IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 08, Issue 2 (February. 2018), ||V1|| PP 08-13

Determination of the Viscosity and Density of Mahogany Seed Oil

E. IKE[1], J. B. YERIMA[2] and A. B. Dikko[3]

[1,2,3]*Department Of Physics, Modibbo Adama University Of Technology, P. M. B. 2076, Yola, Adamawa State, Nigeria*

Corresponding Author: E. IKE[1]

ABSTRACT The Present Study Is Aimed At Determining The Viscosity And The Density Of Locally Produced Khaya Senegalensis (Mahogany) Seed Oil In Yola, Nigeria. Viscosity Measurement In Centipoise Ranged Between 60.70 At 30^{o}c To 9.83 At 80^{o}c And The Density Measurement Varied Between 0.9243g/Cm^{3}at 30 ^{O}c To 0.9110g/Cm^{3} At 80 ^{O}c. All The Biodiesel Quality Parameters Examined In The Present Study Showed That Khaya Senegalensis Seed Oil Is A Good Feed Stock For Biodiesel Production And Reveals Its Usefulness In Electric Voltage Transformers.

Date of Submission: 05-02-2018 Date of acceptance: 24-02-2018

I. INTRODUCTION

The Seed Of Khaya Senegalensis (Mahogany) From Which The Oil Was Extracted Is Especially Not Among The Popular Cultivars Of Oil Seeds Like Groundnut, Soya Bean, Palm Fruit And Palm Seed. At Least, It Is Allowed To Waste Away In The Forest. As Suggested By Besbes et al., (2004) Regarding Date Seed Oil, Few Works So Far Done On Some Of These Oils Were Majorly Focused On Their Chemical Composition (Adeyeye et al., 1990; Ajewole And Adeyeye; 1991, Adeyeye And Ajewole, 1992).

Over The Years, There Has Been A Spectacular Increase In The World Demand For Both Oils And Oil Meals With Attending Uptrend In Prices (Mielke, 1988). Estimates Available On Future Production Indicate That This Trend Will Continue (Kaufman, 1990). During The 20th Century, The Non-Edible Uses Of Oil Seed Products Declined Substantially Due To The Availability Of Relatively Inexpensive Oil Derived From Fossil Reserves (Les And Leegood, 1993). It Is, However, Now Realized That The Fossil Reserves Could Be Exhausted Or Become Shorter In Supply And Are Not Renewable (Boelhauwer, 1983). As Such, Looking Into Alternative Oil Sources From Various Seeds Which Abound Around Us Should Remain A Subject Of Active Investigation. Although Such Oils Are Not Expected To Replace Petrochemicals In Their Entirety (Harwood, 1984), Their Applications As Lubricating Oils, Emulsifiers, Retardant Agents Or Components Of Cosmetics For Example, Could Be Very Important. The Purpose Of This Study Was To Determine Some Of The Physical Properties Of The Khaya Senegalensis (Mahogany) Oil, Whether It Qualified To Be A Source Vegetable Oil Raw Material And To Investigate The Possible Technological Applications, Apart From Eating, To Which The Oils Could Be Put.

The Ability To Gather Data On A Material's Viscosity Behavior Gives Manufacturers An Important "Product Dimension" Knowledge Of A Material's Rheological Characteristics Is Valuable In Predicting Pumpability And Pourability, Performance In A Dipping Or Coating Operation Or The Ease With Which It May Be Handled, Processed Or Used. The Interaction Between Rheology And Other Product Dimensions Often Makes The Measurement Of Viscosity The Most Convenient Means Of Detecting Changes In Colour, Density, Stability, Solid Content And Molecular Weight.

Viscosity Is A Principal Parameter When Any Flow Measurements Of Fluid Such As Liquids. Semi Solids Gases And Even Solids Are Made And Are Usually Done In Conjunction With Product Quality And Efficiency. Anyone Involved With Flow Characterization, In Research Or Development Quality Control Or Fluid Transfer, At One Time Or The Other Gets Involved With Some Kind Of Viscosity Measurement. It Is Against The Background That We Intend To Determine The Viscosity, Density And Refractive Index Of Mahogany Oil Which To The Best Of Our Knowledge Has Not Been Done. All Actual Or Fluids Are Compressible And When Flowing Are Capable Of Sustaining Shearing Stress On Account Of Friction Between The Adjacent Layers. Viscosity Is The Inherent Property Of All Fluids And May Be Referred To As The Internal Friction Offered By A Fluid To The Flow. For Water In A Beaker, When Stirred And Left To Itself, The Motion Subsides After Sometime, Which Can Happen Only In The Presence Of Resisting Force Acting On The Fluid. The Temporary Resistance Offered By Fluids To The Shearing Stress Is Called Viscosity. Viscosity Is That Behavior Of Fluids Due To Which They Oppose Relative Motion Between The Adjacent Layer. Liquids Such As Kerosene, Alcohol And Water Etc Which Flows Readily Are Said To Be Mobile While Liquids Such

As Tar, Pitch Etc Which Do Not Flow Readily Are Said To Be Viscous. Liquids Such As Honey, Heavy Oils, Glycerin Etc Are More Viscous Than Tar.

When A Liquid Flows In A Tube, A Viscous Force Opposes The Flow Of The Liquid. Hence, A Pressure Difference Is Applied Between The End Of The Tube Which Maintains The Flow Of The Liquid. If All Particles Of The Liquid Passing Through A Particular Point In The Tube Move Along The Same Path, The Flow Of The Liquid Is Called "Streamed Lined Flow". This Occurs Only When The Velocity Of Flow Of The Liquid In Below A Certain Limiting Value Called The Critical Velocity, The Flow Is No Longer Streamed Lined But Becomes Turbulent. In This Type Of Flow, The Motion Of The Liquid Becomes Zig-Zag And Edge Currents Are Developed. Reynold's Provided That The Critical Velocity For A Liquid Flowing, In A Tube Is (Shukla And Srivastava, 2006);

$$V_c = \frac{k\eta}{\rho a} \qquad 1$$

Where;P = Density, η = Viscosity, A = Radius Of The Tube, K = Reynold's Number Whose Value For A Narrow Tube And For Water Is About 1,000.

When The Velocity Of Flow Of The Liquid Is Less Than The Critical Velocity, Then The Flow Is Controlled By The Viscosity, The Density Having No Effect On It. But When The Velocity Of Flow Is Larger Than The Critical Velocity, Then The Flow Is Mainly Governed By The Density, The Effect Of Viscosity Becoming Less Important. It Is Because Of The Reason That When A Volcano Erupts, Then The Lava Coming Out Of It Flows Speedily In Spite Of Being Very Thick, Rather Very Viscous.

II. METHODOLOGY

Sample, Collection And Preparation

All The Seeds Of Khaya Senegalensis (Mahogany) Were Collected From Michika Local Government Area Of Adamawa State During Their Annual Seasons Of Availability In 2017. The Good Quality Seeds Were Hand-Picked To Separate Them From Bad Ones. Since The Seed Is An Oil Seed, Moisture Content Was Reduced Or Eliminated By Air-Drying Them Under The Sun And Subsequently Preserved In A Well Aerated Cupboard For Further Processing.

Extraction Of The Seed Oil

Seed Decortications Were Manually Done. The Decorticated Dried Seeds Were Flaked Using N-Hexane Blender. A Soxhlet Extractor Was Used For The Extraction With A Hexane As The Extracting Solvent. Activated Molecular Sieves Were Added To The Oil And Left For Two Days To Dry The Oil. The Dried Oil Was Filtered And Stored For Physical Characterization.

III. METHODS

Viscosity Determination

The Ostwald Viscometer Is Commonly Used For Comparing The Viscosities Of Two Liquids Or The Same Liquid At Different Temperatures Such A Viscometer Used In This Experience Is Shown In Plate

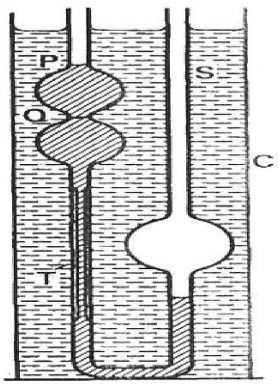

Plate 1: Schematic Diagram For Measuring Viscosity

Procedures

The Mahogany Seed Oil Was Introduced At S, Drawn By Suction Above P And The Time T_1, Taken For The Liquid Level To Fall Between The Fixed Marks P And Q Will Be Observed. The Same Experiment Will Be Repeated With The Same Volume Of Water And The Time T_2 For The Liquid Level To Fall From P To Q Will Be Recorded.

Suppose the liquids have respective densities ρ_1, ρ_2 then, since the average head h of liquid forcing it through T is the same in each case, the pressure excess between the ends of T equals $T = h\rho_1 g$, $T = h\rho_2 g$ respectively. If the volume between the marks P, Q is V, then, from Poiseuille's formula, we obtain that;

$$\frac{V}{t_1} = \frac{\pi(h\rho_1 g)a^4}{8\eta_1 L} \qquad 2$$

Where; a = radius of T, η_1, = the coefficient of viscosity of the mahogany seed oil and L = the length of T. Similarly for the second liquid.

$$\frac{V}{t_2} = \frac{\pi(h\rho_2 g)a^4}{8\eta_2 L} \qquad 3$$

Dividing equation (2) by (1) we have (Oyekunle *et. al.*, 2007);

$$\eta_1 = \frac{\eta_2 t_1 \rho_1}{t_2 \rho_2} \qquad 3$$

Where:
R_1 and R_2 =Viscosity of the mahogany oil seed and water respectively
$t_1$and t_2 = Time taken for the mahogany seed oil and water to fall from P to Q respectively
ρ_1 and ρ_2= Density of mahogany seed oil and water respectively

Thus, Knowing T_1, T_2 And The Densities P_1, P_2, The Coefficients Of Viscosity Can Be Compared. Further, If A Pure Liquid Of A Known Viscosity Such As Water Is Used, The Viscosity Will Be Used To Measure The Coefficient Of Viscosity Of The Mahogany Seed Oil. Since Viscosity Varies With Temperature, The Viscometer Will Be Used In A Cylinder Surrounded By Water At A Constant Temperature. With The Aid Of An Attached Water Bath, It Will Be Possible To Determine The Viscosities Of The Mahogany Seed Oil With Respect To The Water At Various Temperatures (Such As 30 ^{O}c, 40 ^{O}c, 50 ^{O}c, 60 ^{O}c, 70 ^{O}c And 80 ^{O}c).

Density Determination
A Pycnometer Will Be Used For Determining The Density Of The Mahogany Seed Oil.

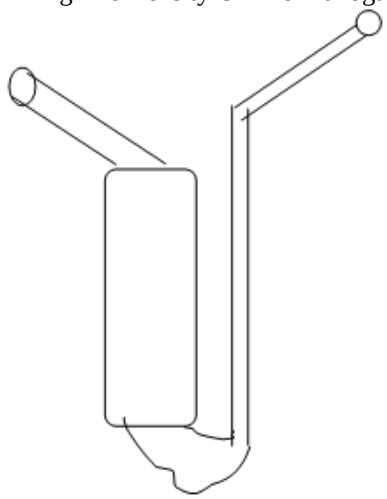

Figure 1: The Pycnometer

Procedures
The Pycnometer (100 Cm^3) Will Be Washed With Soap And Rinsed With Water, Then With Small Amount Of Acetone. It Will Then Be Dried In An Oven. The Dried Flask And The Stopper Will Be Weighed (W_o). The Pycnometer Will Be Filled With Water (At 20 ^{O}c) And Weighed (W_1). The Water Will Be Emptied And The Pycnometer Dried. The Pycnometer Will Then Be Filled With The Oil Sample And Weighed (W_2). The Density Of The Oil Sample Will Be Computed As Follows (Danbature et al., 2015);

$$\rho = \frac{M_B - M_O}{M_W - M_O} \qquad 4$$

Where;$M_b$and M_W= Mass Of The Mahogany Seed Oil And Water Sample
M_O = Mass Of Pycnometer

IV. RESULTS AND DISCUSSIONS

Table 1: The Observed Colour, Flavour And Physical Condition Of The Mahogany Seed Oil At Room Temperature.

OIL SAMPLE	COLOUR	ODOUR	TASTE	PHASE
Khaya Senegalensis	Light Yellow	Bland	Bitter	Liquid

Table 2: Measurement Of The Viscosity Of The Mahogany Seed Oil In Centipoise (Cp)

Viscosity (CP)	Temperature (^{O}c)
60.70	30
37.75	40
25.30	50
17.26	60
13.31	70
9.83	80

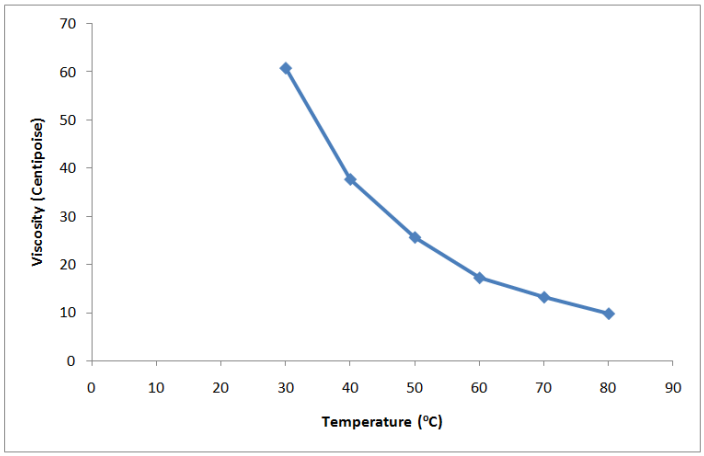

Figure 2: Variation Of Viscosity (Centipoise) Of The Mahogany Seed Oil With Temperature (^{O}c)

Table 3: Comparing The Density Of Water And That Of The Mahogany Seed Oil (G/Cm^3)

Density (G/Cm^3)	Water (^{O}c)	Temperature (^{O}c)
0.9243	0.7975	30
0.9190	0.6529	40
0.9142	0.5468	50
0.9130	0.4665	60
0.9120	0.4042	70
0.9110	0.3547	80

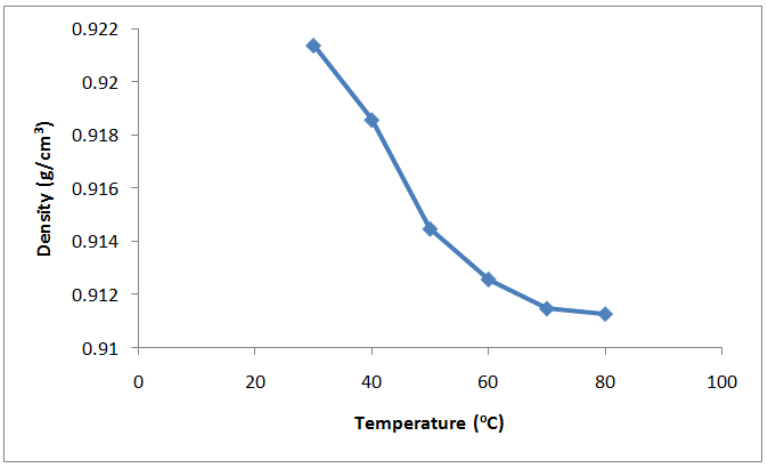

Figure 3: Variation Of Density Of The Mahogany Seed Oil With Temperature (^{O}c)

V. DISCUSSIONS

Physical Observations Of The Mahogany Seed Oil Sample (Table 1) Indicates That The Colour Is Light Yellow, Had Essentially Bland Odour, A Very Bitter Taste, Which Convincingly Suggest The Presence Of Alkaloids And Resins.

Other Physical Parameters Of The Oil Sample Such As Viscosity And Density Were Also Determined And These Physical Constants Are Temperature Dependent. The Viscosity And Density Values Of The Oil Sample Compares Closely To Those Obtained For Glycine Max (Soya Bean) By Akanni et al., (2005).

The Khaya Senegalensis Have Comparable Viscosity Values (Table 2) To That Obtained For Jatropha Curcas By Oyekunle et al., (2007). Also, We Are Informed That The Oil From Jatropha Curcas Was Used By Many Villagers In Some Tropical Countries Such As Mali For Driving Stationary Machineries/Engines (SPORE Magazine, 1997). Therefore, It Is Very Possible To Use The Mahogany Seed Oil In Starting The Engines If Left Overnight Since The Solidification Temperature Of The Oil Sample Is Quiet Below The Lowest Possible Temperature Which Is About 10^{o}c In Any Season (Oyekunle et al., 2007).

The Density Values (Table 3) For The Oil Sample Are Observed To Be Less Than That Of Water Within The Given Temperature Range. This Result Is In Agreement With The Values Observed For Some Conventional Seed Oil Such As Groundnut Oil. Hence, Khaya Senegalensis, Can Be Conveniently Applied In Inhibiting The Vaporization Of Water In Any Process Especially In Arid Region Where We Have Acute Water Shortage. However, The Water For Which The Oils May Serve As Retardants Should Not Be Drinkable One Since Pre-Oxidation Of The Oils May Transfer Rancid Oil Odour To The Water. Also, Since Seed Oils Are Susceptible To Bio-Degradation Unlike Fossil Fuels, There Is Little Or No Fear Of Possible Long-Term Environmental Pollution That May Occur Due To Their Use.

Finally, The Seed Oil Yield Of About 60% Volume Per Weight Is Higher Than That Obtained By Okieimen And Eromosole, (1999); And Abdulhameed et al., (2012). It Is Also Higher Than That Obtained For Soya Beans (15 – 21) % And Rape Seed (>40%) (Okieimen And Eromosole, 1999). This Value Therefore Is Considered As Reasonable Recovery Yield. A Crop That Produces High Amount Of Oil Is Desirable For Biodiesel Production As It Could Be Used As A Feasible Alternative (Jibrail And Kaet, 2013). However, The Observed Improvement In The Oil Recovery Of Mahogany Seed Could Be Attributed To The Modified Method Of Extraction. Also, The Density Of Mahogany Seed Oil Is Higher Than That Obtained By Abdulhameed *Et Al.,* (2011) But Lower Than That Reported By Okieimen And Erosomole (1999). The Density Of Mahogany Seed Oil Obtained In This Research Falls Within The European Standard Of (0.86 – 0.90) G/Cm^3 (EN14214).

VI. CONCLUSION

The Dry Zone Mahogany (Khaya Senegalensis) Is An Oil Rich Tree Crop That Grows Well In Subharan Africa. Its Round, Woody, Capsular Fruit That Has Four To Five Valves In Which Up To 6-18 Seeds Are Embedded. The Tree's Importance Lies Mainly On Its Seed, Which Contains Kernel With Oil Content Of 67%. The Seed Oil "Mayin Daci" (In Hausa Language) Is Used For Cooking And In The Manufacture Of Cosmetics And Pharmaceutical Products In West Africa. The Present Methods Of Handling And Processing The Mahogany Seed Involves Operations That Are Not Only Slow And Full Of Drudgery But Also Wasteful. Improved Methods Of Handling And Processing The Seed Using Suitable Machines And Equipment Could Be Developed If The Physical Properties Are Known. The Seeds Which Are Commonly Found In Adamawa State Were Sampled And Subjected To Physical Property Test At A Moisture Content Of About 12.20% Wet Basis.

The Oil Sample In This Study Could Serve As Grease For Engine Parts Anywhere In The Tropics And At Temperatures Close To 5^{o}c Such As In Temperate Regions Because The Oil Was Less Viscous Around Such Temperature.The Seed Of Khaya Senegalensis Is Non-Drying Oil, Consisting Of Long Chain Fatty Acids, And The Extract From The Seed May Contain Bioactive Compounds Of Potential Therapeutic And Prophylactic Significance. It Could Also Be Concluded That Mahogany Seed Oil Is A Good Feed Stock For Biodiesel Production. Also, These Results Would Play A Very Important Role In Understanding The Agronomic Properties Of The Seed When Designing Processing Or Handling Machine For The Seed.

REFERENCES

[1]. Abdulhameed Hamza, Auwal Aliyu and Elisha Lemshaka (2012). Production of Biodiesel Via NAOH Catalyzed Trans-esterification of Mahogany Seed Oil. Advances in Applied Science Research. 3, 615 – 618. Available online at www.pelagiaresearchlibary.com.

[2]. Adeyeye, A. K., Ajewole and Onasanya, L. O., (1990). Characteristics and Fatty Acid Composition of Jatropha Curcase Seed Oil. Pak. J. Sci. Ind. Res., 33,436.

[3]. Adeyeye, A. and Ajewole, A. (1992). Chemical Composition and Fatty Acid Profiles of Cereals in Nigeria. Food Chemistry, England, Great Britain. 44, 41 – 44.

[4]. Ajewole, K. and Adeyeye a., (1991). Seed Oil of White Star Apple (Chrysophyllum albidium) – Physiochemical Characteristics and Fatty Acid Composition. J. Sci. Food Agric. London. 54, 313 – 315.

[5]. Akanni M. S., Adekunle A. S. and Oluyemi E. A. (2005). Physiochemical Properties of Some Non-Conventional Oilseeds. J. Food Technol. Faisalabad, Pak., 3920; 177 – 181.
[6]. Aviara N. A.; Lawal A. A.; Msheila H. M. and Musa D. (2014). Effect of moisture Content on Some Engineering Properties of Mahogany (Khaya Senegalensis) Seed and Kernel. Res. Agric. Eng. 60(1), 30 – 36.
[7]. Besbes, S. C. ; Blecker, C. Deroane, G. Lognay, N. E. Drira and Attia H. (2004). Quality Characteristics and Oxidative Stability of Data Seeds Oil During Storage. Food Sci. Technol., Int'l., 333 – 338.
[8]. Dinsdale, A; Moore, F. (1962). Viscosity and its Measurement. Chapman and hall. London, 1-60.
[9]. Harwood, H. J. (1984). Oleo Chemicals as Fuel: Mechanical and Economic Feasibility. J. Am. Oil Chemists Soc., 61, 315 – 324.
[10]. Kaufman, A. (1990). Oleo Chemicals a Look at World Trends, INFORM. 1, 1034 – 1048 Lea, P. J. and Leegood R. C. (1993). Plant Biochemistry and Molecular Biology (Chister, John Wiley). 269
[11]. Mielke, T. (1988). Oil Pieces on Uptrend. J. Am. Oil Chemist Soc., 1066 – 1075.
[12]. Nagala, D. W.; Boufaida, M (2004). The Importance of Online Viscosity Measurement for Leak Detection and Other Simulation Applications. In International Pipeline Conference, Calagary, Alberty, Canada.
[13]. Okieimen F. E. and Eromosele C. O. (1991). Fatty Acid Composition of the Seed of Khaya Senegalensis Bioresource Technology. 69, 279 – 280.
[14]. Pearson D. (1981). The Chemical Analysis of Foods. 7th edition. Churchill Livingstone Edinburgh. 504 – 530.
[15]. Rossell, J. B. (1991). Vegetable Oils and Fats. In: Rossell J. B.., Prichard J. L. R. (eds). Analysis of Oil Seeds, Fats and Fatty Foods. Elsevier Science Publishers LTD. London. 261 – 325.
[16]. Spore (1997). Technical Centre for Agriculture and Rural Cooperation. CTA-ACP-EU Home Countries, Cotton Research and Developmental Inst., North Philipines.
[17]. Swindells, J. F.; Coe, J. R.; Godfrey, T. B. (1952). Absolute Viscosity of Water at 20 oC.
[18]. J. Res. Natl. Bur. Stand. (U. S.). 48, 1 – 31.

E. IKE "Determination of The Viscosity And Density Of Mahogany Seed Oil."IOSR Journal of Engineering (IOSRJEN), vol. 08, no.2, 2018, pp. 08-13.