)
6. *Sapium Sebiferum* (Chinese tallow tree)
7. Physic nut. Hydrocarbon: *Euphorbia* spp.
8. Medical: *Croton* spp.; *Jatropha* spp.

*Jatropha curcas* oil has been characterized through various studies, highlighting its potential as a biodiesel feedstock and its physicochemical properties.

### Oil Yield and Composition

Recent literature indicates that *Jatropha curcas* seeds can yield oil contents ranging from 43% to 58%, depending on factors like genotype, age of the plant, and environmental conditions. For example, a study noted that the oil content in seeds varied significantly, with some genotypes producing up to 53.75% oil by weight.

### Physicochemical Properties

The oil's physicochemical characteristics are crucial for its application in biodiesel production. Specific Gravity: Generally low, which is favourable for biodiesel applications. Free Fatty Acid (FFA) Content: Ranges from 1.26% to 7.78%, with younger plants typically yielding higher FFA. Iodine Value: Indicates the degree of unsaturation; values can range from 61.10 to 93.60 mg/g oil, with older plants often producing oils with higher iodine values. Saponification Value: Varies with plant age, showing significant differences among genotypes. Cetane Number, ranges from 55.32 to 59.58, which is essential for diesel fuel performance.

### POLLUTION SOURCES

One of the most major sources of pollution in the environment is pollutants created by the burning of fossil diesel fuel. Diesel engine pollutants have a substantial impact on both the environment and human health. Researchers are looking into the clean combustion of diesel engines using other fuel sources due to a number of factors, including worldwide

environmental concerns, growing petroleum costs, and the expected depletion of fossil diesel fuel. For decades, scientists have been working throughout the world to discover new alternative fuels that are widely available, technically feasible, economically viable, and environmentally beneficial (Valipour, 2014).

Alternative energy sources are needed to address the world's growing energy demands. Biodiesel fuels are being researched as a possible replacement for diesel due to the predicted future depletion of fossil fuel sources and the present rising cost of such fuels. It has a higher cetane index and emits less carbon dioxide emissions, among other advantages.

Biodiesel is a clean-burning, oxygenated mono-alkyl ester fuel manufactured from natural, renewable sources like new or used vegetable oils and animal fats (Enweremadu & Mbarawa 2019).

### **DIESEL FUEL USES**

The first commercial diesel engines were large and operated at low speeds. They were used to power ships, trains, and industrial plants. By the 1930s, diesel engines were also powering trucks and buses. An effort in the late '30s to extend the engine's use to passenger cars was interrupted by World War II. After the war, diesel passenger cars became very popular in Europe; but, they have not enjoyed comparable success in the United States yet. Today, diesel engines are used worldwide for transportation, manufacturing, power generation, construction, and farming. The types of diesel engines are as varied as their use from small, high-speed indirect-injection engines to low-speed direct-injection behemoths with cylinders one meter (three feet) in diameter. Their success comes from their efficiency, economy, and reliability.

### **DIESEL FUEL KEEPS THE WORLD ECONOMY MOVING**

From consumer goods moved around the world, to the generation of electric power, to increased efficiency on farms, diesel fuel plays a vital role in strengthening the global economy and the standard of living.

The major uses of diesel fuel are

1. On-road transportation
2. Farming
3. Rail transportation
4. Marine shipping

In the United States, on-road transportation, primarily trucks, accounted for nearly 60 percent of the diesel fuel consumed in 2004. Because diesel fuel is used to move goods from manufacturer to consumer, its sales are linked to the strength of the economy.

### **DIESEL FUEL EFFECTS**

Advances in heavy-duty engine design have produced very large reductions in NO<sub>x</sub> and PM emissions, and it is expected that future advances in engine technology will reduce emissions even more. The composition of diesel fuel has traditionally had much less influence on emissions; however, reformulated diesel fuels have played a modest role in achieving needed emissions reductions. The most important fuel parameters in this regard are sulfur, cetane number, density, aromatics and volatility.

### **MATERIAL AND METHOD**

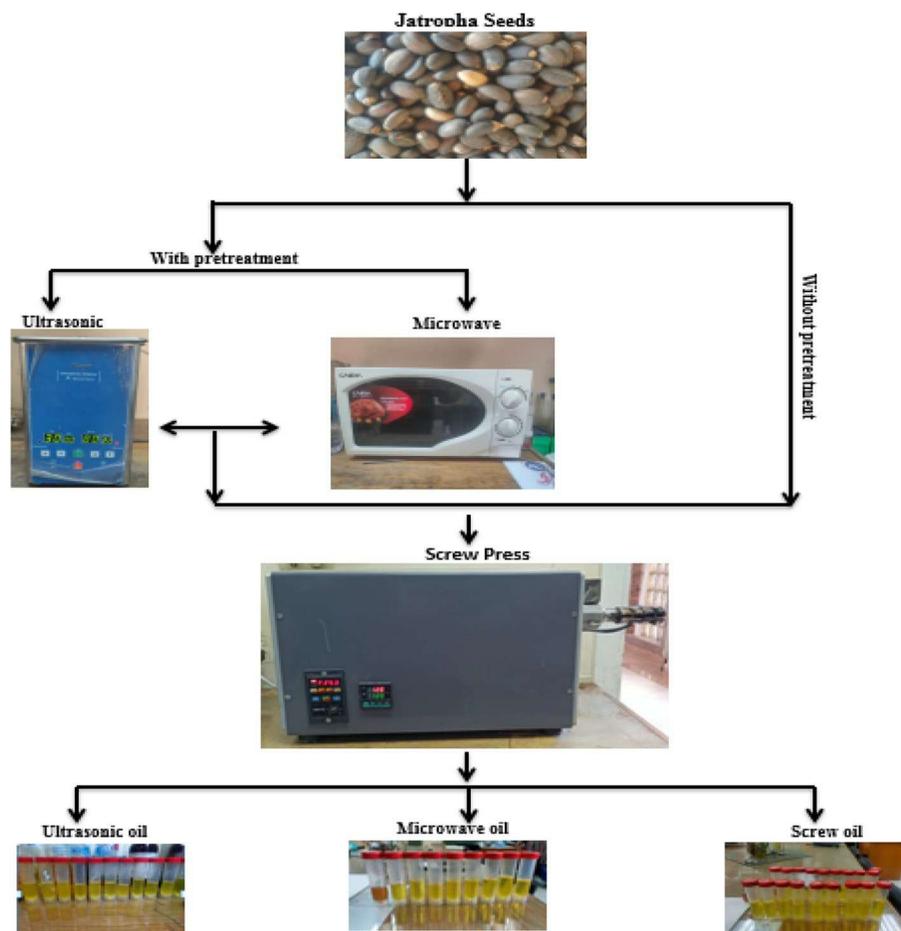
#### **The material and methods used in this research**

Jatropha seeds were obtained from a private farm. The seeds were peeled manually and crushed to ensure that the seeds contained embryo, that contains the oil content. To ensure that the seeds were not empty so that the empty seed husks, would not absorb a percentage of the oil.

#### **Mechanical Screw Extraction Method**

The oil extraction was performed using a specially designed laboratory-scale mechanical screw press. The specifications of the device were obtained from Ibrahim et al. (2020).

A photograph of the screw press and its components was shown in Fig. 2. Jatropha seeds were pressed at a speed of 120 rpm. The extracted oil was passed through a thermal chamber at 120 °C in order to remove moisture content.



**Figure 1. Schematic diagram of oil extraction by screw press from Jatropha seeds.**

### Ultrasonic Pretreatment

An ultrasonic device (Model: UD50Sh-2.5LQ), with ultrasonic power of 50W, total consumption power of 160W, and power supply of (220 VAC, 50 Hz), manufactured by Eumax in the USA, was utilized for the study. Three different exposure times (15, 30, and 45 minutes) and temperatures (40, 60, and 80 °C) were applied.

Crude Jatropha oil was extracted from Jatropha seeds using a screw press. Prior to extraction, the seeds were subjected to pretreatment (preheating) using both microwave and ultrasonic methods to enhance bio-oil production. The schematic diagram in Fig. 4 illustrated the sequence of oil extraction using the screw press.

For blending, the crude Jatropha oil was mixed with conventional diesel in proportions of 5%, 10%, 15%, 20%, and 25%. These blends were heated to three different temperatures (40, 60, and 80 °C) for each sample and labelled as JD1, JD2, JD3, JD4, JD5, along with Crude Jatropha oil (CJ) and diesel fuel. The viscosity of each sample was recorded accordingly.

Diesel fuel meter was installed in between the tank compartment and the injector system. All samples were stored in a safe location before being used to test fuel consumption on a Perkins 2206A-E13TAG2 engine (6 cylinders, 13 litres, turbocharged and aftercooled) equipped with a direct injection and electronic control system. The engine was compliant with EU Stage V/U.S. EPA Tier 4 Final or other global emissions standards, featuring a compression ignition system and constant speed operation. Viscosity at different temperature as well as Fuel consumption were recorded at various engine load levels: 25%, 50%, 75%, and 100%.

## RESULT AND DISCUSSION

### Results

This presents a detailed discussion and interpretation of the findings obtained from the experimental investigation into the application of Jatropha (*Gossypifolia Linneus*) seed oil as additive for the reduction emissions from diesel engine combustion. The Result focused on the elemental composition and physicochemical properties of JSO and its impact on fuel consumption at various engine loads of (25%, 50%, 75% and 100%) and JSO blend concentrations (DJ1: 5%, DJ2: 10%, DJ3: 15%, DJ4: 20%, and DJ5: 25%).

Understanding the equipment used is fundamental to contextualized the results.

### Technical characteristics of the diesel engine Used

details the specifications of the Perkins 2206A-E13TAG2 diesel engine employed for this research. This is a 6-cylinder, 13-litre, turbocharged, and aftercooled engine with a direct injection electronic control system, rated at 350 kVA (280 kW) prime power. Key specifications include a bore of 130 mm, a stroke of 157 mm, a displacement volume of 12.5 litres, and a compression ratio of 16.3:1. The engine is designed to meet EU Stage V/U.S. EPA Tier 4 Final emissions standards, operating at a constant speed of 1500 RPM.

The choice of a modern, electronically controlled engine like the Perkins 2206A-E13TAG2 is significant as it represents current engine technology widely used in power generation.

Its compliance with stringent emission standards (EU Stage V/U.S. EPA Tier 4 Final) means it incorporates advanced combustion and emission control strategies. Testing JSO blends in such an engine provides insights relevant to contemporary applications.

The direct injection system and electronic controls allow for precise fuel delivery and combustion management, which can influence how the engine responds to alternative fuels with different properties compared to standard diesel. The constant speed operation (1500 RPM) is typical for generator sets, making the findings particularly relevant for stationary power applications. The relatively high compression ratio (16.3:1) is characteristic of diesel engines and is crucial for auto ignition of the fuel.

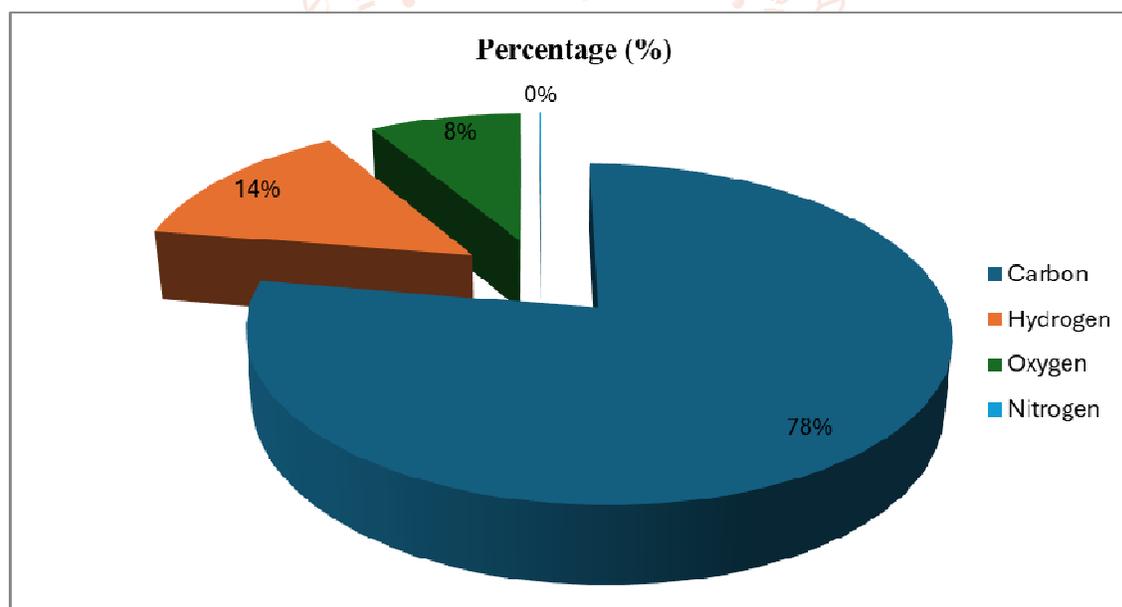
Fuels with good cetane numbers are important for such engines. The detailed specifications allow for reproducibility and comparison with other studies using similar engine platforms.

### Fuel Properties and their Implications

The inherent properties of *Jatropha* seed oil and its blends with diesel are pivotal in determining engine performance and emission outcomes.

**Table 1 Composition of the Sample (*Jatropha*) oil**

S/No	Element	Percentage (%)
1	C	77%
2	H	13.8
3	O	8.5
4	N	<0.1



**Figure 2 Show composition of the *Jatropha gossypifolia* seed oil (JSO)**

Table 1 presents the elemental composition of the *Jatropha gossypifolia* seed oil (JSO) used in this study, showing Carbon (C) at 77.6%, Hydrogen (H) at 13.8%, Oxygen (O) at 8.5%, and Nitrogen (N) at <0.1%.

The high carbon and hydrogen content are characteristic of hydrocarbon fuels, providing the energy upon combustion. The most notable element here is oxygen, present at 8.5%. Conventional diesel fuel has negligible oxygen content. This fuel-bound oxygen in JSO can act as an internal oxidant during combustion, potentially leading to more complete burning of the fuel.

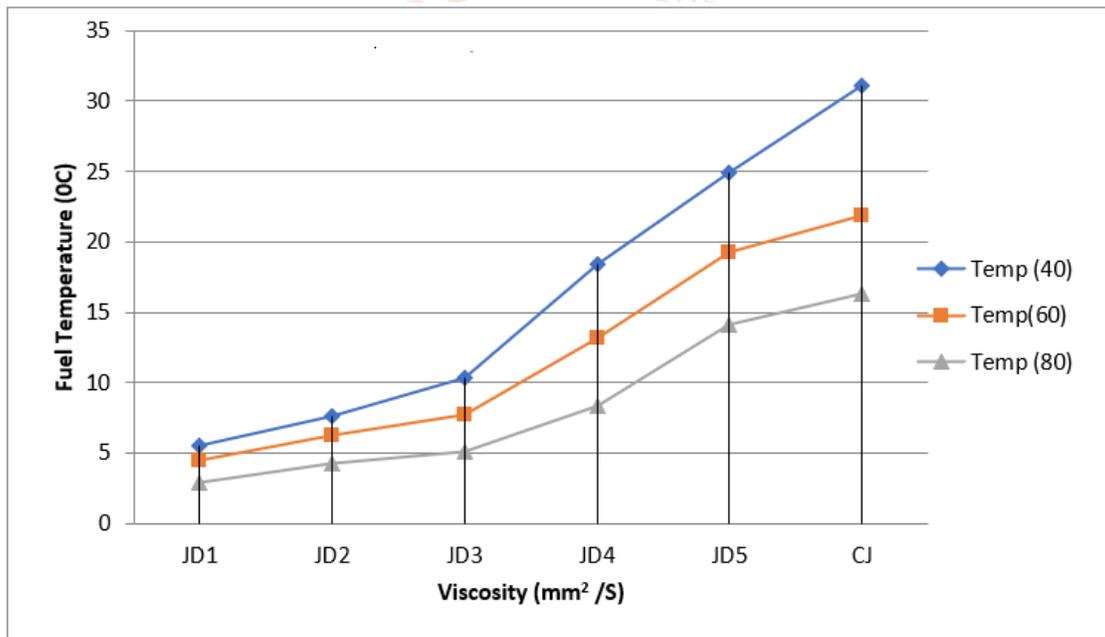
This improved combustion completeness is often associated with reductions in emissions like carbon monoxide (CO), unburned hydrocarbons (HC), and particulate matter (PM) (Mosquera et al., 2023; Hossain & Boyce, 2021).

The very low nitrogen content (<0.1%) is also beneficial, as fuel-bound nitrogen can contribute to NO<sub>x</sub> formation, although atmospheric nitrogen is the primary source in diesel combustion. The elemental composition directly influences the fuel's heating value and air-fuel ratio requirements.

**Table 2: Kinematic viscosity trend depending on the temperature (°C)**

Fuel Temperature (°C)	Viscosity (mm <sup>2</sup> /s)		
	40	60	80
DJ1	5.55	4.50	2.94
DJ2	7.67	6.29	4.34
DJ3	10.39	7.72	5.08
DJ4	18.40	13.26	8.34
DJ5	24.98	19.36	14.11
CJ	31.15	21.95	16.38
Diesel Fuel	3.06	2.01	

Table 2 above, presents the kinematic viscosity (mm<sup>2</sup>/s) of various fuel samples JSO-diesel blends JD1 (5% JSO) through JD5 (25% JSO), crude Jatropha oil (CJ), and standard diesel fuel at temperatures of 40°C, 60°C, and 80°C.



**Figure 3: Kinetic Viscosity Trend**

Two primary trends are evident from Table 5. Firstly, viscosity increases with increasing JSO concentration in the diesel blends. At 40°C, diesel fuel has a viscosity of 3.06 mm<sup>2</sup>/s. JD1 (5% JSO) has a viscosity of 5.55 mm<sup>2</sup>/s, which increases progressively to 7.67 mm<sup>2</sup>/s for JD2 (10% JSO), 10.39 mm<sup>2</sup>/s for JD3 (15% JSO), 18.4 mm<sup>2</sup>/s for JD4 (20% JSO), and 24.98 mm<sup>2</sup>/s for JD5 (25% JSO). Crude Jatropha oil (CJ) exhibits the highest viscosity at 31.15 mm<sup>2</sup>/s at 40°C.

This trend is consistent across all tested temperatures (60°C and 80°C). High viscosity is a well known characteristic of raw vegetable oils compared to diesel (Anbarasu & Karthikeyan, 2016; Adhikari *et al.*, 2020).

Moreover, viscosity decreases significantly with increasing temperature for all fuel samples. For example, the viscosity of JD5 drops from 24.98 mm<sup>2</sup>/s at 40°C to 19.36 mm<sup>2</sup>/s at 60°C, and further to 14.11 mm<sup>2</sup>/s at 80°C. This temperature dependency is crucial, as fuel is often preheated in engine systems or experiences elevated temperatures, which can help mitigate some of the adverse effects of high initial viscosity.

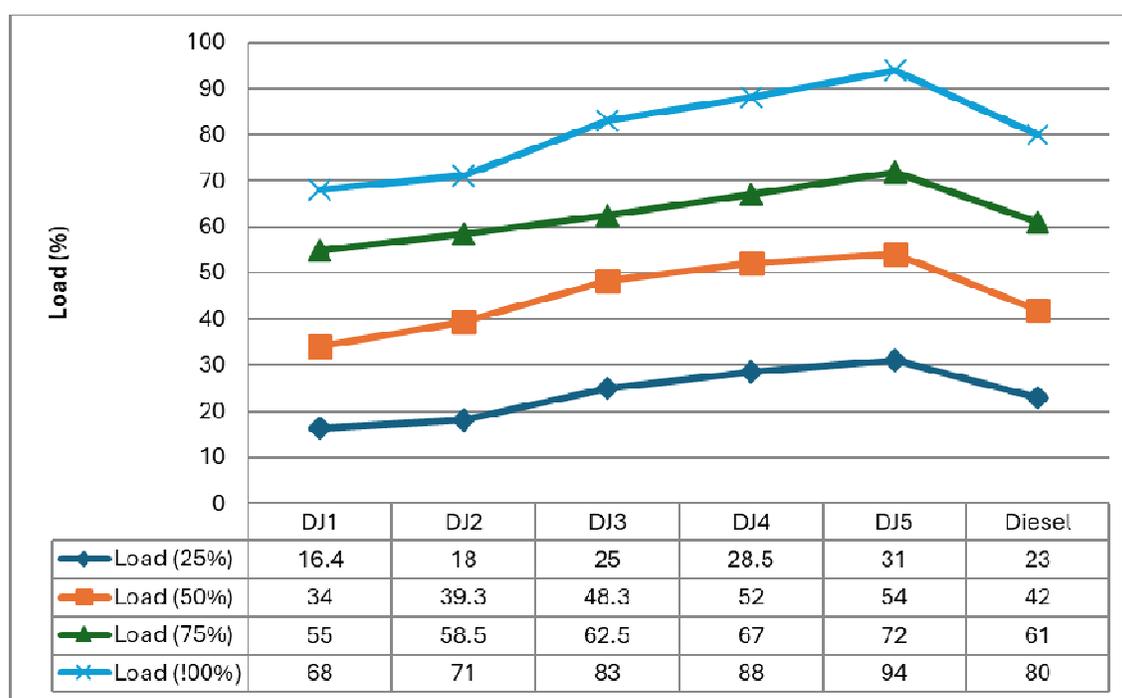
The implications of higher viscosity are significant for engine operation. Increased viscosity can lead to poorer fuel atomization during injection, resulting in larger fuel droplets.

These larger droplets have a smaller surface-area-to-volume ratio, leading to slower evaporation and mixing with air, which can cause incomplete combustion, increased engine deposits, injector cooking, and piston ring sticking (Pramanik, 2003; Adhikari, Koirala, Khatiwada, & Mahato, 2020). This, in turn, can negatively affect engine performance, increase fuel consumption. While blending JSO with diesel reduces its viscosity compared to crude JSO, even the 5% blend (DJ1) has a considerably higher viscosity (5.55 mm<sup>2</sup>/s) than pure diesel (3.06 mm<sup>2</sup>/s) at 40°C. This highlights that viscosity remains a critical parameter to consider even with low blend percentages.

**Table 3 Fuel Consumption**

	Load (25%)	Load (50%)	Load (75%)	Load (100%)
DJ1	16.4	34.0	55.0	68.0
DJ2	18.0	39.3	58.5	71.0
DJ3	25.0	48.3	62.5	83.0
DJ4	28.5	52.0	67.0	88.0
DJ5	31.0	54.0	72.0	94.0
Diesel	23.0	42.0	61.0	80.0

Table 3 details the fuel consumption (FC) in liters per hour (L/hr) for the five JSO-diesel blends (DJ1 to DJ5, representing 5% to 25% JSO respectively) and standard diesel fuel, measured at four different engine loads: 25%, 50%, 75%, and 100%.



**Figure 4: Fuel Consumption**

### Several cardinal trends emerge from the fuel consumption data:

1. Effect of Engine Load: For all tested fuels, fuel consumption consistently increases with increasing engine load. For example, diesel consumption rises from 23 L/hr at 25% load to 80 L/hr at 100% load. Similarly, DJ1 consumption increases from 16.4 L/hr at 25% load to 68.0 L/hr at 100% load. This is expected, as higher power output demands greater fuel input.

2. Comparison of Blends with Diesel

- A. Low Concentration Blends (DJ1 and DJ2)

Notably, the 5% JSO blend (DJ1) and the 10% JSO blend (DJ2) exhibit lower fuel consumption than

standard diesel across all engine loads. For instance, at 100% load, DJ1 consumes 68.0 L/hr and DJ2 consumes 71.0 L/hr, both significantly less than diesel's 80 L/hr. At 25% load, DJ1 (16.4 L/hr) is markedly lower than diesel (23 L/hr).

This suggests that at these low concentrations, JSO might be acting as a combustion enhancer or improving fuel properties in a way that more than compensates for its inherently lower energy content. Pramanik (2003) also reported that very low percentage Jatropha oil blends (e.g., 2.6%) could yield better engine performance and lower specific fuel consumption than diesel, possibly due to an ignition-accelerating effect.

**B. High Concentration Blends (DJ3, DJ4, and DJ5)**  
As the JSO concentration increases to 15% (DJ3), 20% (DJ4), and 25% (DJ5), fuel consumption surpasses that of standard diesel, especially at higher engine loads. At 100% load, DJ3 consumes 83.0 L/hr, DJ4 consumes 88.0 L/hr, and DJ5 consumes 94.0 L/hr, all higher than diesel's 80 L/hr. This trend is commonly observed with higher biodiesel or vegetable oil blend ratios and is primarily attributed to the lower net calorific value (heating value) of vegetable oils compared to diesel fuel (Mosquera, Trujillo, and Gonzalez, 2023; Adhikari et al., 2020). To produce the same power output, the engine must consume a larger volume of the lower-energy density fuel. Additionally, the higher viscosity of these blends could lead to poorer atomization and less efficient combustion, further contributing to increased fuel consumption (Anbarasu & Karthikeyan, 2016).

### C. Effect of JSO Concentration within Blends

At any given engine load, fuel consumption generally increases as the percentage of JSO in the blend rises from DJ1 through DJ5. For example, at 75% load, FC increases from 55.0 L/hr for DJ1, to 58.5 L/hr for DJ2, 62.5 L/hr for DJ3, 67.0 L/hr for DJ4, and 72.0 L/hr for DJ5.

The superior performance of DJ1 and DJ2 in terms of lower volumetric fuel consumption is a significant finding. It suggests an optimal range for JSO as an additive where its potential benefits (e.g., improved combustion due to oxygen content, better lubricity) might outweigh the negative impact of its lower heating value and higher viscosity. However, as JSO content increases beyond 10%, the detrimental effects of lower energy density and increased viscosity appear to dominate, leading to higher fuel consumption than diesel.

## Conclusion and Recommendation

### Kinematic Viscosity

The kinematic viscosity data clearly shows that while blending with diesel reduces JSO's viscosity, all blends remain more viscous than diesel, and viscosity increases with JSO concentration. This increased viscosity is a critical factor that can negatively impact fuel atomization and combustion quality, especially at higher blend ratios (Pramanik, 2003).

### Fuel Consumption

Results (Table 3) were particularly interesting. The 5% (DJ1) and 10% (DJ2) JSO blends demonstrated lower volumetric fuel consumption than standard diesel across all engine loads. This is a significant positive finding, suggesting that at these low concentrations, the benefits of JSO (perhaps improved combustion efficiency due to oxygen, or an ignition enhancing effect as suggested by Pramanik

(2003) for very low *Jatropha* blends) outweigh its lower energy density. However, as JSO concentration increased to 15% (DJ3) and above, fuel consumption surpassed that of diesel, a trend consistent with the lower calorific value and higher viscosity of *Jatropha* oil (Mosquera et al., 2023; Adhikari et al., 2020).

## Relevance to Sustainable Development Goals (SDGs)

1. SDG 7. Ensure access to affordable, reliable, sustainable, and modern energy (Affordable and Clean Energy).

*Jatropha gossypifolia linnues* seed oil can be converted into biodiesel, a renewable and cleaner alternative to fossil diesel. It offers higher cetane number and reduces emissions such as carbon monoxide and sulphates significantly, thus promoting clean and sustainable energy sources.

2. SDG 12. Ensure sustainable consumption and production patterns (Responsible Consumption and Production).

*Jatropha gossypifolia linnues* grows on marginal, degraded, or wastelands with minimal agricultural inputs, helping avoid competition with food crops and promoting sustainable biofuel production without harming food security.

## References

- [1] Achten W (2010) Sustainability evaluation of biodiesel from *Jatropha curcas* L. A life cycle oriented study. Katholieke Univer siteit Leuven.
- [2] Adhikari, S., Koirala, A., Khatiwada, D., & Mahato, K. (2020). Engine performance and emission characteristics of *Jatropha* biodiesel blends in CI engine. *Himalayan Journal of Science and Technology, Engineering, Agriculture and Food (HiJASE)*.
- [3] Alptekin Ertan (2017). Emission, injection and combustion characteristics of biodiesel and oxygenated fuel blend in a common rail diesel engine. *Energy*.119:44–52. [Google Scholar]
- [4] Aydin, H. and C. İlkılıç (2010), Effect of ethanol blending with biodiesel on engine performance and exhaust emissions in a CI engine. *Applied Thermal Engineering*, 30(10): p. 1199-1204.
- [5] Basinger, M., Reding, T., Williams, C., Lackner, K.S. and Modi, V. (2010) Compression Ignition Engine Modifications for Straight Plant Oil Fueling in Remote Contexts: Modification Design and Short-Run Testing. *Fuel*, 89, 2925-2938. <https://doi.org/10.1016/j.fuel.2010.04.028>

- [6] Bhangwar, K., Larik, S. A., & Mari, A. (2024). Analysis of Particulate Matter Emissions and Performance of the Compression Ignition Engine Using Biodiesel Blended Fuel. *Engineering, Technology & Applied Science Research*, 5(204).
- [7] Blimpo, M.P. and Cosgrove-Davies, M. (2019) Electricity Access in Sub-Saharan Africa Uptake, Reliability, and Complementary Factors for Economic Impact. World Bank, Washington DC. <https://doi.org/10.1596/978-1-4648-1361-0>
- [8] Carbonnier, G. and Jacques, G. (2011) Energie et développement. *International Development Policy*, 2,9-28. <https://doi.org/10.4000/poldev.687>
- [9] Daho, T., Vaitilingom, G., Ouiminga, K.S., Piriou, B., Zongo, S.A., Ouoba, S. and Kouliadiati, J. (2013) Influence of Engine Load and Fuel Droplet Size on Performance of a CI Engine Fueled with Cottonseed Oil and Its Blends with Diesel Fuel. *Applied Energy*, 111,1046-1053. <https://doi.org/10.1016/j.apenergy.2013.05.059>.
- [10] Datta A, Mandal BK (2014) Use of Jatropha biodiesel as a future sustainable fuel. *Energy Technology & Policy* 1: 8-14.
- [11] Elsanusi Osama Ahmed, Roy Murari Mohon, Singh Sidhu Manpreet (2017), Experimental investigation on a diesel engine fueled by diesel-biodiesel blends and their emulsions at various engine operating conditions. *Appl. Energy*. 203:582–593. [Google Scholar]
- [12] El-Seesy, A. I., Hassan, H., & He, M. A. (2023). Performance and emissions of a diesel engine burning blends of Jatropha and waste cooking oil biodiesel. *Case Studies in Thermal Engineering*, 49, 103200. Environment 2012. 3 p. 63-66. feedstock, *Datura stramonium L. Fuel*, 2012. 91(1): p. 182-186.
- [13] Gad, M. E., El-Shafay, A. S., & El-Gohary, M. S. (2022). Performance and exhaust emissions of a diesel engine fueled with Jatropha biodiesel and its blends. *Egyptian Journal of Petroleum*, 31(1), 29-36.
- [14] Hashimoto, N., H. Nishida, and Y. Ozawa (2014), Fundamental combustion characteristics of Jatropha oil as alternative fuel for gas turbines. *Fuel*, 126: p. 194-201.
- [15] Hoekman, S.K. and C. Robbins, (2015) Review of the effects of biodiesel on NOx emissions. Fuel characterization of oils and their esters as the substitute of diesel: A review. *Renewable and scale laboratory furnace fired by a heavy-oil swirl burner. Applied Thermal Engineering*, 2015.
- [16] Hossain, N., & Boyce, B. (2021). Combustion and emission characteristics of a compressionignition engine fuelled with Jatropha-curcas biodiesel-diesel blends. *International Journal of Renewable Energy Research*, 11(2), 846-856.
- [17] Jinlin Xue, T.E.G., Alan C. Hansen, Effect of biodiesel on engine performances and emissions. *Renewable and Sustainable Energy Reviews*, 2011. 15: p. 1098-1116.
- [18] Khoobakht, G., et al., Exergy and Energy Analysis of Combustion of Blended Levels of work. *Energy Conversion and Management*, 2011. 52(2): p. 1479-1492.
- [19] Kinney AJ, Clemente TE (2005) Modifying soybean oil for enhanced performance in biodiesel blends. *Fuel Processing Technology* 86: 1137-1147.
- [20] Koh, M.Y. and T.I. Mohd. Ghazi, A review of biodiesel production from Jatropha curcas L. oil. *Renewable and Sustainable Energy Reviews*, 2011. 15(5): p. 2240-2251.
- [21] Kumar, S., Choubey, A., Singla, A., & Kumar, R. (2023). Assessment and usability of Jatropha biodiesel blend with phenolic antioxidant to control NOx emissions of an unmodified diesel engine. *Chemosphere*, 340, 139809.
- [22] Mosquera, J. D. P., Trujillo, M. F. H., & Gonzalez, J. R. S. (2023). Performance and gaseous emissions of a diesel engine operating with blends of Jatropha biodiesel and diesel fuel: An economic and environmental assessment. *Energies*, 16(16), 5964.
- [23] Parawira W (2010) Biodiesel production from Jatropha curcas: A review. *Scientific Research and Essays* 5: 1796-1808.
- [24] Rajak Upendra, Nashine Prerana, Verma Tikendra Nath (2019). Assessment of diesel engine performance using spirulina microalgae biodiesel. *Energy*. 166:1025–1036. [Google Scholar]
- [25] Saravanan, N., Sakthivel, G., & Senthilkumar, K. (2016). Performance and emission characteristics of a direct injection diesel engine fuelled with Jatropha and Rubber seed oil blends with pure diesel fuel. *Ain Shams Engineering Journal*, 7(2), 649-657.

- [26] Sidibe, S., Blin, J., Daho, T., Vaitilingom, G. and Koulidiati, J. (2020) Comparative Study of Three Ways of Using *Jatropha curcas* Vegetable Oil in a Direct Injection Diesel Engine. *Scientific African*,7,290-308. <https://doi.org/10.1016/j.sciaf.2020.e00290>
- [27] Singh, S.P. and D. Singh (2010), Biodiesel production through the use of different sources and Sustainable Energy Reviews, 14(1): p. 200-216. 81234567890
- [28] Thanh LT, Okitsu K, Boi LV, et al. (2012) Catalytic technologies for biodiesel fuel production and utilization of glycerol: A review. *Catalysts* 2: 191-222.
- [29] Zongo, A.S., Daho, T., Vaitilingom, G., Piriou, B., Valette, J., Caillol, C., Segda, B.G., Higelin, P. and Koulidiati, J. (2018) The Effect of Atmospheric Oxygen on the Puffing and Bursting Phenomena during Vegetable Oils Droplets Vaporization Process for Their Use as Biofuel in Diesel Engine. *Energy and Power Engineering*, 10, 518-533. <https://doi.org/10.4236/epe.2018.1012033>.

