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Experimental Study and Prospects of Valorization of Jatropha Curcas Seeds into Biodiesel

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Abstract:- Jatropha curcas L. is a promising oilseed plant for biodiesel given its oil content and its tendency to grow in harsh environmental conditions. In this study, we conducted experiments on the valorization of jatropha seeds into biodiesel in order to estimate the key parameters of the process and the properties of the obtained biodiesel. The results revealed that the molar ratio between triglycerides and methanol, catalyst concentration, and reaction temperature played an important role in the diesel yield. The biodiesel produced had physicochemical characteristics in line with international standards for diesel fuels, with combustion properties comparable to those of conventional diesel. This study shed light on the optimization of the process of valorization of jatropha curcas seeds into biodiesel and on the support of the potential as a renewable fuel source.

Keywords:- *Jatropha Curcas, Biodiesel, Valorization, Characterization, Yield*

I. INTRODUCTION

The deepening of alternative and renewable energy sources has become a global emergency to minimize the addiction to fossil fuels and weaken the environmental impacts of the transport area. In this situation, non-edible vegetable oils, such as those extracted from jatropha seeds, are used as a source for biofuel production. Jatropha has several advantages, including its ability to grow on marginal lands and its resistance to adverse environmental conditions. This study aims to explore the potential of valorization of jatropha curcas seed into biodiesel and to estimate the specificities of the produced biodiesel.

II. MATERIALS AND METHODS

➢ *Stage of Valorization of Jatropha Seed into Biodiesel*

Jatropha seeds were collected, cleaned and dried before being pressed to extract the oil. The oil thus obtained was subjected to a transesterification process to convert triglycerides into methyl esters, which are biodiesel.

Then preheat the oil free of water to 45 ° C.

Then mix the alcohol with a catalyst. There are two catalysts: acid and basic, but for the reaction to be fast we preferred to use a basic catalyst. In this method, we focused on the basic catalyst so that the reaction will be fast and on methanol because in relation to the price it is the least expensive and most reactive. The definition of a volume of methanol and soda is necessary before mixing them in a well-dry and hermetically sealed glass bottle.

Mix the mixture well until the catalyst is completely dissolved. After that, add the preheated oil to the mixture prepared beforehand. Shake well and mix until there is a vortex on the surface.

Finally, decantation, this last step begins with decantation in the ester phase: let the mixtures cool and decant for at least 10 hours. The biofuel floats on top of the gelatinous mass of glycerin. Follow-up purification: Let the resulting biodiesel settle for about 3 days and then collect the clean biofuel at the top.

➢ *Parametric Analysis of Transesterification*

The experiment was done at the same time of the transesterification reaction phase. We used sodium hydroxide as a catalyst with a rate of 1.5% and methanol as an alcohol with a purity of 99%. The change in the stoichiometric coefficient of the alcohol was between 100% and 150% excess which are between 6:1 and 9:1. And the temperature varies between 35 and 70 ° C. Samples were taken every 30 minutes until the end of the conversion.

➢ *Physicochemical Analysis of Biodiesel*

Several parameters characterize them but in this work we were able to do only the characteristic analysis of what they are the most important on the performance of the diesel engine such as viscosity and density.

- *Viscosity*

By definition, it is the resistance to uniform and turbulent flow occurring in the mass of matter. The flow time, on the other hand, is the measure of the time it takes for a fluid to flow through a specific device, as in the case of a viscometer.

More precisely, the relationship is often described by Newton's law of viscosity for Newtonian fluids:

$$Vs = Coef \times tp \tag{1}$$

With:

Vs: kinematic viscosity, in centistokes or cSt or mm^2/s,

Coef: coefficient of viscosity,

tp: flow time, in seconds.

Commonly used vegetable oils have on average a viscosity 5 to 15 times higher than that of diesel [9; 17]. The influence of viscosity on the diesel engine is heating, wear, increases power, decreases noise, and increases the duration of the mechanical state of the engine. The higher the viscosity rate, the more it minimizes the injection flow rate [2; 3; 12; 14]. With a high viscosity, it is preferable to preheat the oil before using the engine [3; 7]; and it can also be mixed with diesel [3; 4; 5] or transformed into biodiesel [6; 13].

The objective is to define the flow time of the sample in the viscometer.

To perform this viscosity analysis, we used: thermometer, single-calibration viscometer hotplate, stopwatch and thermostatic bath. The sample and the thermostatic bath are heated to a temperature specified in the analyses. If the temperature is reached, the liquid flow time is sampled.

- *Density*

It is the ratio between the mass of a volume of a liquid or a solid and the mass of the same volume of water under conditions of pressure and temperature.

$$d = \rho_{eau} \frac{m+A}{m'+A} \quad (2)$$

With:

ρ_{eau} : density of water,

m: mass of the sample to be analyzed,

m': mass of water,

A: correction coefficient due to the thrust of the air of fluid contained in the pycnometer. In general, A=0.0012.

To determine the viscosity, we used the materials during the analysis made with the viscosity such as the thermometer, balance, hot plate. In addition to this, we use the pycnometer.

Our objective is to know the mass of the empty pycnometer, and then contains water, then that which contains the samples to be experimented so that we can determine the values of the density according to the temperature.

The experiment begins by heating the sample in the appropriate temperature. Once the temperature is reached, the preheated sample is placed in the pycnometer. If all this is done, the masses can be measured.

➢ *Characterization of Engine Performance*

- *Exhaust Gas Temperature Measurement*

The exhaust gas temperature is proportional to the average temperature of the combustion chambers. The exhaust gas temperature was measured using a LAMBDA probe. Inside this probe there is a calculator. For the measurement, the probe was placed at the exhaust manifold outlet to capture the burnt gas temperature.

- *Specific Consumption*

$$C_s \text{ (g/kWh)} = \frac{C_v \times \rho}{P_f} \quad (3)$$

$$\text{Or } C_v\text{(l/h)} = \frac{débit\ volumique}{\Delta t} \quad (4)$$

With:

C_s: specific consumption,

ρ: fuel density (g/l),

C_v : volumetric consumption (l/h),

P_f : effective power collected on the alternator,

Δt: consumption time (h).

- *Yield*

This is the ratio of energy provided by the system to the energy consumed by it.

$$\eta = \frac{3600}{C_s * PCI} \quad (5)$$

C_s : specific consumption g/kWh,

PCI::calorific value of the briquette in MJ/kg.

III. RESULTS

➢ *Kinematic analysis of Transesterification*

- *Molar ratio*

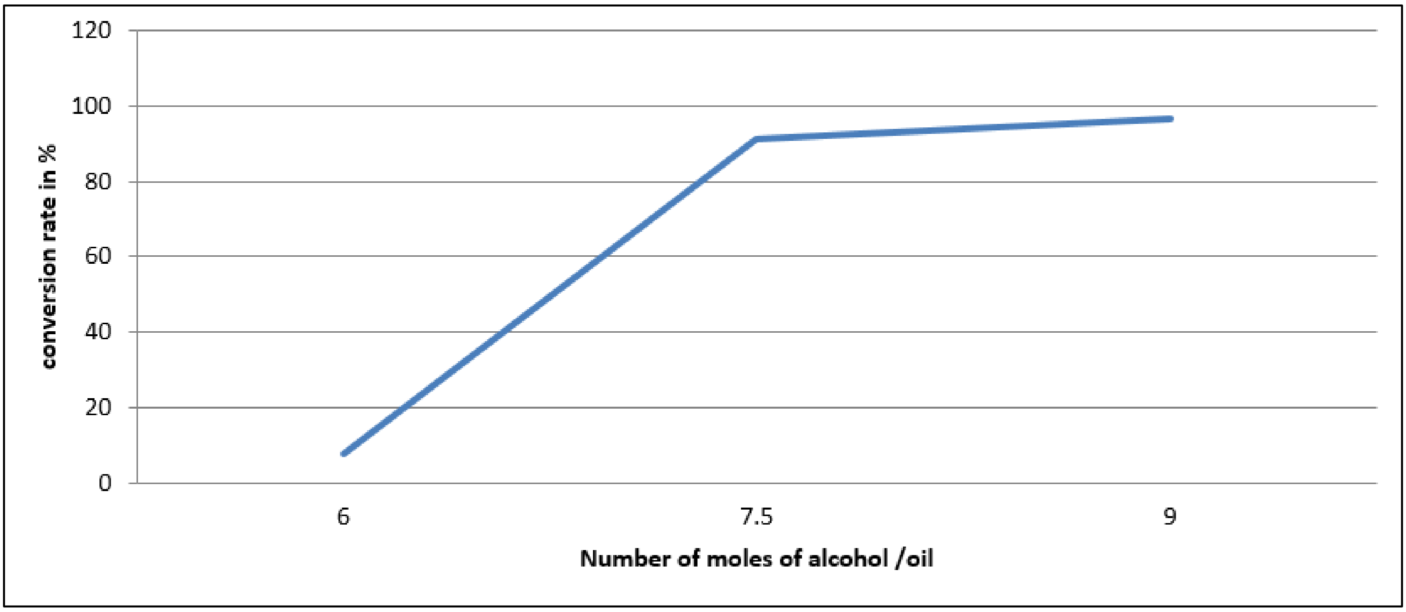

Fig 1 Ester Conversion rate as a Function of Alcohol/Oil Molar ratio

We have observed that the difference in conversion rate between 125% and 150% methanol is minor. So by reducing the amount of methanol used, it can reduce the costs of the ester produced. This high ratio is also necessary to ensure that the reaction is complete and to maximize the biodiesel yield.

- *Catalyst*

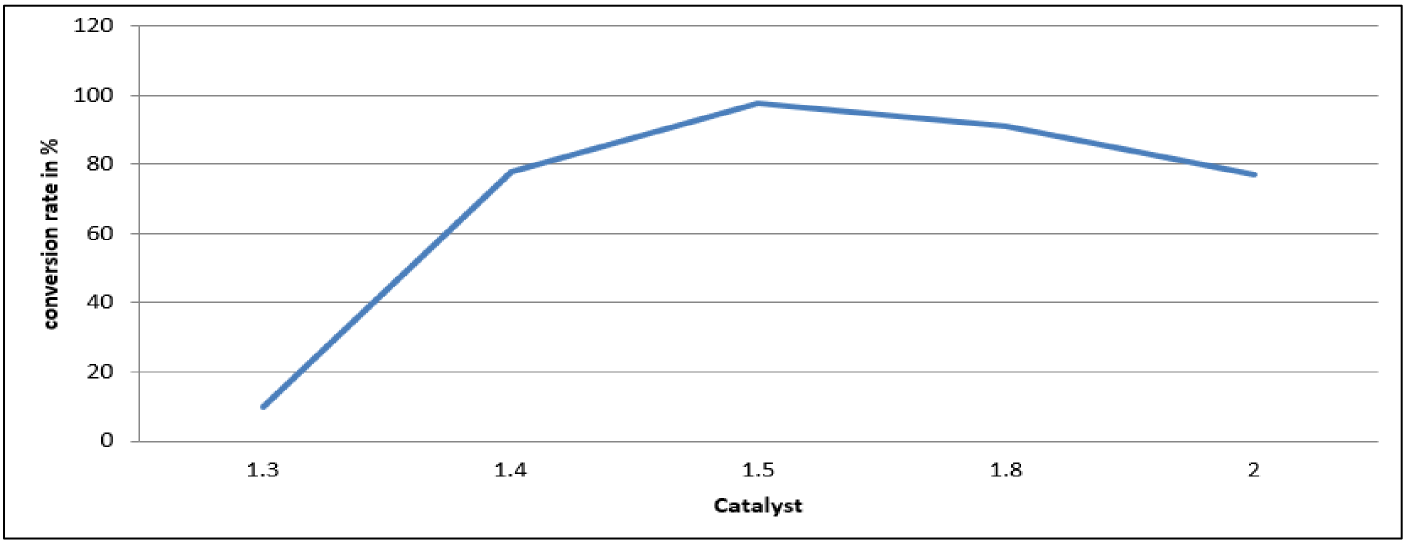

Fig 2 Ester Conversion rate as a Function of Catalyst

It is noted that, the good conversion of jatropha oil into biodiesel is achieved with a catalyst rate of 1.5% and this is confirmed by [1]. And that the catalyst rate of 1.8% on the mass of jatropha oil is in excess, that is to say the products may contain soaps.

- *Temperature and Agitation*

Agitation is one of the important parameters in the transesterification reaction. The interaction between temperature and agitation is avoided when the reaction mixture is stirred firmly. If it is avoided then, even with room temperature, the reaction rate is fast and this is confirmed by [10], [11].

* *Reaction Time*

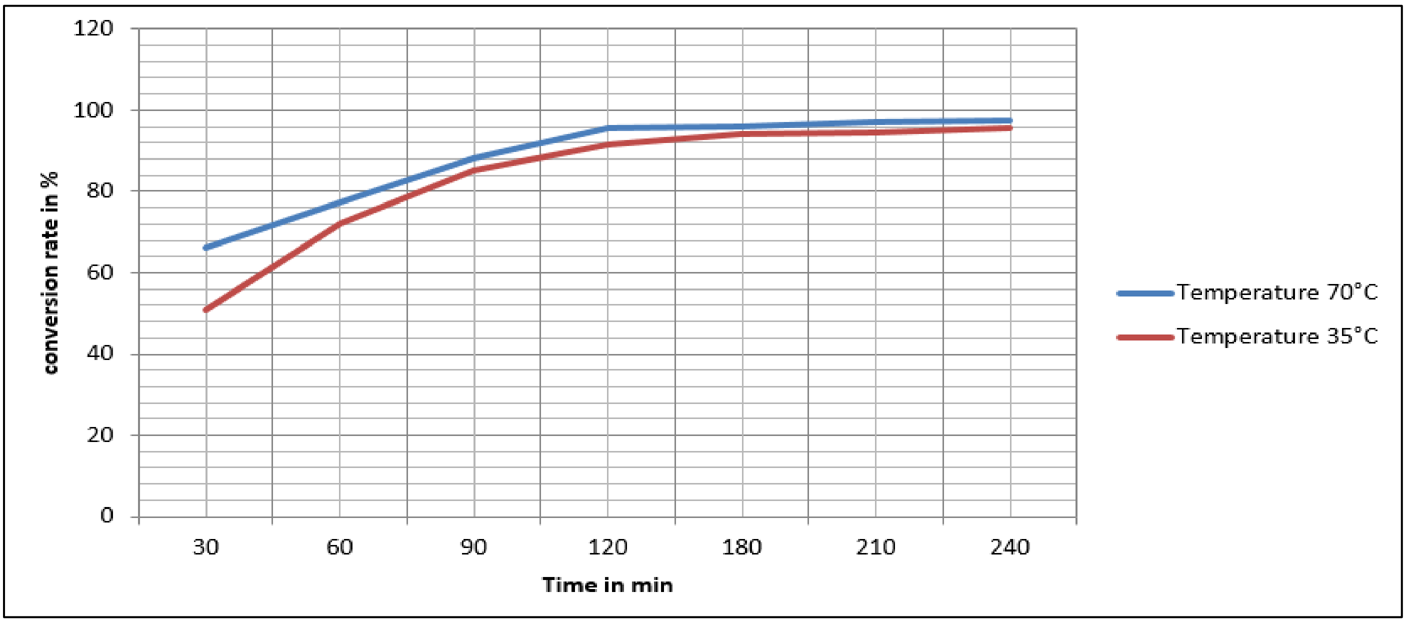

Fig 3 Ester Conversion rate as a Function of Temperature

Initially, given the very high viscosity, the reaction increases slowly. From 30min we see that the reaction begins to be rapid because the esters are more miscible with methanol and less dense. After 120 min of the reaction all the oil is transformed into methyl esters. We note that with these two different temperatures, the yield is very high. And that after 4 hours, the quantity of esters produced is almost the same.

➢ *Physicochemical Parameter*

* *Viscosity*

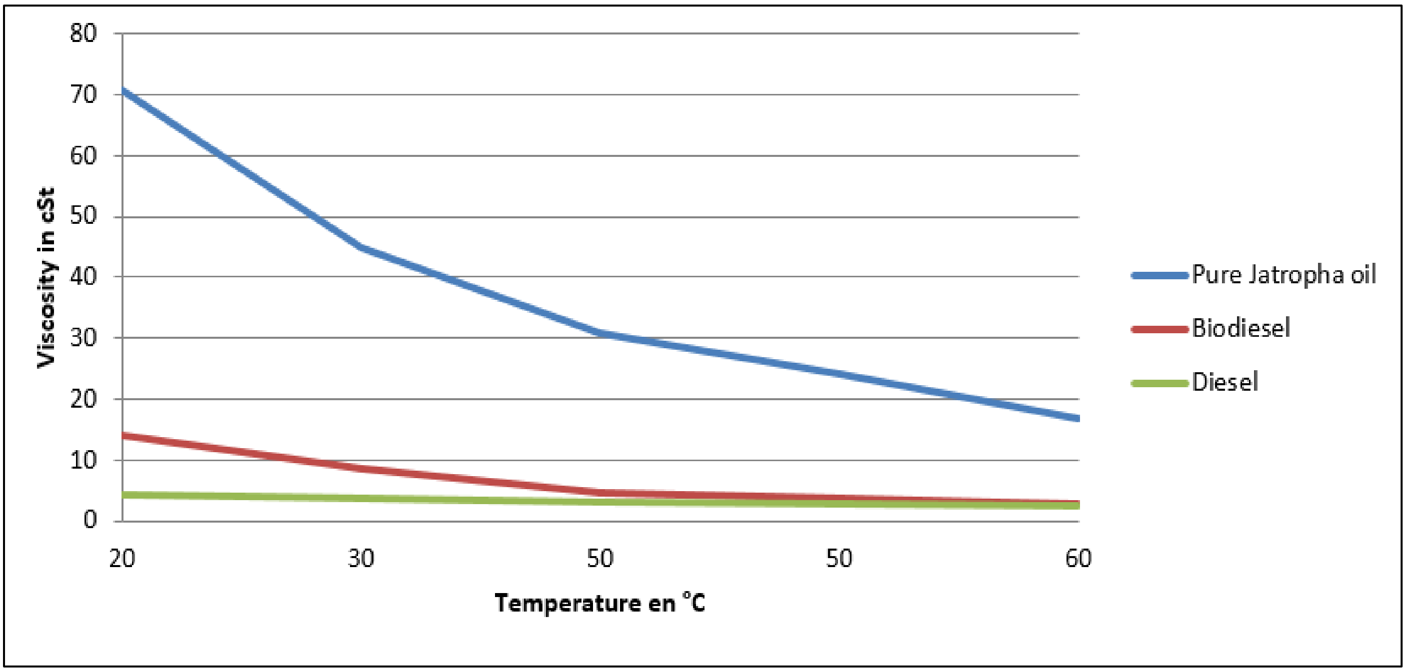

Fig 4 Viscosity as a Function of the type of Fuel

We observe on the curve, the rapid decrease of pure vegetable oil and biodiesel compared to that of diesel. This means that above the temperature of 60 ° C, the three curves tend to come closer together.

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The viscosity of pure vegetable oil is generally higher than that of biodiesel and mineral diesel, which may pose challenges for its direct use in diesel engines without modification such as pumping and flow problems at pipes and filters. And also the lower the viscosity, the finer the product is atomized, and this improves the combustion/air fusion [16]. Therefore, viscosity has an influence on the regularization of the spray property.

- *Density*

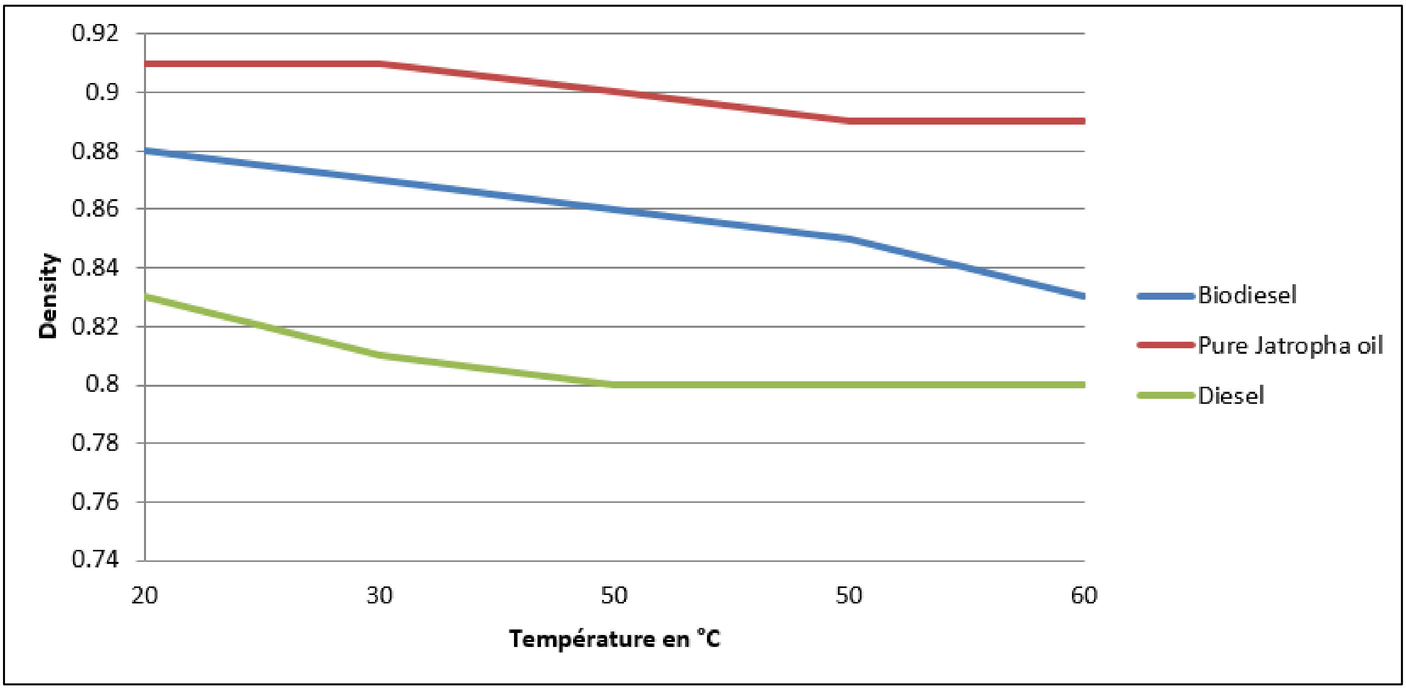

Fig 5 Density as a Function of Temperature

Biodiesel is denser than conventional diesel, although the difference may be relatively small. Comparatively, vegetable oil has a higher density than biodiesel resulting from its conversion. And that the more the density decreases, the more the temperature increases. It is also observed that from 40°C, the biodiesel curve continues to decrease while that of diesel remains constant. The decrease is beneficial for the spraying of oil and biodiesel in the combustion chamber of engines.

➢ *Engine Performance*

- *Specific Consumption*

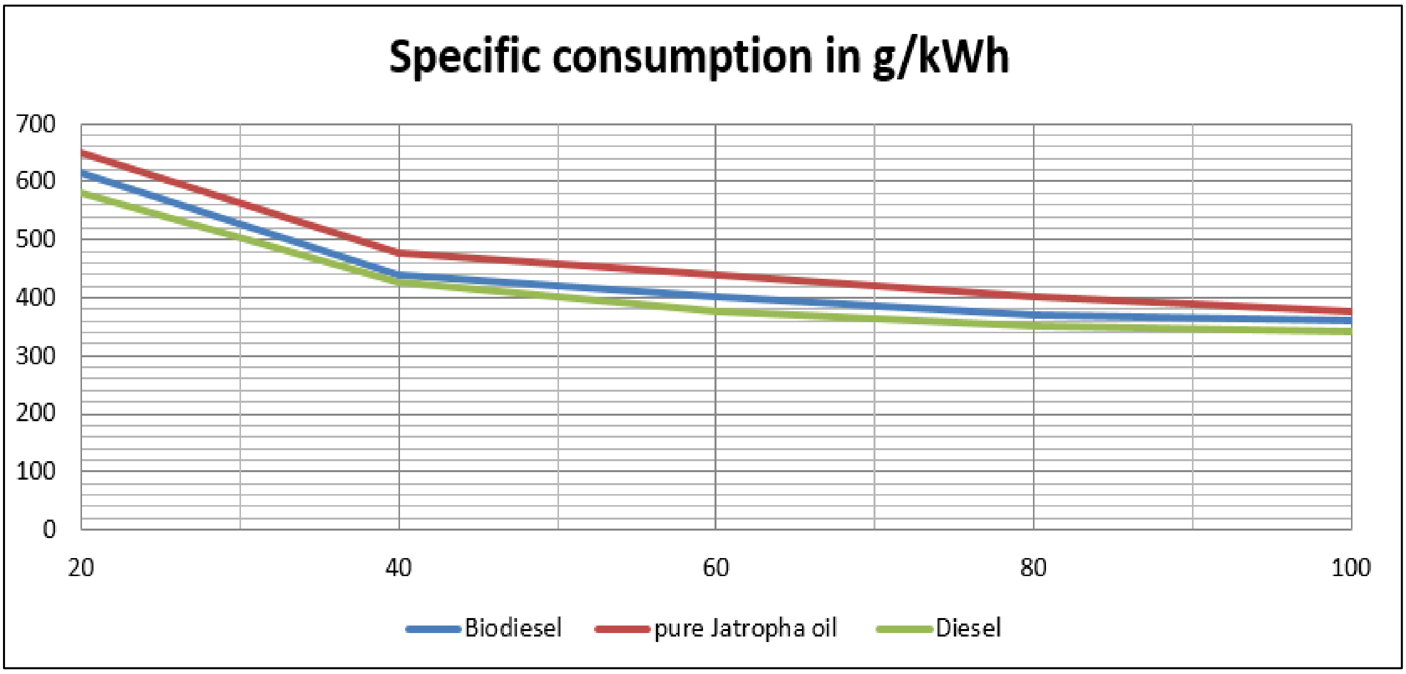

Fig 6 Specific Consumption as a Function of Load

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It is observed that biodiesel can have specific fuel consumption similar to that of mineral diesel, or even slightly higher. However, this is a chain of various factors such as the property of biodiesel, chemical compositions and combustion properties. In some cases, minor adjustments may be necessary in existing diesel engines to optimize the specific consumption when using biodiesel.

- *Efficiency*

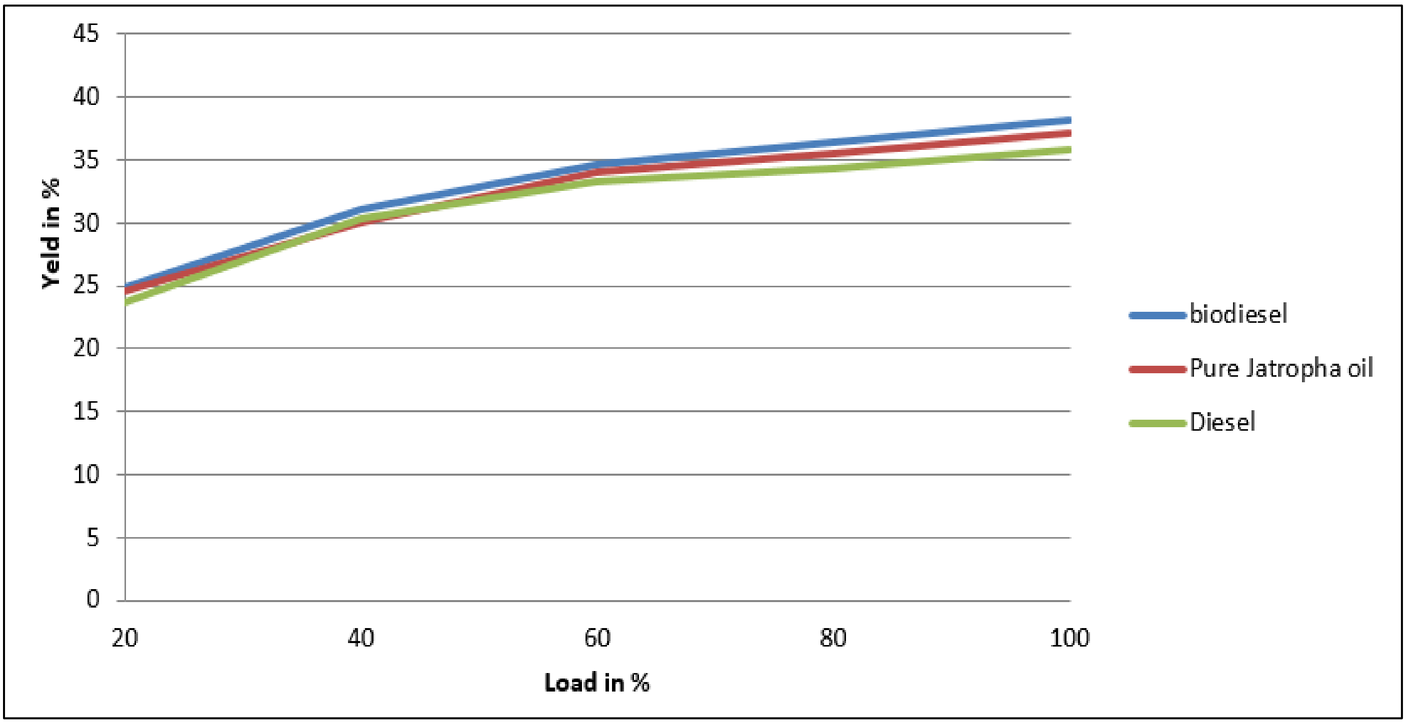

Fig 7 Efficiency as a Function of Load

It can be seen that biodiesel is generally considered to offer comparable fuel efficiency to mineral diesel. However, there may be variations depending on the specific properties of the biodiesel used, such as chemical composition, viscosity, and production process. In many cases, minor adjustments in existing diesel engines may be necessary to optimize the efficiency when using biodiesel.

- *Exhaust Gas Temperature*

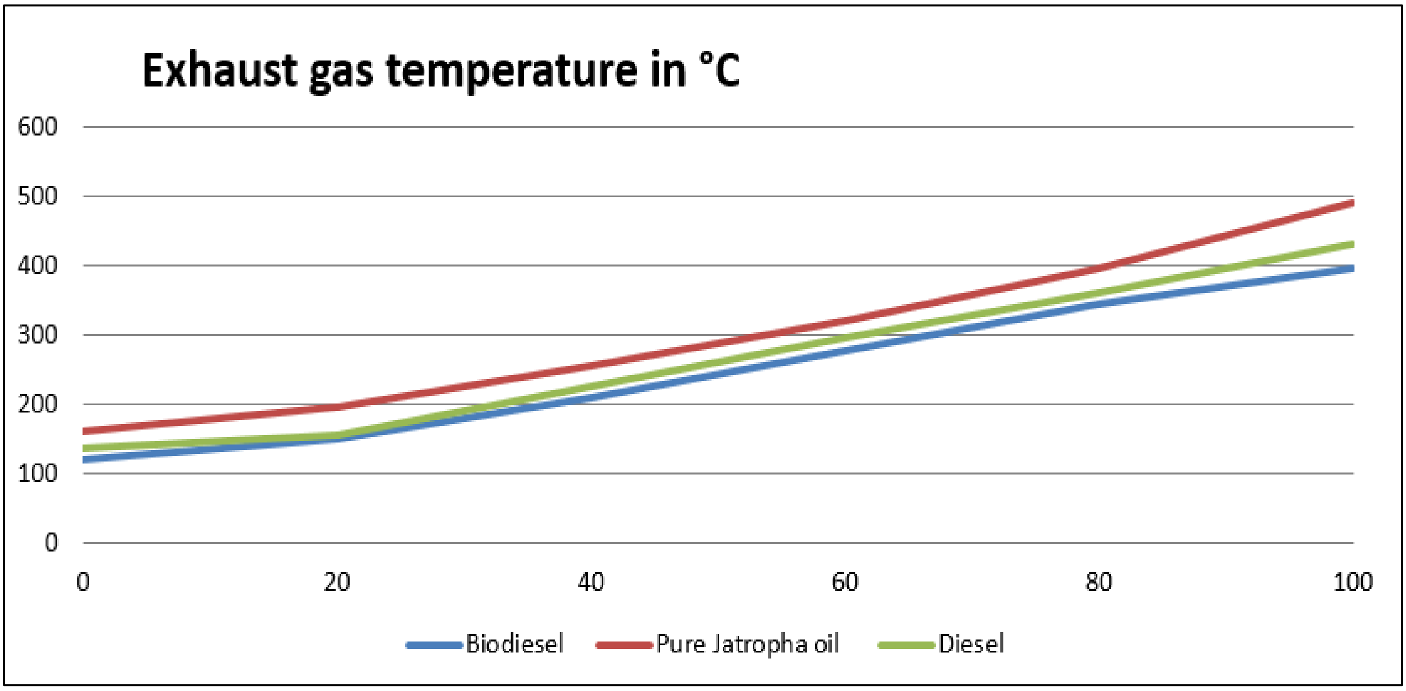

Fig 8 Exhaust Gas Temperature as a Function of Fuel Type

It can be seen that with both fuels, the exhaust gas temperature of the engine increases as the load increases. Higher exhaust temperatures can influence emissions and overall engine performance. Mineral diesel and biodiesel exhaust temperatures can be influenced by factors such as fuel properties, engine operating conditions. In general, mineral diesel is formulated to produce relatively moderate exhaust temperatures while maximizing combustion efficiency.

IV. DISCUSSIONS

Our results confirm the potential of valorization of jatropha seed in biodiesel and highlight the importance of optimization of reaction parameters to maximize biodiesel yield. Jatropha biodiesel has physicochemical characteristics in accordance with international standards for diesel fuels and offers a sustainable alternative to fossil fuels. According to [8], vegetable oil-based fuels (biodiesel) generate less coking and exhaust smoke, and develop engine thermal efficiency compared to the use of diesel. According to [15], biodiesel is more efficient than diesel in terms of power and engine torque.

V. CONCLUSION

The experimental study on the valorization of jatropha seeds in biodiesel confirms that the use of plant as a source of biofuel gives a promising result. The analyses revealed that the viscosity of jatropha oil is very high, making it an attractive feedstock for biodiesel production.

The biodiesel production trials confirmed the ability of jatropha seeds to provide high quality oil, suitable for conversion to biodiesel by transesterification. The transesterification reaction parameters were optimized to maximize the biodiesel yield while minimizing the formation of undesirable effluents.

In addition, extensive characterization studies were conducted on the produced biodiesel, particularly with regard to its physicochemical properties, oxidation stability and pollutant emissions. The results showed that jatropha biodiesel meets the quality standard required for diesel fuel, with comparable or even superior performance to conventional biodiesels.

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