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EVALUATION OF PERFORMANCE OF BIODIESEL PRODUCED FROM AFRICAN PEAR (DACRYODESEDULIS) SEED OIL.

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Abstract This study evaluates the performance of biodiesel and its blends produced from African pear seed oil via homogeneous alkali catalyzed transesterification route. The physiochemical properties of the extracted oil were determined according to American Society for testing and Materials (ASTM) standard. The free fatty acid (FFA) value of the oil extracted was 1.296 MgKOH/g oil, which was greater than 1% and as such have relatively high acid value. The oil was pretreated to reduce the FFA percentage to less than 1%. The pretreated oil was transesterified with sodium hydroxide. The fuel properties of biodiesel produced was determined and the biodiesel produced was tested in an internal combustion diesel engine. The percentage oil extraction yield from the substrate was 49%. Fuel properties of biodiesel produced in the present work meet the ASTM standard. From performance evaluation, B20 had the lowest and best Break Specific fuel Consumptions (BSFC) for biodiesel from D.edulis compared with that of standard diesel.CO and HC emissions reduced with biodiesel and its blends, while NO_x emission increased with biodiesel and its blends compared with the conventional diesel fuel. The thermal efficiency and brake power of biodiesel blends especially B20 were almost similar to conventional diesel fuel. Therefore, the feed stock proved its potency as raw material for production of standard biodiesel.

Keywords: Dacryodesedulis seed, Biodiesel, Transesterification, Free fatty acid, Engine Performance evaluation.

1. Introduction

The largest proportion of the energy consumed in most parts of the world comes from fossil fuel sources. The high dependence on fossil fuels is attributed to the persistent global growth in industrialization and modernization. Nevertheless, the key resultant indicator of such high consumption and dependence are evident in the dwindling petroleum reserves and numerous environmental pollution challenges occasioned by emission of greenhouse gases. Biodiesel is a promising alternative diesel which has attracted attention worldwide (Fan *et al.*, 2011). This is primarily due to its outstanding benefits over the conventional petro diesel, such as its renewability, biodegradability, non-toxic, high flash point and reduction in greenhouse emissions (Demirbans, 2009; Kaya *et al*., 2009; Ghesti *et al.*, 2009; Aderemi and Hameed, 2010). Biodiesel is the free fatty acid methyl esters, popularly referred to as FAME, derived from oil sources. There are various processes that have been adopted in production

of biodiesel from vegetable oils and animal fats namely; micro-emulsification with alcohols, catalytic cracking, pyrolysis and transesterification (Demirbes, 2009; Leng *et al*., 1999; Li *et al.,* 2009; Aderemi and Hameed, 2010). Among these methods, transesterification is the key and foremost important process to produce a cleaner and environmentally safe biodiesel fuel (Younis *et al., 2*009; Atlanatho *et al.*, 2004).

The transesterification is usually carried out using primary and secondary alcohols. Fukuda *et al.*, (2001) reported that methanol and ethanol are most frequently used in the production of biodiesel but methanol is more preferred due to its low cost. During transesterification a basic catalyst breaks the fatty acids from the glycerin one by one. If an alcohol typically methanol contacts a fatty acid it will bond and form biodiesel while the hydroxyl group from the catalyst stabilizes the glycerin (Vendkata *et al.*, 2012). Biodiesel has been produced through transesterification of palm oil, soya bean oil, sunflower seed oil, rapeseed oil and cottonseed oil to mention but a few using homogeneous and heterogeneous catalysts (Fan *et al.*, 2011).

Utilization of edible oils as feedstock for biodiesel production poses a lot of concerns as this practice competes with food supply leading to high cost of edible vegetable oil, and consequently makes biodiesel relatively expensive. Therefore, concerted research efforts are geared towards identifying and evaluating indigenous non-edible seed oils as suitable feedstock. The African pear or African plum or Safou, locally called 'Ube' by the Igbos in the South eastern part of Nigeria belongs to the family of Burseraceae and botanically known as Dacryodesedulis. It is an indigenous fruit tree grown in the humid low lands and Plateau regions of West, Central African and Gulf of Guinea countries. In south-eastern Nigeria, the trees are grown around homesteads and flowering takes place from January to April. The major fruiting season is between May and October. It is an annual fruit of about 3 cm in diameter and contains a leathery shelled stone surrounded by a pulpy pericarp of about 5 mm thick. The pericarp is butyraceous, i.e., it has the qualities of butter. It is this portion of the pear which is eaten, either raw or cooked that forms a sort of 'butter'. Besides, the seed contains about 48% oil and a plantation can produce 7-8 tonnes of oil per hectare. This makes it useful as feedstock for biodiesel production (Awono *et al.*, 2002).

Interestingly, there are some factors that affect the yield of biodiesel through transesterification of vegetable oils. The effects of alcohol/oil molar ratio, catalyst concentration, reaction temperature, reaction time and agitation speed have been widely investigated and the process parameters optimized. Some researchers have adopted different techniques of optimization. Some employ the traditional 1-Factor-At-A-Time approach, which is time consuming and nearly impossible to achieve the true optimal condition for a multi-variable system. Another approach employed by some researchers is Response Surface Methodology (RSM). It is an experimental strategy described first by Box and Wilson for seeking an optimal condition for a multivariable system. It is an efficient technique for process optimization (Cavazzuti *et al.*, 2013). Zabeti *et al.*, (2010) used response surface methodology in production of biodiesel using alumina –supported calcium oxide. Fan (2011) employed response surface methodology in optimization of biodiesel production from crude cottonseed oil using sodium hydroxide.

Moreover, engine performance testing of bio-diesel is indispensable for evaluating its relevant emission and fuel properties. Several groups have investigated the properties of a biodiesel from various feedstocks in diesel engines and found that particulate matter (PM), carbonmonoxide (CO) and soot mass emissions decreased, while NOx increased. Labeckas and Slavinskas (2006), examined the performance and exhaust emissions of rapeseed oil methyl esters in direct injection diesel engines, and found that there were lower emissions of CO, CO_2 and hydrocarbon (HC). Similar results were reported by Kalligeros *et al.*, (2003) for methyl esters of sunflower oil

and olive oil when they were blended with marine diesel and tested in a stationary diesel engine.

Therefore this research studied the biodiesel engine performance produced from the transesterification of African pear seed oil with methanol and sodium hydroxide catalyst.

2.0 Materials and Methods

2.1 Materials

African pear seed was sourced from Ideato South Local Government Area of Imo State, Nigeria. The methanol, n-hexane, sodium hydroxide, methanol, ethanol, chloroform, iodine acetic, potassium iodine, Starch Indicator, sodium thiosulphate, HCl, chloroform and sulphuric acid, were all purchased from De-Cliff Integrated Services Ltd Enugu and they are of analytical grade. The following equipment were used in the course of this research: Viscometer, Magnetic Hot Plate, Refractometer, Separating Funnels, Conical flask, Distillation column, Gas Chromatography Mass Spectrometry (M910 Buck scientific gas chromatography, GCMS-QP2010 plus Shimadzu, Japan.) and Fourier Transform Infrared Spectroscopy (M530 Buck scientific FTIR)

2.2 Methods

2.2.1 Samples Preparation.

4 kg of Dacryodesedulis seed was sundried for 2 days after which they were pulverized to fine texture using an industrial blender.

2.2.2: Extraction of the Oil

3.5 kg each of African pear (Dacryodesedulis) seed was measured using an analytical weighing balance into containers and soaked with 2 liters of n-hexane for 2 days. The container were covered and made air tight to avoid evaporation of n-hexane. Decantation was carried out, followed by sieving and then filtration. Distillation of the filtrate to recover the n-hexane was done at a temperature of 65^{o}C (AOAC, 1990). The percentage yield of the oil was calculated as thus:

$$\% \text{ yield} = \frac{\text{weight of the oil extracted}}{\text{weight of the sample used}} \text{ x } 100 \qquad (1)$$

2.3 Characterization of the Oil Obtained From African Pear Seed (Feedstock).

Free Fatty Acid/ Acid Value.

0.5 g of the samples (African pear seed oil) were weighed into a dry beaker and 20 ml of ethanol added to it. 3 drops of phenolphthalein indicator was added and shook. The solution was titrated with 0.1N sodium hydroxide until a pink colouration was observed.

$$Acid\ Value = \frac{\text{Titre Value X Normality of the base X } 56.1}{\text{Weight of the sample used}} \qquad \textbf{(2)}$$

Where,

56.1 = Molecular mass of potassium hydroxide

Percentage free fatty acid (% FFA) was determined by multiplying the acid value with the factor 0.503 (Akubugwo *et al.,* 2008). Thus;

$$\% \text{ FFA} = 0.503 \text{ x Acid value} \qquad (3)$$

3.3.2: Refractive Index

Refractometer was used in the determination of refractive index. Few drops of the sample were transferred into the glass slide of the Refractometer. Water at 30^{o}C was circulated round the glass slide to keep its temperature uniform. Through the eye piece of the Refractometer the dark portion viewed was adjusted to be in line with the intersection of the cross. At no parallax error, the pointer on the scale pointed to the refractive index. This was repeated thrice and the mean value calculated and recorded as the refractive index.

Iodine Value

The iodine number was determined based on ASTM D4067-86 (1986) by using the sodium thiosulphate volumetric method. This was determined by measuring out 0.5 g of African pear seed oil, which was poured into a 25 ml conical flask and dissolved with 15 ml of chloroform. 25 ml of the Wiji's solution (mixture of iodine, acetic acid and chloroform) was added also into the conical flask and mixed properly. The flask was covered and kept in a dark place for 30 mins at room temperature. At the end of the 30 minutes, the flask was brought out and 20 ml of 10% potassium iodide solution and 150 ml water

were added into the flask and the solution turned reddish. Thus, the reddish solution was titrated with 0.1N sodium thiosulphate until the reddish colour cleared.

Then, 5 ml of 5% starch solution was added to the solution as an indicator and the solution turned bluish-black, then the bluish-black solution was further titrated against 0.1N sodium thiosulphate until the sample again turned colorless.

A blank (without sample) solution was also prepared and titrated with 0.1 sodium thiosulphate. The titre values of both the sample and blank were noted and recorded respectively

$$\text{Iodine value} = \frac{12.69 * N\,(V_2 - V_1)}{Weight\ of\ sample\ (W)} \quad (4)$$

Where

12.69 = Molecular mass of iodine
N = Normality
V_2 = Blank titre value
V_1 = Sample titre value
W = Weight of sample

Saponification Value

This was determined by weighing out 0.5 g of the sample (African pear seed oil) into a conical flask. 50 ml of 0.5N ethanoic potassium hydroxide was added and heated in a refluxed round bottom flask for about 3 minutes. The essence of the reflux was to get a perfect dissolution of the oil sample in the ethanoic potassium hydroxide thereafter. The heated mixture was allowed to cool for another 30 minutes after which 3 drops of phenolphthalein was added to the mixture, and the mixture was titrated against a 0.5N hydrochloric acid (HCl) until there was a change from pink to colorless. Then a blank (without the oil sample) solution was also prepared and this titrated until the colour change was observed. Hence;

$$Saponification\ value\ (number) = \frac{56.1 * N\,(V_2 - V_1)}{W} \quad (5)$$

Where;

56.1 = Molecular mass of potassium hydroxide
N = Normality of 0.5
V_2 = Titre value of blank
V_1 = Titre value of sample
W = Weight of the sample used

Peroxide Value

0.5 g of the sample (African pear seed oil) was weighed into a conical flask. Using measuring cylinder, 25 mls of solvent mixture was added (acetic acid and chloroform 2:1), that is, 2 volume of glacial acetic acid and 1 volume of chloroform. 1ml of 10% potassium iodide was added and shaken vigorously. The solution was covered and kept in the dark for 1 minute. 35mls of starch indicator was added to the solution (V_1) and titrated with 0.02N sodium thiosulphate until end point is attained. A blank was carried out as well. Colour changed from pale yellow to white. Peroxide value was calculated as shown below;

$$Peroxide\ value = \frac{100 * N\ (V_1 - V_2)}{Weight\ of\ sample\ (W)} \quad (6)$$

Where

N = Normality of sodium thiosulphate ($Na_2S_3O_3$)
100 = Peroxide value constant
V_1 = Titre value of sample
V_2 = Titre value of blank
W = Weight of the sample

Specific Gravity

This was determined using a 50 ml specific gravity bottle. The bottle was washed dried and weighed and the weight was noted and recorded as M_1. It was then filled with sample and weighed again. The weight was also noted and recorded as M_2. The bottle was then washed, dried, filled with water and weighed. The weight was noted and recorded as M_3. The specific gravity was thus calculated:

$$\text{Specific gravity (S.G)} = \frac{M_2 - M_1}{M_3 - M_1} \quad (7)$$

2.4 Pretreatment of the Oil Extracted.

A pre-treatment procedure was performed on the oil extracts due to the high free fatty acid (FFA) content of above 1%. The FFA was reduced below 1.0% using methanol and concentrated sulphuric acid as catalyst prior to transesterification reaction. The oil Sample was first heated on a heating mantle at 110˚C for 10

minutes for any available moisture to go off. The sample was cooled to 60°C in a water bath The oil sample was weighed into a 500 ml flat bottomed flask respectively, methanol of 60% w/w of oil was mixed with 7% (w/w of oil) of concentrated sulphuric acid. The mixture were agitated at a high speed of 450 rpm and temperature of 60˚C using magnetic stirrer with a reaction time of 120 minutes. The mixture were then transferred into a 50 ml separating funnel which later separated into three layers comprising water at the bottom, pre-treated oil in the middle and methanol at the upper layer. The mixture were carefully separated by removing the water first, followed by the oil and finally the methanol. Hot distilled water was poured into the oil, shaken and allowed to stand. This was done to wash the esterified oil. After a while, 2 layers were observed; water (below) and oil (above). The water is tapped out from the separating funnel .The pre-treated oil were poured into a beakers and dried carefully in an oven regulated at a temperature of 105˚C until the residual water evaporated off completely. After this process, the pre-treated oil was made ready for the transesterification process (Iloamaeke et al., 2016).

2.5 Transesterification Reaction

The African pear seed oil reacts with methanol in the presence of NaOH to produce methyl esters of fatty acids (biodiesel) and glycerol.

The African pear seed oil was precisely quantitatively transferred into a flat bottom flask placed on a hot magnetic stirrer. Then specific amount of catalyst (by weight of African pear seed oil) dissolved in the required amount of methanol was added. The reaction flask was kept on a hot magnetic stirrer under a defined temperature with defined agitation according to the design of the experiment. At the defined time, sample was taken out, cooled, and the biodiesel (i.e. the methyl ester in the upper layer) was separated from the by-product (i.e. the glycerol in the lower layer) by settlement overnight under ambient condition. The biodiesel layer was washed with hot water 3-4 times. 0.5N sulphuric acid standard solution was added to the biodiesel to eliminate the base from it. This was done while washing the biodiesel. The sulphuric acid standard solution was added until the water layer tapped off stopped changing to purple colour when a drop of phenolphthalein was added. The biodiesel was then heated on a heating mantle at 110˚C to dry it. The percentage of the biodiesel yield was determined by comparing the volume of layer of biodiesel with the volume of African pear seed oil used. The procedure was repeated by varying the factors affecting the transesterification reaction catalyzed by NaOH such as; time, catalyst concentration, temperature, alcohol/oil molar ratio and agitation speed. (Iloamaeke et al., 2016).

2.6 Determination of Fuel Properties of the Biodiesel

The ASTM - 08 methods were used for all the determinations. The determinations were carried out at the PRODA Laboratory Enugu (fuel properties), Mechanical engineering Department University of Nigeria Nsukka and Energy Centre University of Nigeria Nsukka (Engine test), National Research Institute for Chemical Technology Zaria (GCMS). Most of the properties analysed are used to determine the efficiency of a fuel for diesel engines.

2.7 Engine Test Analysis (Performance Evaluation).

The performance of the bio-diesel produced by the transesterification process was evaluated on a Perkins 4:108 diesel engine mounted on a steady state engine test bed. The engine is a four cylinder, water-cooled, naturally aspirated and 4-stroke CI engine. The engine has the following specification represented in Table 1. The experiments were conducted with standard diesel fuel, biodiesel and blends. The blends are 20% biodiesel (B20), 40% biodiesel (B40), 60% biodiesel (B60) and 80% biodiesel (B80). A short trial run was done in order to ensure that all essential accessories were in the working order before the actual test.

Table 2.1: Engine Specifications

Components	Values
ENGINE	
Type	Perkins 4:108
Bore	79.735mm
Stroke	88.9mm
Swept volume	1.76litres/cycle
Compression ratio	22:1
Maximum BHP	38
Maximum speed	3000rpm
Number of cylinder head	4
Diameter of exhaust	$1\frac{1}{2}''$
Length of exhaust pipe	$36''31'$
DYNAMOMETER	
Capacity	112kw/150hp
Maximum speed	7500rpm
KW	(N_mx rev/min)/9549.305
FUEL GUAGE	
Capacity	50-100 cc
AIR BOX	
Orifice size	58.86mm
Coefficient of discharge	0.6

Source: Department of Mechanical Engineering University of Nigeria Nsukka.

2.8 Engine Test at Varying Speed (Constant Load).

In carrying out this test, the engine was started and kept at maximum load. The rpm was measured using tachometer attached with the dynamometer and kept at a relatively low speed of 1300 rpm and then the value of the torque was taken and recorded. The time taken for a given volume (100 cm^3) of the fuel to be consumed at this speed was noted using stop watch. The manometer reading was taken, as well as the reading of exhaust temperature. The above procedure was repeated for higher speed values of 1600 rpm, 1900 rpm, 2200 rpm, and 2500 rpm.

2.9 Engine Emission at Constant Speed (Varying Load)

For this test, the engine was started and kept at a constant speed of 1900 rpm, and loaded with a body weighing 20 kg. The exhaust gases including: NO_x, CO, HC, and SO_2 were measured with a portable digital gas analyzer (Testo XL 450). The data of exhaust emissions were taken from the end of the pipe of the engine. After taking the necessary readings at this specified speed, the load on the engine was varied using the dynamometer loading wheel. The procedure was repeated for higher loads 40 kg, 60 kg, 80 kg and 100 kg.

Calculations on Engine Test Performance

$$\text{Fuel Volume Flow rate, } V_f\,(m^3/s) = \frac{V}{t} \qquad (8)$$

Where:

V = Volume v (m^3) = volume (cm^3)/1000000 t = Time (s)

$$\text{Mass Flow rate of fuel, } M_f\,(kg/s) = \rho_f V_f \qquad (9)$$

$$\text{Brake Power bp, (KW)} = \frac{T \times N}{9549.305} \qquad (10)$$

Where

T is the Torque, N is the Speed

Brake Thermal Efficiency

$$\text{Brake Thermal Efficiency } n_{bt}(\%) = \frac{bp}{M_f \times 44200} \qquad (11)$$

$$\text{BSFC (kg/KWh)} = \frac{3600 M_f}{bp} \qquad (12)$$

3. Results and Discussions

3.1 The Yield of Oil

The percentage of oil extracted from the seed of the African pear using Equation 1 is 49%. The oil yield was relative to 50% yield reported by Ogunsuyi (2015), and was relatively higher than the yields reported for other non-edible seed oil like Mangiferaindica, 30.7% (Ogunsuyi, 2012) and Almond seed oil, 47% (Ogunsuyi and Daramola, 2013). The observed oil yield of D. edulis was also found competitive with the yields of some edible oil such as soybeans, 65% and cotton seed, 60% (Rashid *et al*., 2009). The relatively high oil content of D. edulis will encourage less

dependence on edible oils as feedstock for biodiesel production, thereby promoting food security and food availability.

3.2 Characterization of the African Pear Seed Oil

3.2.1 Physiochemical properties of the African pear seed oil

The summary of the characterization are shown in the Table 3.1. From the table, the FFA value of the African pear seed oil is greater than 1% and as such has relatively high Acid values. These are unacceptable levels for transesterification reaction because of its high tendency for soap formation, reduction in biodiesel formation and inhibition of the separation of esters from glycerol. After the pre-treatment, the FFA was reduced to less than 1% which is better and within acceptable level for transesterification reaction. The density and high viscosity of the oil will make atomization difficult in internal combustion engine, hence it cannot be used directly as bio-fuel. The low pour point shows that the oil will hardly solidify at room temperature hence can be stored for a long time.

Table 3.1: The Summary of Characterization Results of the African Pear Seed Oil (D.edulis)

Properties	D. Edulis
Specific gravity	0.97
Kinematics viscosity (mm^2/s) at 40^oC	7.75
Acid value (MgKOH/g oil)	2.58
Iodine value (g/iodine/100g)	23.9
Pour point ($^{\circ}C$)	14
Saponification value (MgKOH/g oil)	129.03
Refractive index	1.38
Peroxide value (meq/kg)	4.4
Free fatty acid (MgKOH/g)	1.296
Moisture content (%)	0.12
After Pretreatment	
Acid value (MgKOH/g oil)	1.30
Free fatty acid (MgKOH/g)	0.654

3.2.2 The Fatty Acid Profile of African Pear Seed Oil (GC –MS)

The fatty acid composition/profile of D.edulis oil was carried out with the aid of Gas Chromatography Mass Spectrometry (GC-MS). African seed oil comprises 5.3244% of saturated acids (Lauric Acid, Myristics Acid, Arachidic Acid) and 94.6707% unsaturated acids (oleic, linoleic and Palmitlinoleic Acid). The dominant monounsaturated fatty acid of the oil was oleic, which accounted for 75.7% of the total fatty acid content, hence, the oil belongs to oleic acid category (Sonntag, 2012). This is in agreement with 76% oleic acid content reported by Ogunsuyi (2015). The oleic acid content of Dacryodes is comparatively higher than 7- 40% reported for coconut oil, palm oil, cottonseed oil and soya beans oil (Ampaitepin *et al.*, 2006; Rashid *et al*., 2009). This shows that D. edulis seed oil is highly unsaturated triglycerides (Triolein). Nevertheless, the fatty acid components of the Dacryodes seed oil were found to be consistent with the fatty acids present in typical oils used for producing biodiesel.

Table 3.2: Summary of the Fuel Properties of FAME from D.edulis seed compared with ASTM D6751.

Properties	Units	ASTM Limits	Biodiesel From
Density	kg/m^3	830-880	860
Kinematics Viscosity	Mm^2/s	1.6-6.0	4.98
Flash Point	$^{\circ}C$	130 Min.	156
Fire Point	$^{\circ}C$	150 Min.	165
Pour Point	$^{\circ}C$	+15	7
Cloud Point	$^{\circ}C$	-3 – 12	7.5
Aniline Point	$^{\circ}C$		87
Cetane index	$^{\circ}C$	40 Min.	62
Cetane Number	$^{\circ}C$	47 Min.	55

3.3 PERFORMANCE EVALUATION OF FAME FROM D.EDULIUS

3.3.1 Variation of Engine Speed with Torque.

Figure 3.1 shows the plot of engine torque against speed for biodiesel, biodiesel blends and standard diesel at full load. From the Figure below, the torque increases as the engine speed increases up to 1900 rpm and started decreasing. This could be as a result of increase in the fuel temperature and reduction in the viscosity and the lubricity. However, the torque of the engine with standard diesel was higher than for biodiesel and its blends. This may be attributed to low calorific value of biodiesel (Abdullah *et al*.,2011).

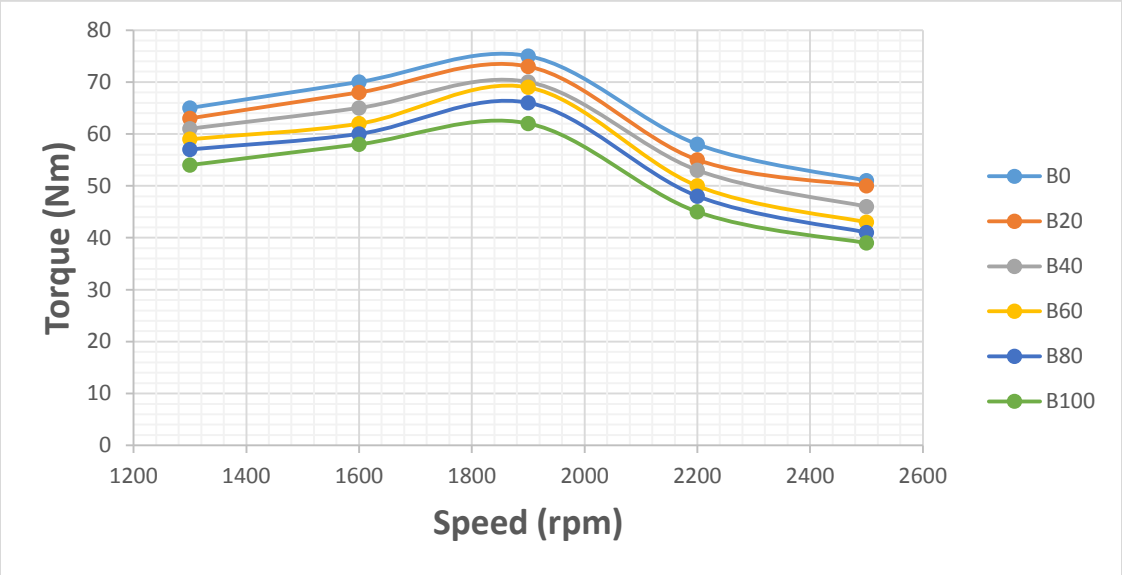

Figure 3.1: Variation of Torque with Engine Speed for Standard Diesel, Biodiesel and Blends from D.edulis.

3.3.2 Variation of Engine Speed with Break Specific Fuel Consumption (BSFC)

Break specific fuel consumption is the rate of fuel consumption per unit brake power. It is a measure of efficiency of the engine in using the fuel supplied to produce work. It is desirable to obtain a lower value of BSFC, the engine used less fuel to produce the same amount of work. Figure 3.2 shows that Fuel consumption increase when using biodiesel, but this trend will be weakened as the proportion of biodiesel reduces in the blend fuel with diesel. B100 has the highest BSFC this may be due to its low heating value, as well as its high density and high viscosity. B20 has the lowest and best BSFC.The trend from the figure 3.2 also implies that the BSFC decreases with the increase in engine speed until minimum BSFC is found at about 1900 rpm and then increases with increase in engine speed until 2500 rpm. The similar trend was also reported by Azad *et al.,* (2016) with minimum BSFC found at 1600rpm and then increases until 2400 rpm using FAME from Macadamia oil. The difference in value may be as result of difference in feedstock used for FAME production. BSFC of B20 from D.edulis is lowest and best compared with that of standard diesel.

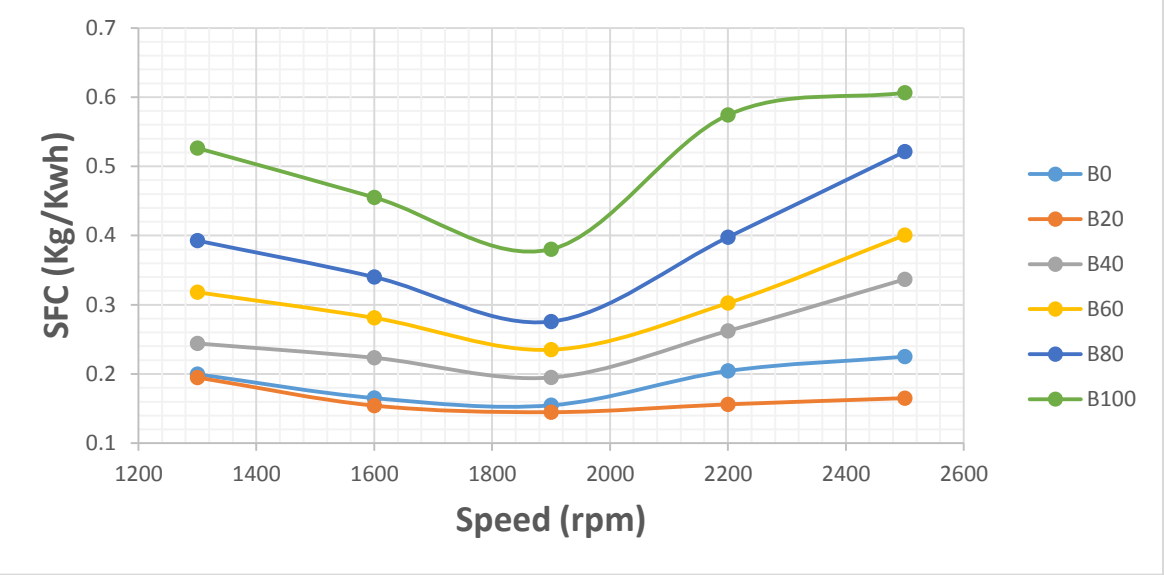

Figure 3.2: Variation of Specific Fuel Consumption with Engine Speed for Standard Diesel and Biodiesel Blends from D.edulis.

3.3.3 Variation of Engine Speed with Break Thermal Efficiency (BTE).

Figure 3.3 Shows that the brake thermal efficiency of the engine gradually increases with increase in engine speed at full load. After reaching the maximum value, it then decreased. This is due to the fact that, initially with the increase in engine speed, the torque produced by the engine increased, hence efficiency increases. But at higher rpm (>1900 rpm) more amount of fuel is injected into the engine cylinder per cycle and due to higher engine speed this fuel does not get sufficient time to burn completely which reduce the efficiency of the engine. In addition, it was seen that biodiesel and blends have lower thermal efficiency than standard diesel. This may be attributed to their lower break power and decrease in heating value. The Figure also shows that the efficiency of the engine at B20 is similar to that of standard diesel up to maximum BTE.

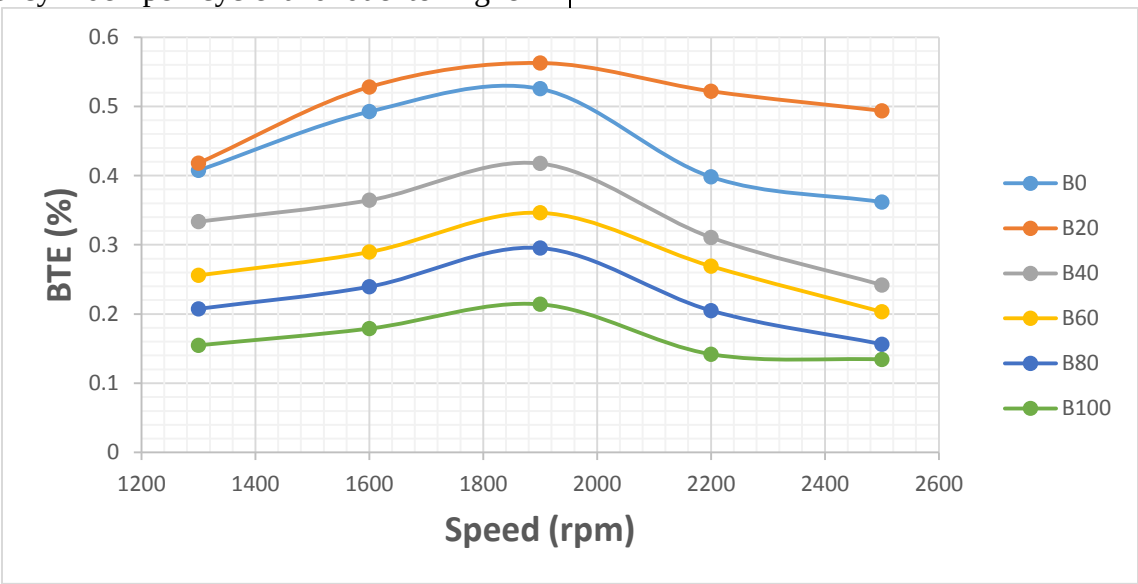

Figure 3.3: Break Thermal Efficiency with Engine Speed for Standard Diesel and Biodiesel Blends from D.edulis.

3.3.4 Variation of Engine Speed with Break Power (BP).

Brake power is the engine net output. From Figure 3.4 it could be seen that brake power increases as the speed increases at full load and decreased after reaching a maximum value. This is may be attributed to reduction in lubricity at higher speed. Moreover, brake power of the engine with standard diesel was higher than for biodiesel and blends at any speed. This is due to lower calorific value of biodiesel and its blends (Abdullah *et al*., 2011). In addition, the brake power of B20 is comparable with that of standard diesel and this is due to decrease in biodiesel content of B20.

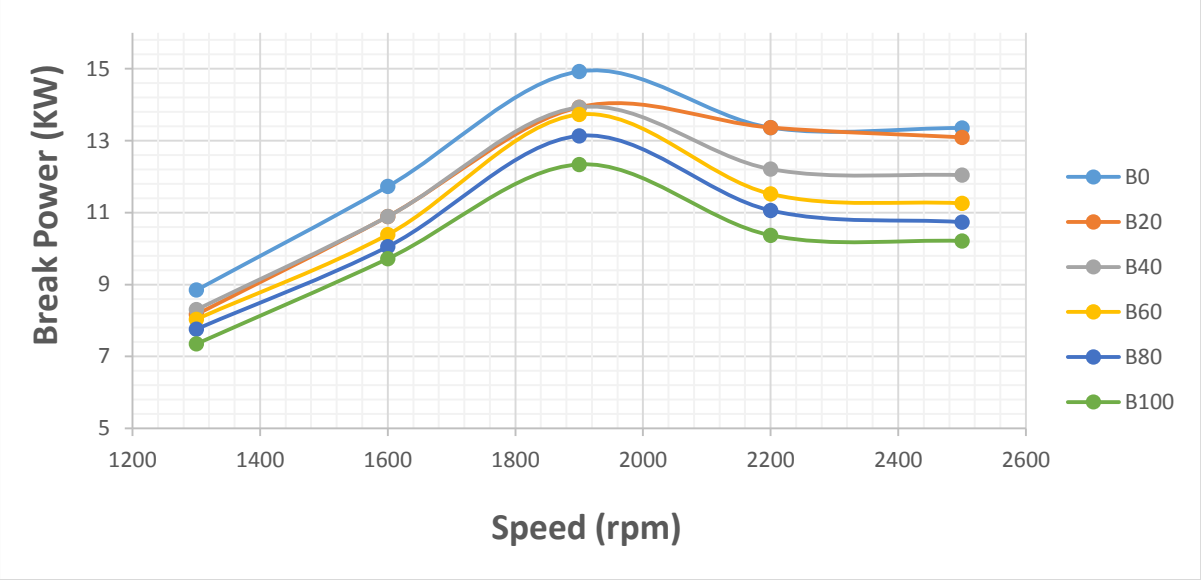

Figure 3.4: Break power with Engine Speed for Standard Diesel and Biodiesel Blends from D.edulis.

3.3.5 Variation of CO Emission with load for FAME from D.edulis.

Figure 3.5 shows the variation of CO emission with load. It was seen that CO emissions reduced as biodiesel content increases. This is may be attributed to high oxygen content and lower carbon to hydrogen ratio in biodiesel and due the fact that Oxygen molecules in biodiesel enhanced vaporization and atomization of biodiesel blends compared to diesel fuel. Also as the engine load increases, the CO emission increases due to decrease in air-fuel ratio in the engine.

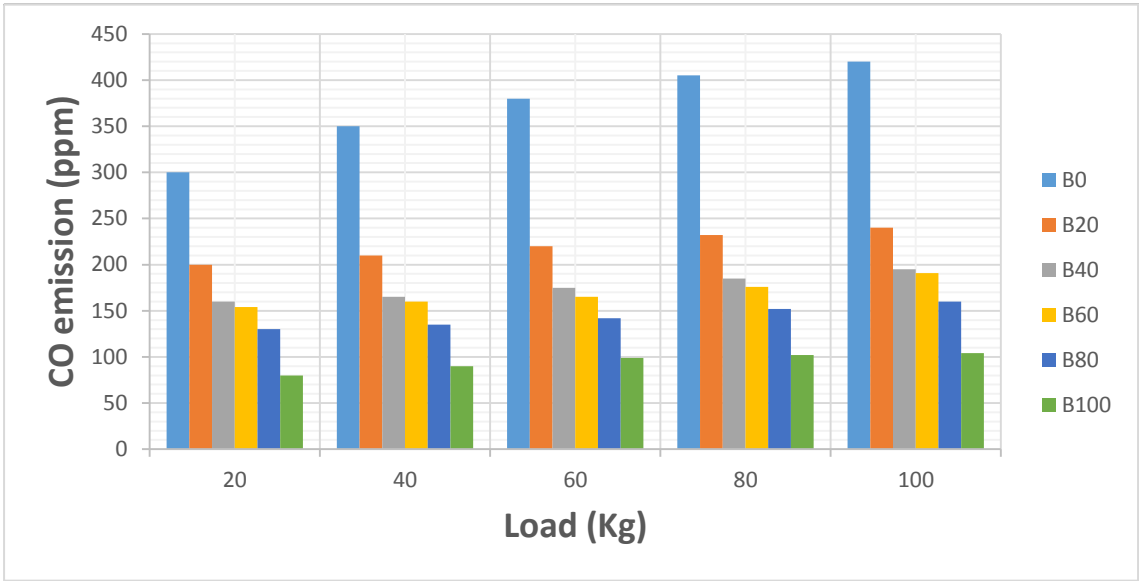

Figure 3.5: Variation of CO Emission with Load for standard diesel, Biodiesel from D.edulis and Blends at 1900 rpm.

3.3.6 Variation of NO_X Emission with load for FAME from D.edulis.

Figure 3.6 shows the variation of NO_x with load. It indicates that NO_x emissions increases with increase in biodiesel content. This is mainly due to higher oxygen content and cetane number in biodiesel. It also shows that as engine load increases, the NO_x emission from biodiesel increases due to higher combustion chamber temperature and higher fuel consumption.

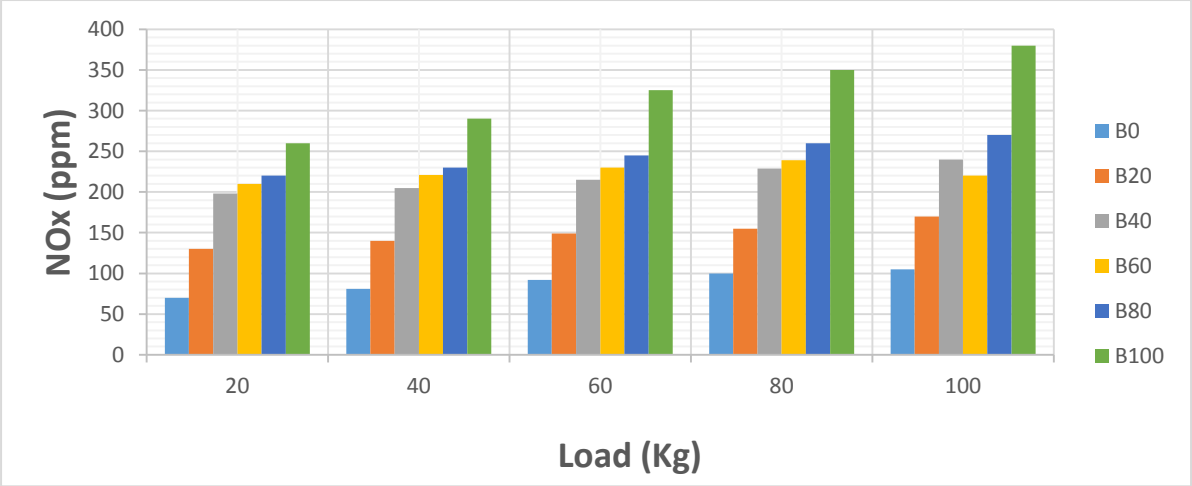

Figure 3.6: Variation of NO_X Emission with load for standard diesel, Biodiesel from D.edulis and Blends at 1900 rpm.

3.3.7 Variation of Hydrocarbon (HC) Emission with load for FAME from D.edulis.

Figure 3.7 shows the variation of HC emission with load. It shows that HC emission reduces with increase in biodiesel content. HC emission for biodiesel increases with increase in load and this may be attributed to high fuel consumption. This is in agreement with observation made by Xue *et al.*, (2010).

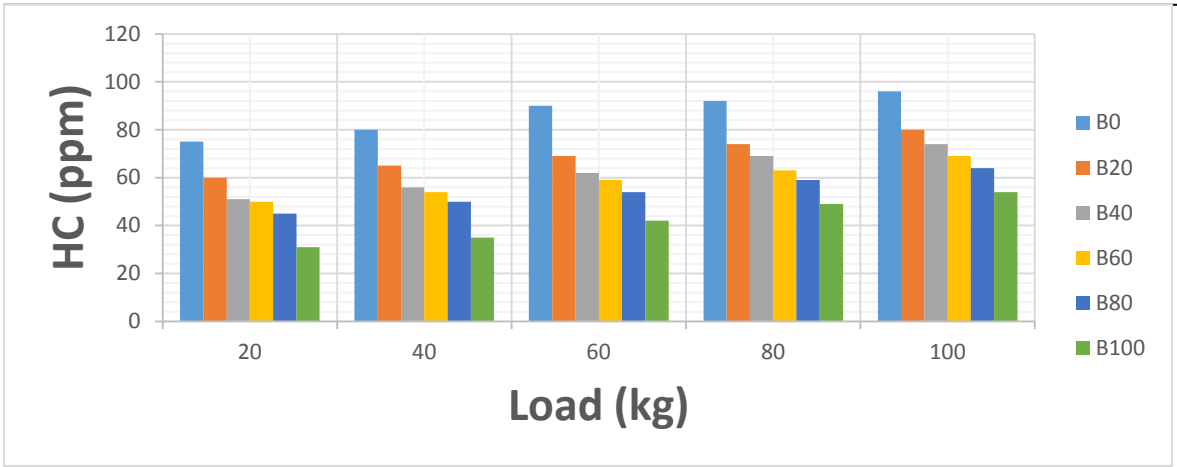

Figure 3.7: Variation of HC Emission with load for standard diesel, Biodiesel from D.edulis and Blends at 1900 rpm.

4. Conclusion

The performance evaluation of biodiesel from African pear seed oil using homogenous catalysts (NaOH) were carried out. The percentage of oil extraction from the seeds of the African pear was 49%. The FFA value of the African pear seed oil was found to be greater than 1% and with relatively high Acid value. Pre-treatment was carried out to reduce the FFAs to less than 1% which is a safe and acceptable level for transesterification reaction. GC-MS result reveals that the oil is amonounsaturated fatty acid dominant (Triolein). The methyl ester was produced by transesterification of African pear seed oil. The density, viscosity, Cetane index and other fuel properties of biodiesel produced in the present work met the ASTM standard and were within the acceptable limits. From performance evaluation, B20 had the lowest and best BSFC for FAME from D.edulis compared with that of standard diesel.CO and HC emissions reduced with biodiesel and its blends, while NO_x emission increased with biodiesel and its blends compared with the conventional diesel fuel.

Reference

Abdullah, A., John, F., Rob, B., (2011). The effects of using biodiesel as fuel on compression Ignition (CI) engines and its production from vegetable oils. International Conference on Environmental, Biomedical and Biotechnology, IPCBEE, 16.

AbulKalam Azad, Mohammad Rasul, Masud Khan M., (2016). Australia1st International Conference on Energy and Power, ICEP2016, 14-16.

Aderemi, B.O., Hameed, B. H., (2010). Production of biodiesel from palm oil. Nigeria Society of Chemical Engineers Proceedings, 40, 135-143.

Akubugwo, I.E., Chinyere, G.C., and Ugbogu, A.E., (2008). Comparative studies on oils from some common plant seeds in Nigeria. Pak. J. Nutr., 7: 570-573.

Ampaitepin, S., Miyuki, K., Tetsuo, T., (2006). Life Cycle Analysis of Biodiesel Fuel Production. Case Study of Using Used Cooking Oil as a Raw Material in Kyoto, Japan. Proceeding 2nd Joint International Conference on Sustainable Energy and Environment.

Attanatho, L., Magmee, S., Jenvanitpanjakul, P., (2004). Factors affecting the Synthesis of Biodiesel from crude palm kernel oil. Proceedings of the Joint International Conference on Sustainable Energy and Environment (SEE), pp 359-361.

Awono, A., Ndoye, O., Schreckenberg, K., Tabuna, H., Isseri, F., (2002). Production And Marketing of Safou (Dacryodeseduli) in Cameroon and Internationally: Market Development Issues. For. Trees Livelihoods. 12(1): 125-147.

Cavazzuti , M., Optimization Methods (2013). From Theory to Design, 13

DOI: 10.1007/978-3-642-31187-1_2, © Springer-Verlag Berlin Heidelberg.

Demirbas, A., (2009). Progress and recent trends in biodiesel fuels. Energy Conversion and Management 50, 14-34.

Fan, X., Wang, X., Chen, F., (2011). Biodiesel production from crude cottonseed Oil; An Optimization process using Response Surface Methology. The Open Fuels and Energy Science Journal, 4, 1-8.

Ghetsi, G. F., De macedo, J. L., Parente, V. C. I., Dias, J. A., Dias, S. C. L., (2009) Synthesis, Characterisation and reactivity of Lewis acid/surfactant Cerium Trisdodecylsulfate catalyst for transesterification and Esterification reaction. Appl. Cat. A; Gen 355, 139-147.

Iloamaeke, I. M., Onuigbo C. C., Umedum, L. N., Umeobika, C. U. and Oforah P. U. (2016). Production and characterization of biodiesel from the seed of African pear seed. International Journal of Current Research, 8, (01), 25230-25234.

Kalligeros S., Zannikos F., Stournas S., Lois E., Anastopoulos G., Teas C.H.,

Sakellaropoulos .,(2003). An investigation of Using Biodiesel/Marine

Diesel Blends on the Performance of a Stationary Diesel Engine. Biomass Bioenergy vol. 24, 141-149.

Kaya, C., Hamamei, C., Baysal, A., Akba, O., Erdogan, S., Sayduct, A., (2009). Methyl ester of Peanut (Arachis hypogeal L.) seed oil as potential Feedstock For biodiesel production. Renewable Energy 34, 1257-1260.

Labeckas G., Slavinskas S., (2006). The effect of Rapeseed Oil Methyl Ester on Direct Injection Diesel Engine Performance and Exhaust Emissions. Energy Convers Manage, vol. 47, 1954-1967.

Leung, D. Y. C., Guo, Y., (2010). Transesterification of Meat and used frying oil; Optimization for biodiesel production. Fuel Process Technol. 87: 883-890.

Ogunsuyi, H.O., (2012). Acid and Base Catalysed Transesterification of Mango (MangiferaIndica) Seed Oil to Biodiesel. IOSR J. Appl. Chem. (IOSRJAC). pp. 18-22.

Ogunsuyi, H.O., Daramola BM (2013). Evaluation of Almond Seed Oil as Viable Feedstock for Biodiesel Fuel. Int. J. Biotechnol. Res. 1(8): 120-127. Ogunsuyi, H.O., (2015). Production of biodiesel using African pear (Dacryodesedulis) seed-oil as Feedstock Acad. J. Biotechnol. 3(5): 085-092.

Saifuddin N, Refai H. (2014) Spectroscopy analysis of structural transesterification.

Venkata Ramesh Mamilla, Mallikarjun, M.V., Dr. Lakshmi Narayana Rao, G. (2012). Biodiesel Production From Palm Oil By Transesterification Method, International Journal of Current Research, 4(8): 083-088.

Younis, M. N., Saeed, M. S., Khan, S., Furqan, M. U., Khan, R. U., Saleem, M., (2009). Production and characterization of biodiesel, from waste and Vegetable oils. Journal of Quality and Technology Management, 111-121.

Zabeti, M., Mai, W., Daud, M., Aroua, K., (2010). Optimization of the activity of CaO/Al2O3 catalyst for biodiesel production using response surface Methodology, Applied Catalysis, A, General 366, 154-159.