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Comparative Studies on Some Edible Oils for Biodiesel Production in Nigeria

Humphrey Ibifubara[1*], Nsikan I. Obot[1] and Michael A. C. Chendo[1]

[1]Department of Physics, University of Lagos, Akoka, Lagos, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author HI designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors HI and NIO managed the analyses of the study. Authors HI, NIO and MACC managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

With the growing population and subsequent increasing demand for energy in Nigeria, coupled with the under-developed electrical energy platforms and the vast problems of the convectional energy sources such as continuous gas flaring, energy crisis is still lingering and enormous. The aim of this work is to compare the quality of different blends of biodiesel produced from several vegetable oils. The biodiesel was obtained from oil of animal fat and vegetable oils of bleached palm, corn, cottonseed, groundnut and soya through transterification reaction. The physiochemical properties of four blends were measured to ascertain their adherence with the ASTM standard for biodiesel. The results show a high percentage yield from most of the feedstock with the highest yield of 95% from bleached palm oil while the lowest value of 61.5% is from animal fat. Viscosity obtained at temperatures of 10ºC to 60ºC, with the highest value of 7.717mm^2/sec is from B100 of animal fat at 10ºC and lowest value of 1.840mm^2/sec is from B20 of corn oil at 60ºC. Also other values for density, flash point, cold point and sulfur content all conform to the ASTM standard range.

Keywords: Biodiesel; energy; physiochemical properties; Nigeria.

**Corresponding author: Email: ibisubara@yahoo.com;*

1. INTRODUCTION

Abundance of different energy sources exists in Nigeria ranging from conventional which are non-renewable to the non-conventional which are renewable [1,2]. Nigeria regarded as the giant of Africa, has a large population of over 150 million people occupying a total land mass of 923,768 km^2 and is saddled with corresponding large energy demand, wherefore as the population is increasing so is the energy demand [3]. Despite the various energy sources, the technological development for adequate provision of power is inefficient, with epileptic power supply or outright unavailability of power. With regards to energy consumption in Africa, Nigeria is second to South Africa and consumes about 90.2 million tons of oil equivalent (Mtoe) where about 80.2% of that consumption is biomass and unfortunately most of the consumed biomass is wood [4]. The continuous overuse of wood pertain danger to sustainable ecosystem and the prober gaseous mix of oxygen and carbon dioxide in the atmosphere [5-7].

The major provider of consumer electricity in Nigeria has been the Power Holding Company of Nigeria (PHCN), formally known as National Electric Power Authority (NEPA), which has been unable to adequately meet the energy needs [8]. Owing to the continuous power outage in Nigeria, lots of alternatives, out of necessity have been tried out. For instance almost all households mostly in the urban areas have some affordable generating set to power their electrical equipment. In this, individuals are responsible for generation of their energy, which has side effects such as noise and air pollution, the problem of disposal of worn out parts and the release of greenhouse gases. Solar energy is another form of energy readily available in Nigeria, but its initial high cost with regards to photovoltaic system has been the obstacle of harnessing this energy however, some use it for drying grains, food and clothes and heating of water [9-11].

Energy from petroleum products has been the easiest and common source of energy in Nigeria, more so Nigeria has a large deposit of crude oil; nevertheless the energy crisis experienced in other parts of the world is also experienced here. It is due to the fact that the existing capacity of the refineries in the country cannot meet demand and owing to diversion of the products to neighbouring counties, ironically the finished petroleum fuels are imported into the country. Furthermore, gas flaring has not been stopped, the continuous oils spills which have been occurring from time to time and the unrest of the community in the struggle for a fair share of the proceeds from the exploitation of crude oil are some of the problems. In addition there are issues of oil bunkering and illegal oil refineries in and around the Niger Delta area as well [12,13]. Because of these economic, environmental and political concerns there is a growing interest in alternative engine fuels, such as biodiesel.

Biodiesel is a renewable energy source which can be produced from virgin oils, waste vegetable oils, algae, oil from halophytes and animal fats. Biodiesel as an alternative fuel source has numerous advantages over conventional fossil fuels such as, biodegradability, renewability, high combustion efficiency, low sulfur, aromatic calorific content and low emission [14,15]. Other advantages of biodiesel include having low idle noise and easy cold starting and when in use reduces engine wear thereby increasing the life of the fuel injection equipment. It has been shown to have high lubricity than any other fuels [16]. Also, it improves the quality of the environment with a pleasant fruity odour with less soot generated in the exhaust of the vehicle. Furthermore, biodiesel actually produces less particulate materials, having higher cetane numbers and producing lower carbon monoxide and hydrocarbon emissions [17].

Biodiesel is composed of long-chain fatty acids with an alcohol attached, often derived from vegetable oils. It is produced through the reaction of a vegetable oil with methyl alcohol or ethyl alcohol in the presence of a catalyst [18-20]. Commonly used catalysts are potassium hydroxide (KOH) or sodium hydroxide (NaOH). The chemical process is called transesterification which produces biodiesel and glycerin. Chemically, biodiesel is called a methyl ester if the alcohol used is methanol. If ethanol is used, it is called an ethyl ester. They are similar and currently, methyl ester is cheaper due to the lower cost for methanol. Biodiesel can be used in the pure form, or blended in any amount with diesel fuel for use in compression ignition engines [21,22]. Biodiesel comes in three categories namely first generation, second generation and three generations. The first generation biodiesel is referred to the use of starch and food crops such as sugarcane, soybeans, groundnut and palm to obtained biodiesel. The second generation is the use of non-edible plants like jatropha and waste from agriculture, domestic and industries such as cassava piles, animal dung and sawdust in obtaining biodiesel and lastly the third generation which in some cases is grouped under the second generation where only two classifications are mentioned is the deployment of algae and other microbes in the production of biodiesel, this categorization has to do with the periods of discovery.

Presently biomasses constitute about 10% of the world's primary source of energy demand [23]. According to [24] in Brazil individuals are encouraged to produce and sell biodiesel and by the law enacted in 2005 it is entailed that by 2010 all diesel sold should have a biodiesel blend of B5 for vehicular use. Brazil has in place low tax to encourage the production of biodiesel especially for small scale farmers tailored toward castor oil and palm agriculture since soybeans is basically available in Brazil. These actions triggered continuous rise in the production of biodiesel in Brazil from 0 million m^3 in 2005 to about 1,500 million m^3 in 2009. Globally biodiesel capacity from 1991 to 2003 grew from 0 million litres to between 1500 and 2000 million litres [25].

The relative large economic incomes of Nigeria mainly from crude oil notwithstanding, majority of the population are impoverished. The main occupation is farming and there is high level of unemployment in the country as many of graduates cannot find meaningful employment due to mismanagement, misappropriation, embezzlement and uneven distribution of resources [26-29]. To curb the large unemployment rate in the country the production of biodiesel from vegetable oil would provide job opportunities. The first section of this work had earlier been published [30] which showed the capability of waste vegetable oil to produce biodiesel. The aim of this study is to undertake the production of biodiesels from different vegetable oils and compare their properties such that depending on the accessibility and availability the production of biodiesel can be adopted even by rural dwellers to meet some of their energy needs.

2. EXPERIMENTAL PROCEDURE

Biodiesel is made through a chemical process known as transesterification; where glycerin is separated from vegetable oil or fat (feedstock). In transesterification reaction, the molar ratio of alcohol to oil theoretically is 1:3, and for alcohol to catalyst 30ml to 1.06g. However, an extra amount of alcohol is recommended for the equilibrium position to shift towards the product and also to increase the rate in the biodiesel conversion, since transesterification is a reversible reaction. Feedstocks such as groundnut oil, corn oil, bleached palm oil, soya oil, cotton seed oil, were purchased as 100% refined oil from the market, while the animal fat was collected from a butcher in Lagos

The transesterification reaction was carried out in a 500mL airtight flat bottom flask containing a magnetic stirrer. 200mL of each of the feedstock was measured into an empty flask and then heated to a temperature of 55ºC. Potassium methoxide (KCH_3O), made by dissolving 2.12g of pure grade Merck potassium hydroxide pellets in 70mL of Analar grade methanol of 99.8% purity was poured into the flask containing the oil. The reaction was carried out in a closed system to prevent the loss of alcohol. The temperature of the system was maintained between 60-65ºC (methanol has a boiling point of 65ºC, above this temperature it will escape from the reaction mixture) throughout the one hour reaction time. The mixture was transferred into a 500mL separating funnel and left for 24 hours at the end of the reaction, to separate the biodiesel from the glycerol by gravity. The biodiesel was then washed five times to a neutral pH with warm water to remove the residue glycerol, catalyst and other impurities. The biodiesel was dried by heat with a heating element for about 1 hour 30 minutes (subject to relative humidity of country).

The following physiochemical properties were determined: - The viscosity by Digital Viscometer SVM 3000 (Anton Paar) at different temperatures according to the ASTM D-445. The density was determined using a density bottle. The pour point and the cloud point were also determined according to ASTM D6371 - 05 Standard Test Method for Heating and Cold Filter Plugging Point of Diesel Fuels. The Sulfur content was determined according to ASTM D5453 and the flash point was determined by an automated Pensky-Martens closed-cup apparatus in the temperature range of 60 to 190ºC according to ASTM D93 - 11 Standard Test Methods for Flash Point. Tables 2.1 and 2.2 shows ASTM biodiesel and petroleum diesel standards respectively.

2.1 Determination of Percentage Yield of Feedstock

Volume of oil = 200mL
Volume of methanol = 70mL
Mass of KOH = 2.12g

$$\text{Biodiesel yield \%} = \frac{\text{wt biodiesel produced}}{\text{wt of oil used}} \quad (1)$$

Table 2.1 ASTM D 6751-02 biodiesel specification

Property	Testing method	Limits
Flash point (ºC)	D 93	100-170
Viscosity, 40 ºC (mm^2/s)	D 445	1.9 - 6.0
Density ($g/cm^{3)}$	D 1298	0.86-0.90
Cloud point(ºC)	D 2500	-3 to 15
Pour point (ºC)	D 97	-5 to 10
Sulfur(ppm)	D5453	15

Table 2.2 ASTM D 975-13 diesel specification

Property	Testing method	Limits
Flash point (ºC)	D 93	100-130
Viscosity, 40 ºC (mm^2/s)	D 445	1.3 – 24.0
Density ($g/cm^{3)}$	D 1298	0.81-0.86
Cloud point(ºC)	D 2500	35
Pour point (ºC)	D 97	35
Sulfur(ppm)	D5453	15

2.2 Determination of FFA

To calculate FFA% from a titration value the formula is:

$$\mathbf{FFA\%} = \frac{(\mathbf{v}-\mathbf{b}) * \mathbf{N} * \mathbf{28.2}}{\mathbf{w}} \quad (2)$$

V is the volume in ml of titration solution
b is the volume in ml of the blank
N is the normality of the titration solution
w is the weight of the sample of oil in grams

2.3 Determination of Density

$$\text{Density} = \frac{mass}{volume} \quad (3)$$

$$\text{Density of water} = \frac{mass\ of\ water}{volume\ of\ water} \quad (4)$$

$$\text{Density of biodiesel} = \frac{\text{mass of biodiesel}}{\text{volume of biodiesel}} \quad (5)$$

3. RESULTS AND DISCUSSION

The results of values of the basic physiochemical properties obtained for the biodiesel in its pure form; B100 and three (3) blends B80, B50 and B20 are discussed below with tables and figures showing values and bar charts representations.

3.1 Percentage Yield of Biodiesel

Table 3.1 shows in milliliters the volume of the feedstock used, the percentage free fatty acid (FFA), the outcome of the biodiesel and their percentage yield. The transesterification process was carried out under the same conditions for all the feedstock however; bleached palm oil gave the highest yield 95%, followed by groundnut oil which yields 93%. Cotton seed oil yield 77.5%, while corn oil and soya oil gave the same yield of 75% each, the lowest yield was gotten from animal fat 61.5%. The percentage yield is inversely proportional to the FFA. i.e the lower the FFA the higher the percentage yield, this is because FFA reacts with alkali catalysts to produce soaps that inhibit the reaction. Fig 3.1 below shows a chart of the biodiesel outcome and the percentage yield of the various feedstocks.

3.2 Density

Density is the weight per unit volume of a material measured in g/cm^3. Oils that are denser contain more energy. For example, petrol and diesel fuels give comparable energy by weight, but diesel is denser and hence gives more energy per litre. Table 3.2 below shows the values of density of biodiesel produced from six feedstock.

Fig. 3.2 is a bar chart displaying the values of the densities for the various biodiesel blends. B100 from Groundnut oil gave the highest density of $0.8867g/cm^3$ as well as in all the biodiesel blends; B80, B50 and B20, while B100 from Animal fat gave the lowest density of $0.8678g/cm^3$ as well as in all the biodiesel blends

Table 3.1. Percentage yield of biodiesel production

S/no	Feedstock	FFA%	Feedstock input (mL)	Feedstock output (mL)	Percentage yield (%)
1	Animal Fat	3.78	200	123	61.5
2	Bleached Palm oil	0.14	200	190	95
3	Groundnut oil	0.27	200	186	93
4	Cotton seed oil	1.12	200	155	77.5
5	Corn oil	1.36	200	150	75
6	Soya oil	1.38	200	150	75

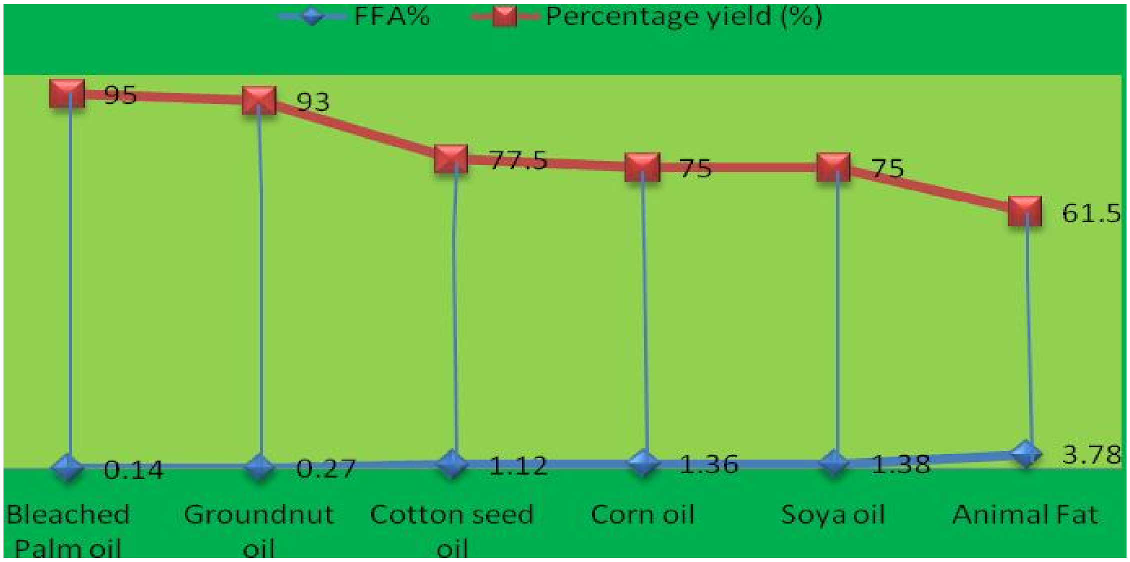

Fig 3.1 A chart of biodiesel production output and percentage yield

Table 3.2. Density values

Feedstock	Density (g/cm^3) B100	Density (g/cm^3) B80	Density (g/cm^3) B50	Density (g/cm^3) B20
Animal Fat	0.8678	0.8596	0.8544	0.8512
Bleached Palm oil	0.8750	0.8630	0.8589	0.8531
Groundnut oil	0.8867	0.8767	0.8674	0.8606
Cotton seed oil	0.8794	0.8697	0.8567	0.8519
Corn oil	0.8802	0.8672	0.8594	0.8527
Soya oil	0.8834	0.8745	0.8656	0.8585

The standard density range for biodiesel is 0.86–0.90 and 0.81–0.86 for petroleum diesel. This shows that the B100 have densities within the standard range. The B80 also falls within the biodiesel standard range. For B50 all except Animal fats fall within the biodiesel standard range nevertheless, it is still within the petro-diesel standard range which is acceptable since it is a blend of petrol-diesel and biodiesel. For B20 Groundnut oil and Soya oil falls within the biodiesel standard range while corn, animal fat, cotton seed and Bleached Palm oil falls in the petroleum diesel standard range. Density is an essential parameter for diesel fuel injection systems and so, the value should be maintained within the tolerable limits to allow optimal air to fuel ratio for complete combustion.

3.3 Viscosity

Viscosity is a measure of a fluid's resistance to flow. It describes the internal friction of a moving fluid. A fluid with high viscosity resists motion because its molecular structure gives it a lot of internal friction, while fluid with low viscosity flows easily due to its molecular structure which results in very little friction when it is in motion, the less viscous the fluid is, the greater its ease of movement (fluidity). For the case of liquid fuels, viscosity refers to the thickness of the oil, and is determined by measuring the amount of time taken for a given measure of oil to pass through an orifice of a specified size. Viscosity affects injector lubrication and fuel atomization. Fuels with low viscosity may not provide sufficient lubrication for the precision fit of fuel injection pumps, resulting in leakage or increased wear; conversely fuels with high viscosity tend to form larger droplets on injection which can cause poor combustion, increased exhaust smoke and emissions.

The graphs of Viscosity in mm^2/sec against Temperature in ºC, in Figures 3.3a to 3.3d shows that viscosity increases with increase in the percentage biodiesel blends, and decreases with increase in temperature. The highest value of viscosity obtained is $7.717 mm^2/s$ from B100 animal fat at 10ºC, while the lowest value is 1.940mm^2/s from B20 corn oil at 60ºC. It was observed that the viscosity values obtained for all the blends were within the recommended ASTM range of 1.9 to 6.0mm^2/s for biodiesel at reference temperatures, 40°C.

At low temperature, i.e. temperature below the reference temperature, 40ºC there is an increase in viscosity with decrease in temperature. At 20ºC all the blends are observed to be within the recommended range, but for B100 animal fat, bleached palm oil and groundnut gave values above the recommended value. And at 10ºC the B100 for all the biodiesels have values above recommended range, while their blends are within the standard range. This means biodiesel without blend that is, B100 at low temperature is not suitable for use in a diesel engine, because of its high viscosity value because high viscosity values affect the fuel fluidity that lead to poor atomization of fuel spray and subsequently give an inaccurate operation of the fuel injectors. Thus, biodiesel is suitable only for use in cold climate when blended.

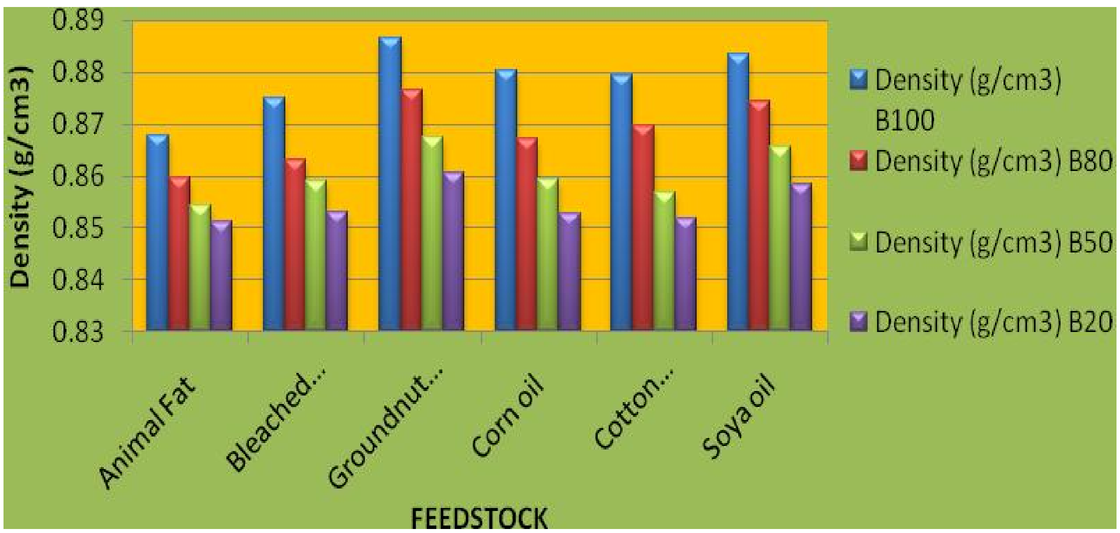

Fig 3.2. Densities chart

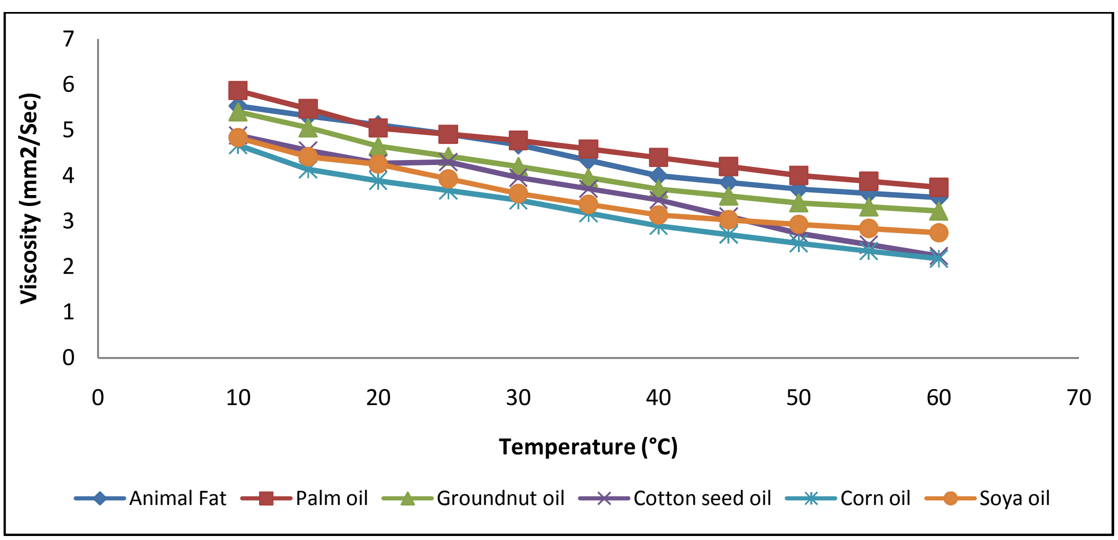

Fig. 3.3a. Graph of viscosity –temperature of B100

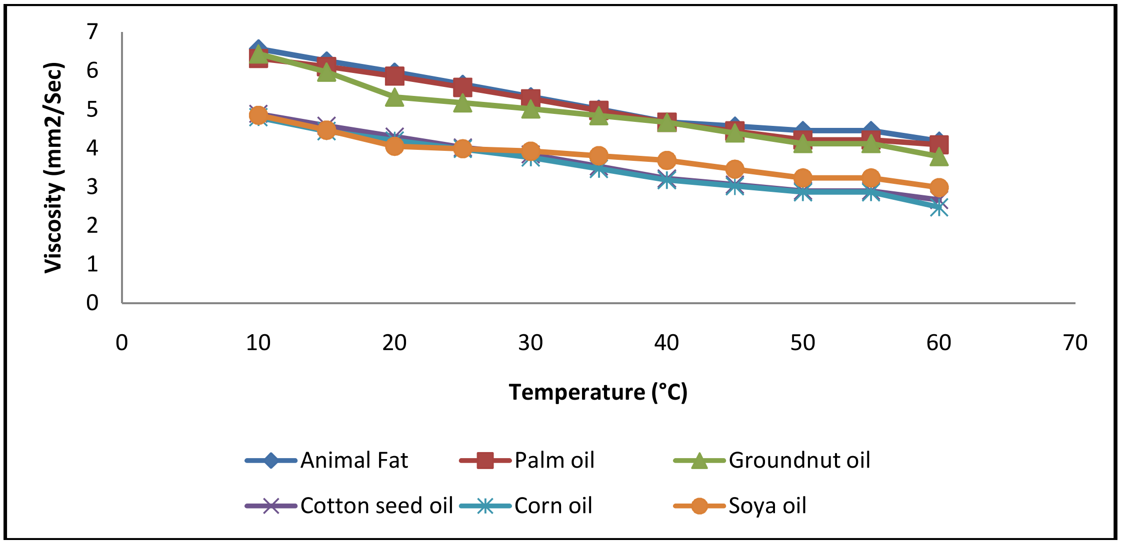

Fig. 3.3b. Graph of viscosity –temperature of B80

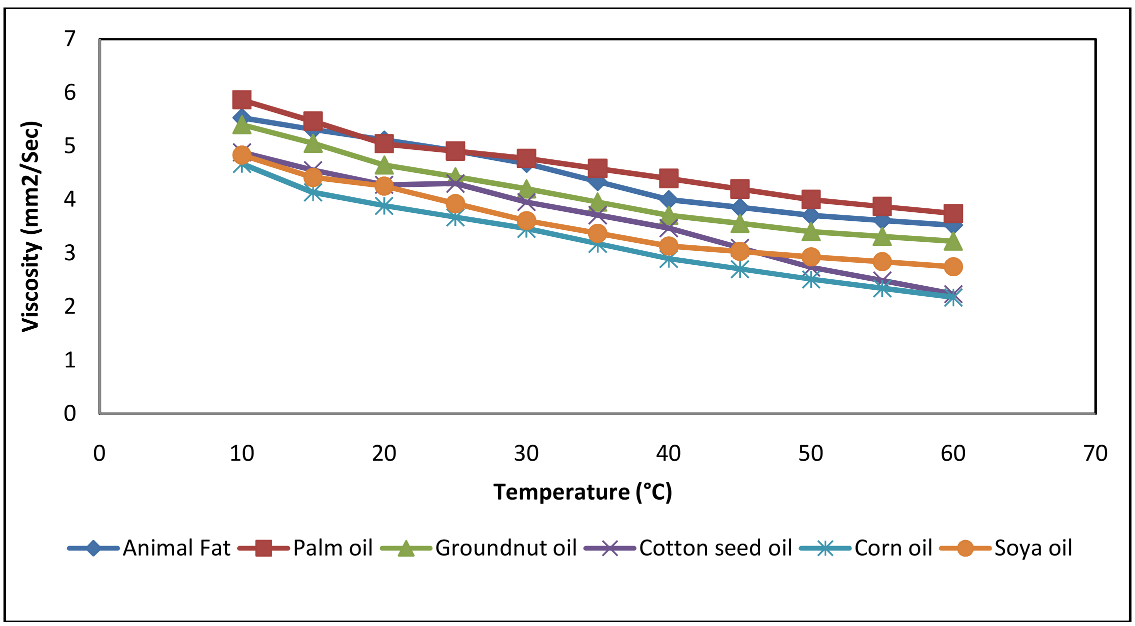

Fig. 3.3c. Graph of viscosity –temperature of B50

3.4 Cloud Point and Pour Point

The temperature at which oil starts to solidify is known as the cloud point, while the temperature at which the oil in solid form starts to melt or pour in known as the pour point. Tables 3.4a and 3.4b below shows the values for the cloud points and the pour points respectively.

The cloud and the pour points vary significantly with feedstock. For B100, corn oil has the lowest cloud point of -3ºC and pour point -4ºC, while animal fats has the highest cloud points of 17ºC and pour point 15ºC. For B80, corn oil has the lowest cloud point of -5ºC and pour point -6ºC, while animal fats has the highest cloud points of 13ºC and pour point 11ºC. For B50, corn oil has the lowest cloud point of -7ºC and pour point -8ºC, while animal fats has the highest cloud points of 9ºC and pour point 6ºC. All other oils have values in between corn oil and animal fat for B100, B80 and B50.

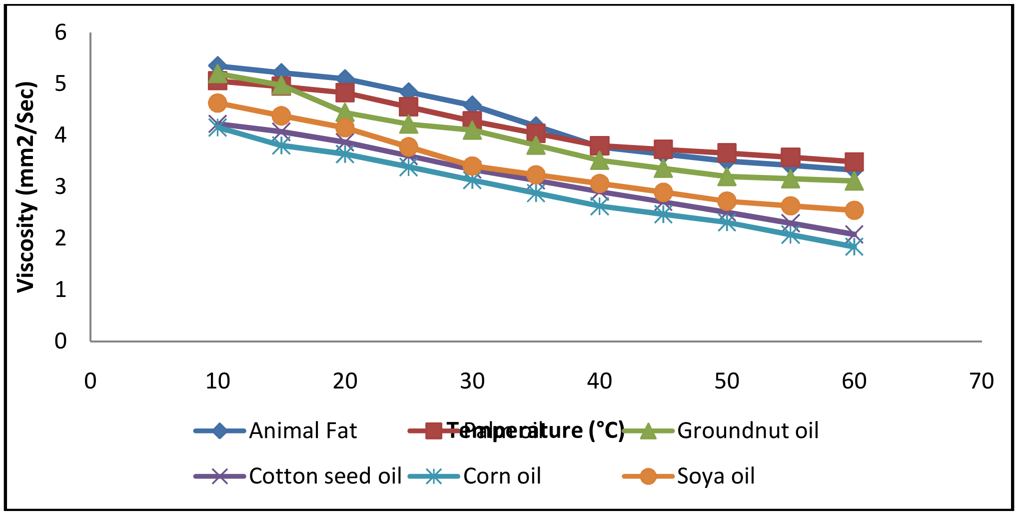

Fig. 3.3d. Graph of viscosity –temperature of B20

For B20, corn oil has the lowest cloud point of -10ºC and pour point -12ºC, while animal fats and bleached palm oil gave the highest cloud points of 3ºC and pour point 0ºC. However, the values of the cloud point and pour point obtained for B100 for all the feedstock are within the specified standard range for biodiesel which is -3ºC to 17ºC for cloud point, and -15ºC to 12ºC for Pour point. These values are higher than petrol- diesel which has value from -15ºC to 5ºC for cloud point, and -35ºC to -15ºC for pour point indicating that B100 biodiesel will tend to gel at lower temperatures than diesel. However, the blends gave better values, i.e. the lower the blends the lower the lower the cloud and the pour points. The implication is at lower temperatures higher blends of biodiesel will easily form get, and so, biodiesel need to be used cautiously in cold climates, as wax crystals can be formed. These wax crystals can plug fuel filters, causing engine problems. Thus, lower percentage biodiesel blend B20, B50 should be used in cold weather. Figs. 3.4a and 3.4b shows a bar chart representation of the cloud and pour points respectively.

3.5 Flash Point

The flash point temperature of diesel fuel is the minimum temperature at which the fuel will ignite (flash) on application of an ignition source. Flash point varies inversely with the fuel's volatility. Table 3.5 below shows values of the flash point obtained.

From the Table 3.5 above and Fig. 3.5 below it is clearly shown that the B100 values were well above the 100ºC minimum ASTM recommended range and therefore, no risk of fire outbreaks in the case of accidents. The blends also have values well over 100ºC except, B20 of animal fats that is 102ºC a little below the specified range. The deduction from this result is that, biodiesel can be conveniently blended with petrol-diesel with the quality of the biodiesel still effective as an alternative fuel. The flash point specifies the temperature to which a fuel needs to be heated for spontaneous ignition of the vapour and air above the fuel to occur. It is the lowest temperature at which the vapour above the fuel becomes flammable, and so determines the safety of fuel during transportation, handling and storage [31].

Table 3.4a. Cloud point values

S/no	Feedstock	B100 (ºC)	B80 (ºC)	B50 (ºC)	B20 (ºC)
1	Animal Fat	17	13	9	3
2	Bleached Palm oil	16	12	8	3
3	Groundnut oil	10	6	2	-2
4	Corn oil	-3	-5	-7	-10
5	Cotton seed oil	-1	-4	-5	-8
6	Soya oil	0	-4	-6	-9

Table 3.4b. Pour point values

S/no	Feedstock	B100 (°C)	B80 (°C)	B50 (°C)	B20(°C)
1	Animal Fat	15	11	6	0
2	Bleached Palm oil	14	10	5	0
3	Groundnut oil	7	4	0	-4
4	Corn oil	-4	-6	-8	-12
5	Cotton seed oil	-2	-5	-6	-10
6	Soya oil	-2	-6	-7	-10

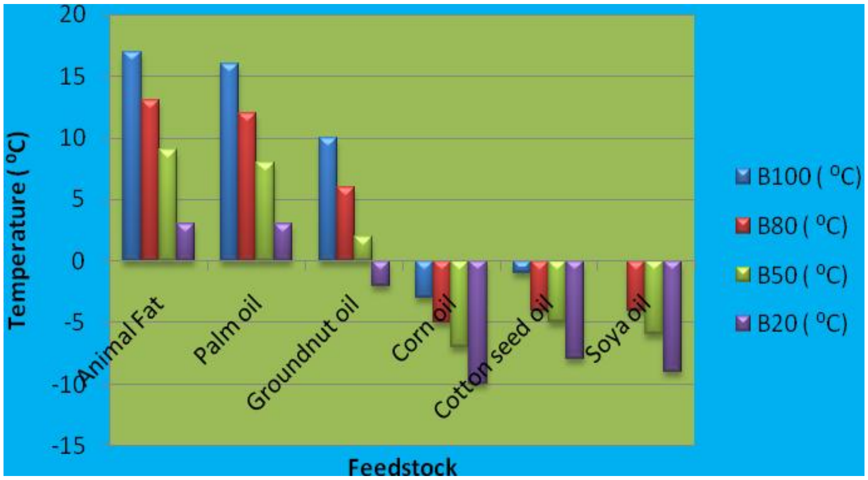

Fig. 3. 4a. Cloud point chart

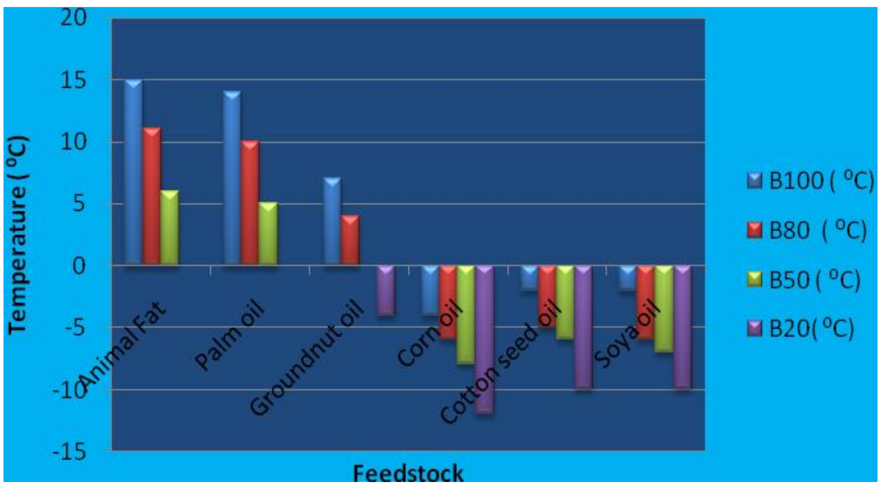

Fig. 3.4b. Pour point chart

Table 3.5 Flash Point Values

S/no	Feedstock	B100 (°C)	B80 (°C)	B50 (°C)	B20 (°C)
1	Animal Fat	141	129	117	102
2	Bleached Palm oil	169	148	134	121
3	Groundnut oil	178	167	149	131
4	Corn oil	174	163	148	130
5	Cotton seed oil	170	159	145	127
6	Soya oil	176	165	148	131

3.6 Sulfur Content

The Results in Table 3.6 showed that animal fat contains more sulfur content than the rest of the feedstock. However, all of the biodiesel samples and their blends investigated in this study contained less than 15ppm sulfur. The Sulfur content in vegetable oils and the animal fat varied greatly among the samples tested. The results have shown that biodiesel with 15ppm or less sulfur could be achieved from all of the feedstocks investigated in this study as long as proper processing of oil extraction, biodiesel conversion, and post reaction treatment are practiced. Fig. 3.6 shows a chart of sulfur content for various biodiesel blends considered in this work. The sulfur content values obtained for the B100 and the blends is in compliance with the Environmental Protection Agency (EPA) Regulations (15ppm) on-highway diesel fuel, which took effect from June 1st, 2006.

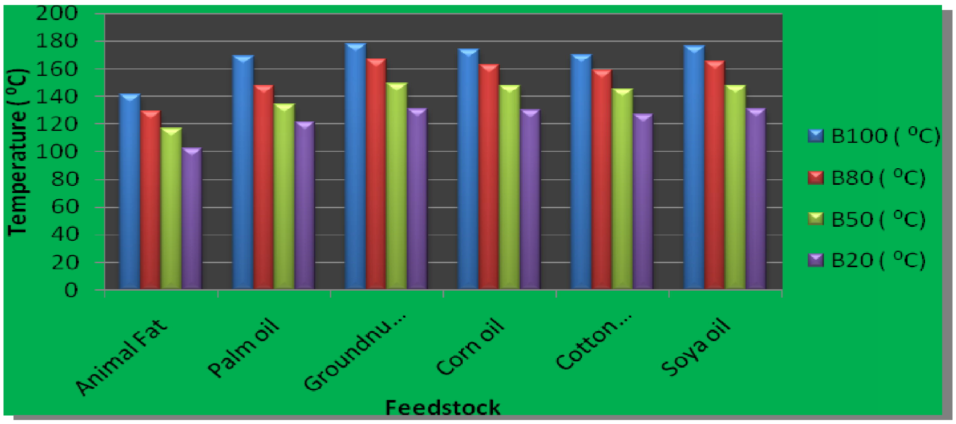

Fig. 3.5 Flash point chart

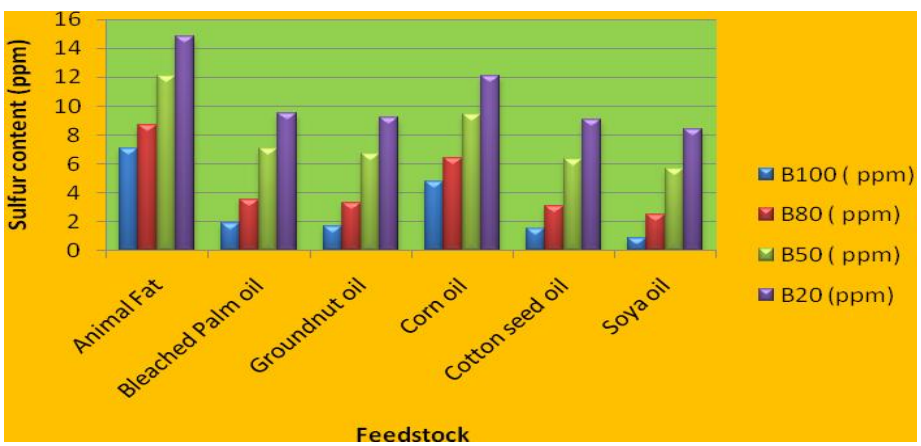

Fig. 3.6 Sulfur Content chart

Table 3.6 Sulfur Content Values

S/no	Feedstock	B100 (ppm)	B80 (ppm)	B50 (ppm)	B20 (ppm)
1	Animal Fat	7.10	8.70	12.10	14.80
2	Bleached Palm oil	1.90	3.50	7.10	9.50
3	Groundnut oil	1.70	3.30	6.70	9.20
4	Corn oil	4.80	6.40	9.40	12.10
5	Cotton seed oil	1.50	3.10	6.30	9.10
6	Soya oil	0.90	2.50	5.70	8.40

4. CONCLUSION

The study involves the production of biodiesels from different vegetable oils and compares their properties such that depending on the accessibility and availability of the feedstocks, the production of biodiesel can be adopted even by rural dwellers to meet some of their esteeming energy needs.

It can be concluded from this comparative study that the production of biodiesel from several feedstocks gave considerable high yield that should encourage investors to consider going into biodiesel business. Although, for animal fat the yield was not as high as the others, but this can be improved upon by pretreatment of the animal fat before the transesterification process. The physiochemical properties; the density and the viscosity that determine the rate of combustion, the flash point that determines the safety of the fuel during transportation, handling and storage, the cold weather properties which are the cloud and pour point that determines the suitability of a fuel in cold climate and the environmental pollution determining parameter sulfur content, were within the ASTM standard range. The fear is that, 100% attention should not be given to conversion of edible oil to biodiesel, which may give rise to food famine. Therefore, attention should be given more to the animal fat and other non-edible oils like jatropha oil, waste vegetable oil, and algae oil.

REFERENCES

1. Smith JL. World Oil: Market or Mayhem? Journal of Economic Perspectives. 2009;23:No3,145-164.
2. Iwayemi A. Investment in Electricity Generation and Transmission in Nigeria: Issues and Options. International Association for Energy Economics. 2008;37-42.
3. Ohunakin OS. Energy utilization and renewable energy sources in Nigeria. Journal of Engineering and Applied Science. 2010.5(2),171-177.
4. Klass DL. Biomass for renewable energy and fuels. Encyclopaedia of Energy. 2004;1:193-211.
5. Angelsen A, Kaimowitz D. Rethinking the Causes of Deforestation: Lessons from Economic Models. The World Bank Research Observer. 1999;14:No.1,73-98.
6. El-Farouk AE. Economic and Social Impact of Environmental Degradation in Sudanese Forestry and Agriculture. British Journal of Middle Eastern Studies. 1996;23:No. 2,167-182.
7. Vitousek PM, Ehrlich PR, Ehrlich AH, Matson PA. Human Appropriation of the Products of Photosynthesis. Bioscience. 1986;36:No. 6,368-373.
8. Oyedepo SO. Energy and sustainable development in Nigeria: the way forward. Energy, Sustainability and Society. 2012;2:15.Doi.10.1186/2192.0567.2.15.
9. Miles RW, Hynes KM, Forbes I. Photovoltaic solar cells: An overview of state-of-the-art cell development and environmental issues. Progress in Crystal Growth and Characterization of Materials. 2005;51:1-42.
10. Tsoutsos T, Frantzeskaki N, Gekas V. Environmental impacts from the solar energy technologies. Energy Policy. 2005;33:289–296.
11. Bouzidi B. Viability of solar or wind for water pumping systems in the Algerian Sahara regions – case study Adrar. Renewable and Sustainable Energy Reviews. 2011;15:Iss 9,4436–4442.
12. Ogri OR. A review of the Nigerian petroleum industry and the associated environmental problems. Environmentalist. 2001;21:11-21.
13. Eweje G. Environmental costs and responsibilities resulting for oil exploitation in developing countries: the case of Niger Delta of Nigeria. Journal of Business Ethnic. 2006;69:27–56.
14. Hill J, Nelson E, Tilman D, Polasky S, Tiffany D. Environmental, economic and energetic costs and benefits of biodiesel and ethanol blends. Proc. Natl. Acad. Sciences. 2006;103:11206-11210.
15. Biodiesel Handling and Use Guide. Fourth Edition. 2009). Available: http://www.osti.gov/bridge
16. Barnwal BK, Sharma MP. Prospects of biodiesel production from vegetable oils in India, Renewable and sustainable energy reviews. 2004;20:170-186.
17. Demirbas A. Relationships derived from physical properties of vegetable oil and biodiesel fuel. Fuel.2008;87:1743-1748.
18. Bajpai D, Tyagi VK. Biodiesel: Source, Production, Composition, Properties and its Benefits, J. Oleo Sci. 2006;55(10):487–488.
19. Van Gerpan. JV. Biodiesel processing and production. Fuel Processing Technology. 2005;86:1097-1107.

20. Ramadhas AS, Muraleedharan C,Jayaraj S. Biodiesel production technologies and substrates. Handbook of Plant-Based Biofuels, 183, New York:CRC Press. Taylors & Francis Group, USA; 2009.
21. Sheehan J, Camobreco V, Duffield J, Graboski M,Shapouri H. An Overview of Biodiesel and Petroleum Diesel Life Cycles. 1998;NREL/TP-580-24772.
22. Demirbas A. Biodiesel: a realistic fuel alternative for diesel engines. Springer-Verlag London Limited. 2007;978-1-84628-994-1 London, UK.
23. Antoni D, Zverlov V, Schwarz WH. Biofuels from microbes. Applied Microbiological Biotechnology. 2007;77:23-35.
24. Nogueira LAH. Does biodiesel make sense ? Energy, doi:10.1016/j.energy. 2010;08:035.
25. Demirbas MF, Balat M. Recent advances on the production and utilization trends of biofuels: a global perspective. Energy Conversion and Management. 2006;47:2371-2381.
26. Akinbobola TO, Saibu MOO. Income inequality, unemployment, and poverty in Nigeria: a vector autoregressive approach. The Journal of Policy Reform. 2004;7:175-183.
27. Okafor EE. Youth unemployment and implications for stability of democracy in Nigeria. Journal of Sustainable Development in Africa. 2011;13:358-373.
28. Owolabi SA, Dada SO, Olaoye SA. Application of forensic accounting technique in effective investigation and detection of embezzlement to combat corruption in Nigeria. Unique Journal of Business Management Research. 2013;1:65-70.
29. Folorunso BA. Determinants and effects of corruption on investment, general price level and sustainable economic growth in Nigeria. African Economic and Business Review. 2007;5:10–25.
30. Humphrey I, Nsikan, IO, Chendo, MAC. Potential of Waste Vegetable Oil for Biodiesel in Nigeria. British Journal of Applied Science & Technology. 2014;4(25):3716-3725,2014.
31. Barua PK. Biodiesel from seeds of jatropha found in Assam, India. International Journal of Energy, Information and Communications. 2011;2(1):60-70.

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