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Comparative Analysis And Characterization Of Biodiesel Production From Moringa Oleifera, Glycine Max And Jatropha Curcasseeds Oil Using Homogenous Catalyst.

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ABSTRACT: Due to the growing energy demand and pollution problems caused by the use of fossil fuels, it has required to develop alternative fuels as well as renewable sources of energy. The use of biodiesel as a substitute for conventional diesel has been of great interest. The aim of this research will be helpful in determining the comparative analysis and characterization of the biodiesel production from Moringa oleifera, Glycine maxand Jatropha curcas due to the yield of the oil extracted from the seed. The percentage oil content of Moringa oleifera, Glycine maxand Jatropha curcas seed were found to be 38.33%, 17.10% and 32.10.The result of this research signifies the identification of the optimum characterization of physical and chemical parameters for the extracted oil and biodiesel production by transesterification from base catalysis such as pH, moisture content, Specific gravity, Kinematic Viscosity at 40 °C, Refractive index, Acid value, Saponification value, Iodine value, Flash point, Fatty acid methyl ester (FAME) composition and Identification of Functional groups.All the results of the seed oil and the Biodiesel product were conformed to the standard specified by USA (ASTM D6751) and European organization (EN 14214) and have met the specified standard recommendation. The fatty acid methyl ester of thebiodiesel was analyzed using GCMS which contains Palmitoleic acid,Palmitic acid,Oleic Acid,Stearic acid,Eicosenic acid, Lignoceric acid, Linoleic Arachic,Behenic acid and found that the oleic acid content of Moringa oil is 70.9% relative amount has the highest level with respect to Jatropha having 56.1% and Soybeans having 28.9. The identification of functional group of Biodiesel result using FTIR also conform that the Moringa oleifera has1768 cm-1, Glycine maxhas1769 cm-1 and Jatropha curcas has 1769 cm-1 contains C=O i.e. carbonyl functional group of typical ester which ranged 1800-1700cm-1. All the result above confirmed that the Biodiesel from Moringa oleifera, Glycine maxand Jatropha curcas seed oil is suitable for use in diesel engines.

Keywords: Biodiesel; Moringa oleifera; Jatropha Curcas; Glycine max; GCMS; and FTIR.

I. INTRODUCTION

Over the years, efforts have been made towards preserving our world through provision of environment friendly alternative energy sources. Biodiesel as methyl ester is a clean glowing fuel obtained from a non-depleted feedstock such as oil of vegetables and or animal fat that consist of long alkyl chain of methyl, ethyl, or propyl esters. Methyl ester (Biodiesel) is usually produced by chemically reacting lipids e.g., vegetable oil, animal fat with an alcohol of methanol or ethanol producing fatty acid esters (Zhang et al., 2003).

Biodiesel is imply to be operates in excellent diesel engines and is separate from the vegetable and waste oils operated to fuel converteddiesel engines. Methyl ester biodiesel can operate alone, and or combined with petroleum diesel in any quantity and can also be operates as heating oil (Omidvarborna; et al., 2014).

Biodiesel is a non-depleted energy source that enhances greenhouse gas emission, GHG reduction and decreases the carbon footmark in Agriculture. Biodiesel also provides a very lower global warming because the carbon in the fuel is detached by the air by the plant raw material (Sheehan et al, 1998).

Biodiesel can be used in the existing engines without any alteration and the biodiesel found from vegetable oils does not have any sulfur,

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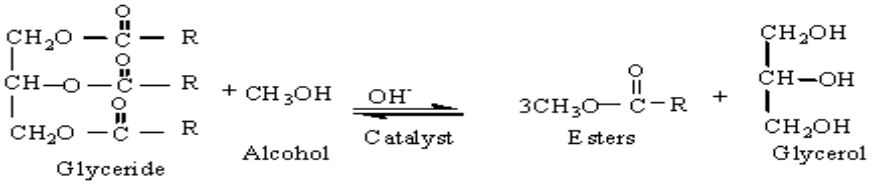
aromatic hydrocarbons, metals or crude oil residues. (Ushakov et al, 2013). Biodiesel consumed fuel due to its lower calorific value; It also has higher nitrous oxide (NOx) emissions than conventional diesel fuel. (Romano and Sorichetti., 2011)

Among all the methods, the transesterification procedure is most suitable for industrial manufacture of biodiesel. Biodiesel can also be obtained from alcohols other than oil of vegetables and fats from animal, which can be used in compression ignition engines or mixed with normal diesel oil. The ASTM International, identify this fuel as a combination of long chain monoalkylic esters from fatty acids found from the renewable resources to be performed in compression ignition engines (Knothe et al 1997).

The Transesterification process is a method whereby reaction of a triglyceride of fat and oil with an alcohol either methanol or ethanol is used to form esters and glycerol. A triglyceride contains a glycerin molecule as its base with three long chain fatty acids attached to it. The presence of the fat is determined by the nature of the fatty acids attached to the glycerin. The nature of the fatty acids can in turn affect the features of the biodiesel. Throughout the esterification procedure, the triglyceride is reacted with alcohol in the presence of a catalyst, usually a strong alkaline like sodium hydroxide or potassium hydroxide. The alcohol then counters with the fatty acids to form the mono-alkyl ester, or biodiesel and some crude glycerol. The chemical routes for Biodiesel is given in figure 1 below;



Scheme 1: Chemical routes for Biodiesel

II. MATERIALS AND METHOD

Materials

Ethanol BDH Chemical England, Methanol BDH England, Petroleum ether JHD China, Sodium hydroxide Titan Biotech LTD India, Potassium Hydroxide Qualikems, Hydrochloric acid E.Merck Germany, Potassium Iodide Qualichems, Carbon tetra chloride , Diethylether Round bottom flask, Water bath, Table top Bunsen burner, Soxlet extractor, Gas Chromatography Mass Spectrometer (GCMS), Fourier Transform Infra-red (FTIR).

METHODOLOGY;

Collection of sample

Matured seeds of Jatropha Curcas and Moringa Oleifera were collected directly from ripe fruits and Glycine maxwere bought locally in the market. The sample were collected from Damaturu, and it's were identified by the Department of Biological Science at Yobe State University. They were decorticated manually. The cleaned seeds were dried in the sun for 24 hours and then oven dried at 105 ^{o}C to a constant weight to reduce the moisture content.

Extraction of the oil

The seeds were dehulled manually. The dehulled seeds were oven-dried for 24 hours and the moisture content was determined. The dried seeds were ground into smaller particle size distribution by using an electrical grinder. The total oil content of seeds was determined by Soxhlet extraction. About 600g of Moringa Oleifera, 960g of Jatropha Curcas and 1960g of Glycine maxof ground seeds placed in an extraction thimble at different time intervals and 250ml Petroleum ether in 500ml round bottom flask was refluxed using a Soxhlet extractor. The temperature of the Petroleum ether was maintained at 40 ˚C and the extraction carried out for 2 weeks.

Determination of Moisture content from the Seeds

The seeds sample was measured (M_1), and oven dried at 105 ^{o}C for 3 hours. After that, they were removed from the oven and placed in a desiccator for 30 minutes to cool, then removed and re-measured (M_2). The percentage moisture in these seeds was calculated (Akpan et al., 2006) as shown below:

$$\text{Moisture} = \frac{(M_1 - M_2) \times 100}{M_2} \%$$

M_1 = Original mass of the sample before drying
M_2 = mass of the sample after drying

Oil Content (yield)

The oil content was calculated from the Equation below;

$$\% \text{ of oil} = \frac{(M_2 - M_1) \times 100}{}$$

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M

Where, M = mass of sample,
M_1= mass of the beaker with glass ball,
M_2 = mass of the beaker with glass ball and oil,
$M_2 – M_1$ = mass of oil. (Doan, 2004)

pH Value determination

Two (2) gram of each sample was transferred into 25ml glass beaker and 13ml of hot distilled water was added to each sample and stirred slowly. The combinations were then allowed to cool in a cold-water bath to 25℃. The pH meter was standardized with buffer solution and then inserted into the sample and pH value was measured (Akpan et al., 2006).

Specific Gravity

Unfilled density bottle of 5ml volume was weighed (D_0), filled with oil, and then stoppered inserted and reweighed (D_1). The oil was replaced with water after washing and drying the bottle and weighed (D_2). The expression for specific gravity is:

Specific gravity = $\frac{(D_1 - D_o) \times 100}{D_2 - D_o}$ = Mass of the substance / Mass of an equal volume of water

(Akpan et al., 2006).

Refractive Index

A few drops of oil samples were moved to glass slide of the refractometer (ATAGO Co. Ltd. Japan). Through the eyepiece of the refractometer, the dark portion viewed was adjusted to be in line with the intersection of the cross, In this case, the pointer on the scale pointed to the refractive index and values were recorded (Akpan et al., 2006).

Kinematic Viscosity

Viscometer of flow time above 200 seconds was elected (Cannon Fenske Opague, Bransted international , Glass capillary viscometer), charged with the sample by inverting the tube's thinner arm into the liquid sample . Suction force drawn up to the upper timing mark of the viscometer. The viscometer was held by metal holder and inserted in a water bath at 40 ℃ for approximately 10 min. to allow the sample to reach bath temperature. The suction force was then applied to the thinner arm to draw the sample slightly above the upper timing mark. The afflux time by timing the sample free flow from the upper timing mark to the lower timing mark was recorded (Akpan et al., 2006).

Acid Value

25ml of diethyl ether and 25ml of ethanol were mixed in a 250ml beaker, and then added to 10gm of oil contained in a 250ml conical flask and drops of phenolphthalein was added. The mixture was titrated with 0.1M NaOH to the end point with regular shaking, A dark pink color appears and the volume of 0.1M NaOH (V_o) was recorded. Free Fatty Acid (FFA) was calculated (Akpan et al., 2006; Kyari, 2008) as shown below;

V_o/W_o X 2.82 X 100 100ml of 0.lM NaOH = 2.83g of oleic acid

W_o = sample weight

Then, acid Value = FFA x 2

Saponification Value

2g of oil sample was measured into a conical flask and 25 ml of 0.1 N ethanolic potassium hydroxide (KOH) was added. The blend was constantly stirred and allowed to boil gently for 60 min. A reflux condenser was placed on the flask containing the mixture. Few drops of phenolphthalein indicator were added to the warm solution and titrated with 0.5 M Hydrochloric acid (HCl) to the end point until pink color of the indicator disappeared. The procedure was the same as for other samples and blank. Saponification value was calculated (Akpan et al., 2006; Kyari, 2008) as in below:

$S.V = 56.1 \times N(V_0 - V_1)/M$

V_0 = volume of the solution used for blank test

V_I = volume of the solution used for determination

N = Actual normality of the HCl used

M = Mass of the sample

Indicator method was used as specified by ISO 3657 (1988).

Iodine Value

0.4 g of oil sample was measured into a conical flask and 20 ml of carbon tetra chloride (CCL_4) was added to dissolve the oil. Then 25 ml of Dam's reagent was added to the mixture using a safety pipette in fume chamber. Stopper was inserted and the content of the flask was vigorously swirled. The flask was placed in the dark for $2^{1/2}$ hrs. Then, 20 ml of 10% aqueous potassium iodide (KI) and 125 ml of water were added using a measuring cylinder. The solution was titrated with 0.1M sodium thiosulphate ($Na_2S_2O_3$) solutions until the yellow color almost disappeared. Few drops of 1% starch solution indicator was added and titration continued by adding thiosulphate drop wise until blue coloration disappeared after vigorous shaking. The same procedure was used for blank test and other samples. The iodine value (I.V) is given by the expression:

$I.V = 12.69 \times C(V_1 - V_2)/M$

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C = Concentration of sodium thiosulphate used
V_1 = Volume of sodium thiosulphate used for blank
V_2 = Volume of sodium thiosulphate used for determination
M = Mass of the sample (Akpan et al., 2006; Kyari, 2008)

Flash point

The biodiesel is measured by flash point tester which consists of 80 ml closed copper cup, heater, and a source that gives continuous sparks. The source that gives continuous sparks consists of a battery connected to small engine, disporater, coil, and spark plug. The engine is used to rotate a disporater, which is used to fractionate the current to electrical pulses. A coil is used to amplify the electrical pulses, and spark plug is used to create sparks inside the cup. Biodiesel sample is heated and the vapor accumulated inside the cup, at the moment that the vapor was sufficient to ignite the flash light noticed, and the temperature measured.

Transesterification procedure, the process involves three steps

1.**Preparing the Methoxide Solution**

Measure 24 ml methanol and place into 250ml conical flask, Close the lid and tighten securely. Then Measure 2 g NaOH catalyst and quickly add it into the methanol, minimizing its exposure to air. Recap the flask with the lid and tighten securely, with enough time, the catalyst will dissolve in the methanol, with gentle agitation which makes all of the solid catalyst dissolved in the methanol before proceeding

2.Transesterification

Measure 100 ml of oil and place in a 250ml beaker. Using hot water bath, heat the oil to 55 ℃ though Methanol boils at about 64 ℃ . Then place oil into the 250 ml conical flask labeled with the type and quantity of feedstock, catalyst, and methanol used. Quickly add the methoxide solution to the flask of oil, with caution when re-opening the flask of methoxide. Ensure that the lid is securely tightened. Shake the flask vigorously for at least 10 minutes.

3.Settling/separation

The mixtures were allowed to settle overnight for completion end reaction. The stable reactant mixture would appear as two layers, the higher layer as biodiesel and traces of glycerin etc. and the bottom layer as glycerin and gums. The glycerin was removed from the biodiesel preparation unit by opening the tap on the bottom of the separating funnel. Then add 100 ml of hot water at approximately 40 ºC per liter of biodiesel with consistence shaking and then allowed to settle to separate two layers for nearly 5-6 hrs. Repeat step above at least three times to remove traces of glycerin and soap from the biodiesel yield. (Penugonda and Venkata, 2012)

Data analysis techniques

Chromatographic analysis GCMS

This involved analyzing the chemical composition of the biodiesel oil samples of Moringa Oleifera and Jatropha Curcas.

Procedure; Transesterification of fatty acids to Fatty Acid Methyl Esters **(FAMES):** 0.5 g of biodiesel oil samples was refluxed with 5 ml of 0.5 N potassium hydroxide methanolic solutions for 5 min. After the reflux, 10ml hexane was added to it and mixed using vortex mixer, then centrifuged at 3000 rpm for 5 min. After the centrifugation, the resultant solution was subjected to GC MS analysis.The GC-MS analysis of oil sample was performed using Agilent 7890B GC System, fitted with a 30 m x 250 µm x 0.25 µm Rtx-5MS capillary column; maximum temperature 325 °C, coupled to Agilent 5977A MSD. Ultra-high purity helium (99.99%) was used as carrier gas at a constant flow rate of 1.0 mL/min. The injection, transfer line and ion source temperatures were 250^0C, 230^0C and 280 °C respectively. The ionizing energy was 70 eV. Electron multiplier voltage was obtained from autotune. The temperature of the oven was programmed from 45 °C (hold for 2 min) to 280 ℃ at a rate of 10 °C/min and hold for 5 mins.

The sample, 1 µL was injected into injector. All data were achieved by collecting the full-scan mass spectra within the scan range.The percentage compositions of the constituents were expressed as a percentage by peak area. The identification and characterization of chemical compounds in the samples was based on GC retention time. The mass spectra were computer matched with those of standards available in mass spectrum libraries.

Determination of functional group using FTIR

The FTIR identifies the functional group present in the feedstock samples of biodiesel.

It was examined and conducted in Yobe State University Chemistry Research Laboratory using FTIR (Buck Scientific).

Procedure; A drop of liquid of biodiesel sample from Moringa oleifera, Jatropha Curcas and Glycine maxwere placed or smeared onto the ZnSe crystal. The sample was scanned into the machine between 4000 $cm^{-}1$ to 400 $cm^{-}1$ in triplicates.

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III. RESULT AND DISCUSSION

Table 1: The physical and chemical properties of oil extracted from Moringa oleifera, and Jatropha Curcas seed results compared with ASTM standard D6751.

Parameters	Moringa O.	Jatropha C.	Glycine Max	ASTM 6751
Oil Yield	38.33	32.10	17.10	-
Moisture content	15.45	6.13	3.33	-
pH	5.50	4.03	3.46	-
Specific Gravity	0.8915	0.8915	0.8969	0.888
Density	0.8969	0.8969	0.9022	0.875-0.90
Acid Value	1.10	0.80	0.84	0.8 max
Saponification Value	68.70	107.99		< 200
Refractive index	1.29	1.39	1.40	1.476-1.479

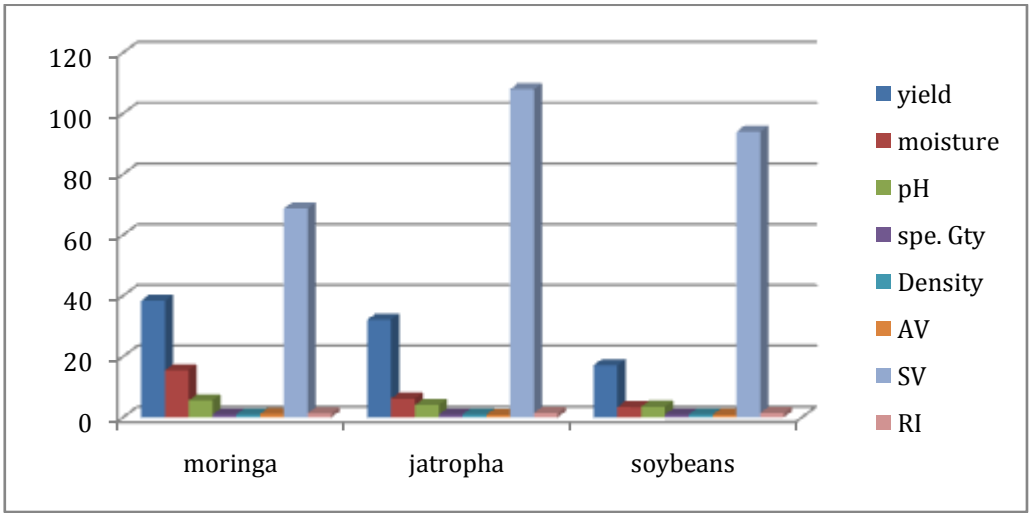

Figure 1 chart showing physicochemical properties ofMoringa, Jatropha and Glycine maxoil.

Result Discussion from table 1

Moisture content, the results obtain from investigation of moisture content of Jatropha curcas is 6.13% and Glycine max is 3.3% were in comparable with which reported by Salunke and Desai, 1941 ranged from 3 to 7 % and Moringa oleifera is 15% in comparison with which reported by mohibbe et al 2005 which is 15-25% moister. Oil yield from Moringa oleifera 38.3 % and Jatropha carcus 32.1%were considered efficient for commercial production of oil in Nigeria. That, soybean oil which is 17.1%, is however low to be considered an oil seed for commercial purposes, but their use may not be prevent from use, as they are important nutritionally. Ene-Bong and Carnovale (1992) observed 18% yields for soybean respectively. The oil yield 38.3% from Moringa oleifera in this study coincides by which reported by mohibbe et al, (2005) that the seed contains 38-40% of oil and 15-25% of moister. Jatropha curcas oil yield 32.1% is in comparable with what Rug and Ruppel (2000) analyses that the Jatropha curcas seed oil contains 25 – 30%. However, the oil content of Jatropha curcas and Moringa oleifera seeds oil in the present analysis was found to exceed those of some conventional oil seed crops: cotton (15.0 – 24.0%), Glycine max(17.0 – 21.0%) (Pritchard, 1991).Kyari, (2008) reported that an oil yield of 26 to 42% was considered to be at reasonable yield levels. It should be observed that the method of extraction is a very important parameter affecting the yield of oil. Specific gravity from the result above it could be observe that the specific gravity of oil Jatropha curcas 0.8943 was in agreement with 0.88 obtained by belewu et al 2010.**Density,** all the densities were in agreement with the specified value reported by ASTM1298 which its limit ranges from 0.875-0.90 and also in agreement with 0.868 reported by Belewu et al, (2010).**Acid value** signifies free fatty

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acid content due to enzymatic activity, and is usually indicative of spoilage. Its maximum acceptable level is 4 mg NaOH/g oil (CODEX Alimentarius Commission, 1982), for recommended international standards for edible. Results obtained from this work indicate that the acid value of the edible Glycine max oils as 0.84mgNaOH/g. The values are within the specified ranged. The measured acid values for Jatropha curcas 0.80mgNaOH/g is in comparison with that of the ASTM standard of 0.8mgNaOH/g for non-edible oils. for Moringa oleifera 1.10mgNaOH/g seed oil, Based on the acidity it can be edible since the value fall below maximum acceptable value of 4.0mgNaOH/g of oil as recommended by Codex Alimentarius Commission,1982.This is an remarkable result since the acid value measures the presence of corrosive free fatty acids and oxidation products. Which is an important variable in considering the quality of oil because the lower the free fatty acid, the better the quality of oil. **Saponification value**, the saponification value obtain above for Moringa oleifera is68.7, Jatropha carcus is107.9 andGlycine maxis93.96were very low compare to what reported by Kyari (2008) that S.V for Glycine maxoil is 195.6 (mg KOH/g sample), for Moringa oleifera is 179 (mg KOH/g sample) and for Jatropha curcas is 114.9 (mg KOH/g sample). These result shows that lower alkali would be required to enable it neutralize the available free fatty acid released by the oil. The saponification values of all the oils are not highly comparable with the result specified for quality oil. The differences detected in the experimental result might be as a result of the differences in the process of extraction. Thus, the oils with SV in the range reported above may be used for soap making, shampoos and lather shaving creams (Oderinde et al., 2009). Oil fractions with saponification values of 200 mg KOH/g and above, had been reported to possess low molecular weight fatty acids (Abayeh et al., 1998).**Refractive index,** the refractive index which is the ratio of the velocity of light in vacuum to the velocity of light in a medium is an indication of the level of saturation of the oil (Oderinde et al., 2009). The refractive index analysis shows that Glycine max is 1.40 , Moringa oleifera is 1.29 and Jatrophacurcas is 1.39 which did not meet the ASTM values that ranges from 1.476 to 1.479 (ASTM International, 2002). These results could be due to the occurrence of some impurities and other components of the crude oil mixture. The refractive index values were similar to those by (Izuagie et al., 2008), for Cucumeropsis edulis, Colocynthis citrillus and Prunus amygdalus.

Table 2. Physicochemical properties result of Methyl ester (Biodiesel) produced from Moringa oleifera and Jatropha curcas and Glycine max seed compared with ASTM D6751 and EN14214.

	Moringa O.	**Jatropha C.**	**Glycine M.**	**ASTM D6751**	**EN 14214**
pH	**6.27**	**7.23**	**6.96**	**-**	**-**
Specific Gravity	**0.8225**	**0.8523**	**0.8502**	**0.8544**	**-**
Density	**0.8300**	**0.8601**	**0.8582**	**0.875-0.90**	**-**
Acid Value	**0.42**	**0.38**	**0.42**	**-**	**< 0.5**
Saponification V.	**171.03**	**166**	**188.0**	**< 200**	**-**
Kinematic value	**4.61**	**4.11**	**4.8**	**-**	**3.5-5.0**
Iodine value	**103.3**	**99.2**	**117.3**	**-**	**Max 120**
Flash point	**180.33**	**170.33**	**171.0**	**-**	**Min 130**
Refractive index	**1.45**	**1.46**	**1.44**		

-Not specified; Note: Values are mean standard deviation of triplicate determination

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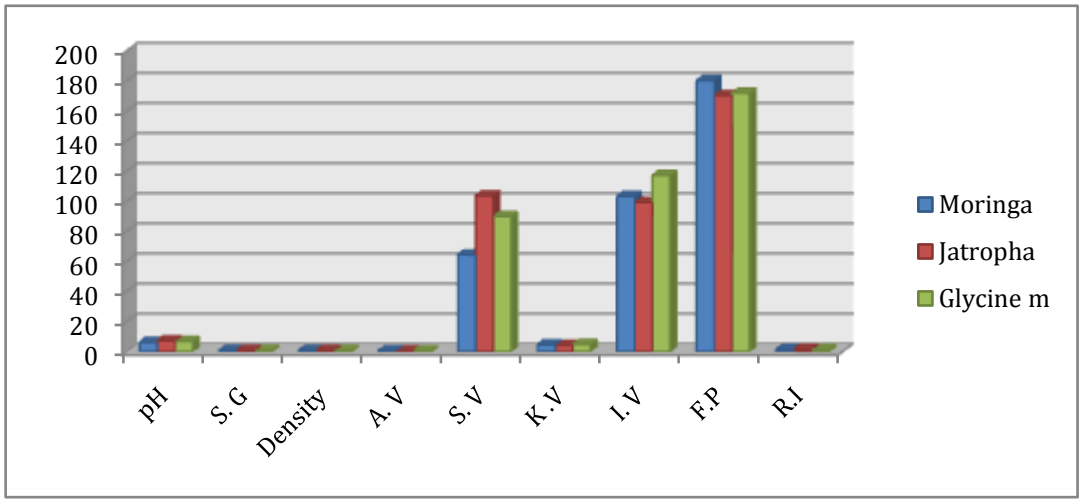

Figure 2 chart. Physicochemical properties Biodiesel ofMoringa, Jatropha and Glycine max

Result discussion from table 2

Specific gravity of the methyl ester of Moringa oleifera, Jatropha carcus and Glycine maxwere all within the specified standard value of ASTM 1298 which limits 0.8544wt/ml. **Density** result for the biodiesel of Moringa oleifera,Jatropha carcus and Glycine maxis 0.83, 0.86 and 0.858. The density result of the biodiesel varied from 0.83–0.86 g cm−3. The results confirms that the density values of the biodiesels obtained from the feedstocks meet the density value specified by the ASTM D6751 ranged from 0.82–0.90 g cm−3.Density depends upon the raw materials used for biodiesel fuel production and the biodiesel methyl ester profile (Blangino et al 2008). There are no significant differences in densities observed between biodiesels obtained from Moringa oleifera, Jatropha carcus and Glycine max. **Acid value,** the result obtain from Moringa oleifera, Jatropha carcus and Glycine max methyl ester is 0.42, 0.38 and 0.42 were in agreement as compared with the specified standard values of ASTM D6751 limits less than < 0.8 and EN14214 limits less than < 0.5.**Saponification value** result obtain from the methyl ester ofMoringa oleifera, Jatropha carcus and Glycine maxare 64.4, 103.6, and 89.96. **Refractive index** values of the obtained from Moringa oleifera, Jatropha carcus and Glycine max biodiesel ranges from 1.44–1.46. These results are in good agreement with those reported by Domínguez et al 1996.Ullah et al 2013 also reportedthat pure biodiesel possesses an RI in the range of 1.45. **Kinematic viscosity** at 40 ^{o}C of biodiesel results from Moringa oleifera 4.61, Jatropha carcus 4.11 andGlycine max 4.8 is in comparable with the standard EN ISO 1304 ranged from 3.5-5.0 mm^2/s, which falls within the limit of biodiesel. So the implication is that biodiesel will have more lubricating effect in engines which will enhance an added advantage to the users, since it will reduce wear and tear in the engine. **Iodine value,** from the result of methyl ester obtain from Moringa oleifera, Jatropha carcus andGlycine max is 102.3, 99.2 and 117.3 gI /100g compared with the standard EN1411 is agreed which has the maximum value of 120 gI/100g.**Flash point** of biodiesel results from Moringa oleifera is176 ^{0}C, Jatropha carcus is168 ^{0}C andGlycine max is171 ^{0}C which are higher than the minimum requirement of 130 ^{o}C specified by ASTM D93 of biodiesel, but for Jatropha is lower compared to 200 ^{0}C reported by Belewu et al 2010. Flash point helps to observe the safe handling and storage of fuel. The more the flash point the safer the fuel and vice versa.

Table 3 Fatty acid composition comparison of Moringa oleifera, Jatropha curcas and Glycine max

Fatty acid	Chemical name	Structure	Moringa	Jatropha	Glycine m.
Palmitoleic acid	9-Hexadecenoic acid, methyl ester	$C_{17}H_{32}O_2$	2.1	0.7	-
Palmitic acid	Hexadecanoic acid, methyl ester	$C_{17}H_{34}O_2$	10.2	11.3	15.4

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Oleic Acid	9-Octadecenoic acid, methyl ester Z	$C_{18}H_{34}O_2$	70.9	56.1	28.9
Stearic acid	Octadecanoic acid	$C_{18}H_{36}O_2$	9.3	8.2	-
Eicosenic acid	cis-11-Eicosenoic acid	$C_{20}H_{38}O_2$	7	-	-
Lignoceric acid	Tetracosanoic acid	$C_{24}H_{48}O_2$	-	4.1	
Linoleic	9-12 octadecadienoic acid methyl ester	$C_{19}H_{34}O_2$	-	-	54.5
Arachic	Eicosanoic acid	$C_{20}H_{40}O_2$	-	-	1.2
Behenic	Docosanoic acid, methyl ester	$C_{23}H_{46}O_2$	-	19.4	

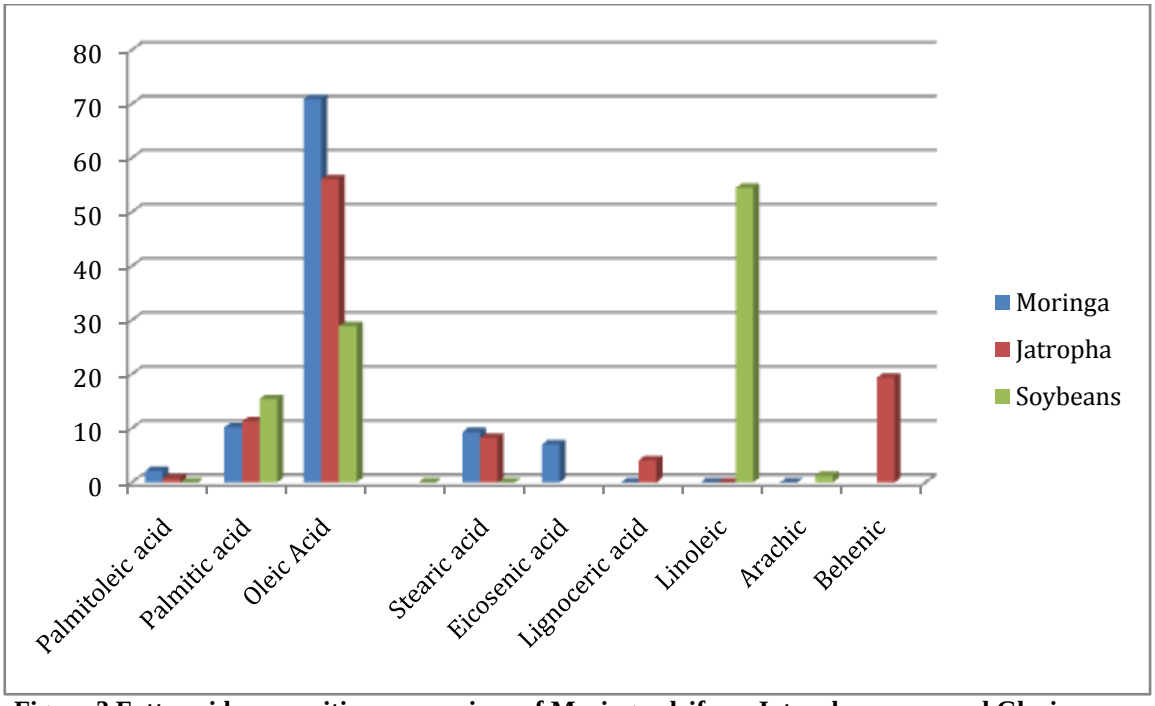

Figure 3 Fatty acid composition comparison of Moringa oleifera, Jatropha curcas and Glycine max

From Figure 3 above compares the fatty acid profile result of Moringa oleifera, Jatropha and Glycine max. It has been found that the oleic acid content of Moringa oil is 70.9% concentration which is the highest level with respect to Jatropha having 56.1% and Glycine max having 28.9. It has been reported from literature that Moringa oleifera oil contains higher amount of oleic acid and it is almost 74.41% of the entire fatty acid profile. (Da Silva et al. 2010).

Determination of Functional Groups using FTIR

The most convenient and effective method of studying the structural characteristics of Moringa oleifera, Jatropha curcas andGlycine maxis by FTIR Spectroscopy. The following FTIR spectra from Fig. 4.4-4.6 depict the spectrum of Moringa oleifera (MO),Jatropha curcas (JC) and Glycine max (GM)

The spectrum of figure 4.4 shows the peaks at 2954cm-1 correspond to **C-H_{sp3}** and 3029cm-1 correspond to **C-H_{sp2}**. In the region from 1800-1700 cm-1 often 1769 cm-1, the peak can be

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attributed to the stretching of Carbonyl i.e. **C=O**, of typical esters, and thus are common in FAME. The peak at 1484 cm-1 corresponds to the asymmetric stretching of **-CH3** present in the biodiesel spectrum (Soares et al., 2008). The main spectrum region that allows for chemical discrimination between FAME is in the range 1500-1000 cm-1, known as "fingerprint" region. Peak at 1484 cm-1 correspond to the asymmetric stretching of CH3 present in the biodiesel spectrum and absent in the refined oil spectrum (Soares et al., 2008).

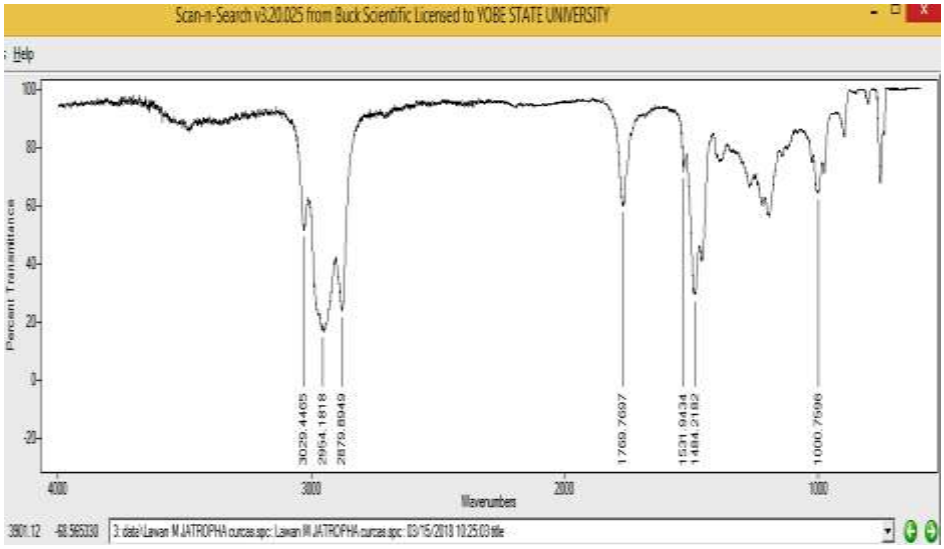

Figure 4 I.R Spectra of Jatropha Curcas biodiesel

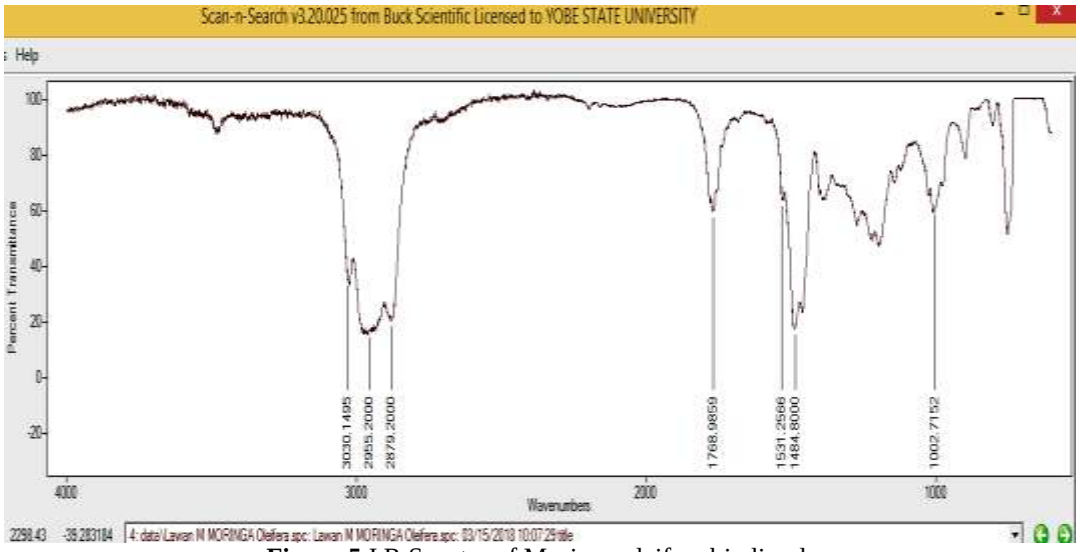

Figure 5 I.R Spectra of Moringa oleifera biodiesel

From the figure above, the peaks at 2955cm-1 correspond to **C-H_{sp3}** and 3030cm-1 correspond to **C-H_{sp2}**. The region from 1800-1700 cm-1 often 1768 cm-1, it can be confirm that the peaks is attributed to the stretching of **C=O**, is carbonyl of typical esters, and thus are common in FAME. The peak at 1484 cm-1 corresponds to the asymmetric stretching of **-CH3** present in the biodiesel spectrum (Soares et al., 2008).

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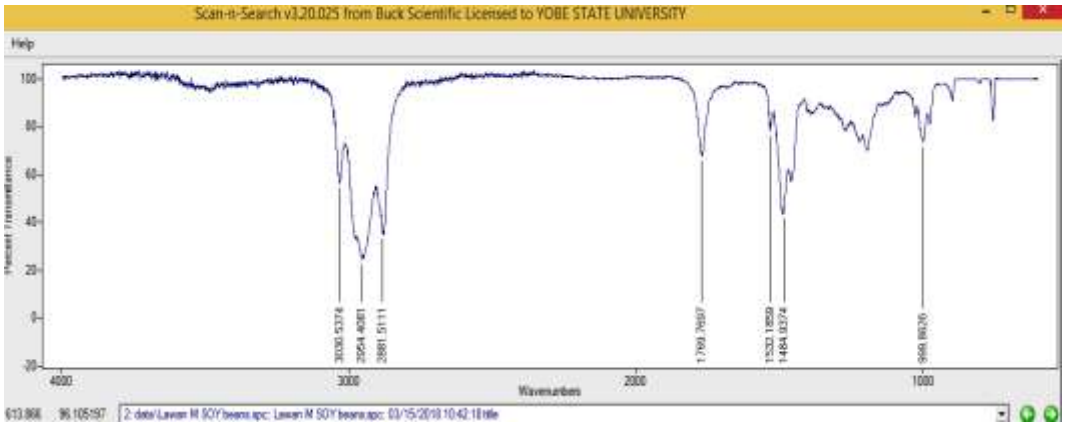

Figure 6 I.R Spectra of Glycine max Biodiesel

From figure 6, the peak region from 1800-1700 cm-1 often 1769 cm-1, it can be observed is attributed to the stretching of carbonyl i.e. **C=O**, of typical esters, and thus are common in FAME. The other peaks at 2954cm^{-1} correspond to **C-H$_{sp3}$** and 3030cm^{-1} correspond to C-H$_{sp2.}$The peak at 1484 cm^{-1} corresponds to the asymmetric stretching of -**CH3** present in the biodiesel spectrum (Soares et al., 2008). The main spectrum region that allows for chemical discrimination between soybean oil and its respective FAME is in the range 1500-1000 cm-1, known as "fingerprint" region. Peak at 1484 cm-1 correspond to the asymmetric stretching of CH3 present in the biodiesel spectrum (Soares et al., 2008).

Thus from all the figures above in **4, 5 and 6** in FTIR spectra, the feedstock frombiodiesel of Moringa oleifera, Soybeans and Jatropha Curcas having the FTIR profile as 1769cm-^{1},1484cm-^{1},2954cm^{-1} and 1002cm^{-1} absorption band compared to biodiesel from different feedstock is similar with other major absorption bands at 1740 cm^{-1}, 1196 cm^{-1}, 2922 cm^{-1} and 1460 cm^{-1}. (Sanford et al. 2009).

Table 4.7: Major bands of FTIR spectra of biodiesel

Wavenumber (cm-1)	Functional group
1740	C=O group
1196	CH3-O
2922 & 2852	C-H stretch
1460	CH2 bend
1433 - 1436	-CH3 asymmetric
1168 - 1170	C-CH2-O vibration

IV. CONCLUSION

From the experimental result it could be concluded that, the percentage oil content of Moringa oleifera, Glycine max and Jatropha curcas seed were found to be 38.33%, 17.10% and 32.10% used. As such a satisfactory result can be gotten by solvent extraction process by laboratory Soxhlet apparatus.Moringa oleifera, Glycine max and Jatropha curcas seed oil and methyl ester (biodiesel) product produced in this research work were examined for pH, moisture content, specific gravity, iodine value, Kinematic Viscosity at 40°C, refractive index, acid value, saponification value, flash point, Fatty acid methyl ester (FAME) composition and identification of their functional groups respectively. Since all the results of the seed oil and the biodiesel product were conformed to the standard specified by USA (ASTM D6751) and European organization (EN 14214) and have met the specified standard recommendation. The fatty acid methyl ester composition ofbiodiesel was analyzed using GCMS which contains palmitoleic acid,palmitic acid,oleic acid,stearic acid,eicosenic acid, lignoceric acid, linoleic, arachic,behenic acid and found that the oleic acid content of Moringa oleifera oil is 70.9% relative amount has the maximum level with respect to Jatropha having 56.1% and Glycine max having 28.9. The biodiesel

result also conform that the Moringa oleifera 1768 cm-1, Gly 1769 cm¯1 and Jatropha curcas1769 cm¯ 1 contains C=O i.e. carbonyl functional group of typical ester which ranged 1800-1700 cm-1. It can be confirmed that the biodiesel originating from the Moringa oleifera, Glycine max and Jatropha curcas seed oil is suitable for use in diesel engines.

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