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Physical Properties of Oils Extracted from Some Nigerian Non-Conventional Oilseeds

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Abstract: Oils extracted from *Cucumeropsis edulis*, *Hevea brasiliensis* (Para rubber), *Hura crepitans* (Sound box tree), *Jatropha curcas* (Physic nut), *Khaya ivorensis* (Lagos Mahogany) and *Citrus sinensis* (sweet orange) were assessed for such characteristic physical properties as colour, flavour (odour and taste), specific gravity, viscosity, dielectric constant, surface tension and refractive index. Specific gravity measurement varied between 0.9004-0.9113 at 80°C and 0.9125-0.9207 at 30°C. Viscosity measurement, in centipoises, ranged between 7.35-9.41 at 80°C and 38.44-60.34 at 30°C. Dielectric constant values varied between 1.63-3.88 within the temperature range of 26-80°C. Surface tension values at 28.5°C were between 0.03492-0.03616 m^{-1} and refractive index values at 28°C lied between 1.46469 and 1.47072. The findings revealed the usefulness of the oils in electric voltage transformers and for impregnation in paper capacitor.

Key words: Physical properties, dielectric constant, oilseeds, non-conventional, extraction

INTRODUCTION

The seeds, namely: *Cucumeropsis edulis*, *Hevea brasiliensis* (Para rubber), *Hura crepitans* (Sound box tree), *Jatropha curcas* (Physic nut), *Khaya ivorensis* (Lagos Mahogany) and *Citrus sinensis* (sweet orange) from which the oils were extracted are essentially not among the popular cultivars of oilseeds like ground nut, soybean, palm fruit and palm seed. At best, they are allowed to waste away in the forest. Like Besbes *et al*. (2004) said 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 oilseed products declined substantially due to the availability of relatively inexpensive oil derived from fossil reserves (Lea and Leegood, 1993). It is, however, now realized that the fossil reserves could be exhausted or become shorter in supply and are not renewable (Boelhouwer, 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 aim of this study was to determine which of the seeds actually qualified to be a source of vegetable oil raw material and to investigate the possible technological applications, apart from eating, to which the oils could be put.

MATERIALS AND METHODS

Sample collection and preparation: All the seeds were collected from three sites in Nigeria (two sites in Osun state and one from Kogi state) during their annual seasons of availability in 2000. *Cucumeropsis edulis* fruits, *Hevea brasiliensis*, *Hura crepitans*, *Jatropha curcas* and *Citrus sinensis* seeds were obtained from various farms in the Western part of Nigeria while *Khaya ivorensis* seeds were collected within the Middle belt of Nigeria. The good quality seeds were hand-picked to separate them from bad ones. The hand-picked ones were then air-dried under the sun and subsequently preserved in a well-aerated cupboard for further processing.

Extraction of the oils: Seed decortications were manually done. The decorticated dried seeds were flaked using a

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Kenwood blender. A soxhlet extractor was used for the extraction with n-hexane as the extracting solvent. Each batch extraction lasted for about 5 h on the average.

Physical characterization

Colour and flavour: The colour of each oil sample was determined by observation using several independent competent individuals. Oil colours were correlated using colour charts. The taste and odour were likewise determined.

Melting/solidification points: 10 cm^3 of each oil sample was put in a test tube, corked with cotton wool ball and placed in a beaker kept and left in a working freezer for 48 h to allow the oil to freeze. The test tube was removed and then placed in a thermo stated water bath maintained at 30°C. The consequent increase in temperature of the frozen oil was monitored using a -10 to 110°C range thermometer and a stop watch to determine the cooling rates.

Conversely, the solidification point was determined by putting 10 cm^3 of each oil sample in a test tube immersed in ice chips and the fall in temperature was similarly monitored. Triplicate analysis was done in each case to ensure accuracy.

Specific gravity (s.g.) and viscosity: The specific gravity of the oils were determined as earlier stated by Omode *et al.* (1995).

Viscosity measurement, in centipoises (cp), was performed using Ostwald Kinematic Viscometer. With the aid of an attached water bath, it was possible to determine the viscosities of the oils with respect to that of water at various temperatures (30, 40, 50, 60, 70 and 80°C).

Viscosity estimation at each temperature was done using the expression:

$$\eta_0 \frac{\eta_w \rho t_o}{\rho_w t_w}$$

where

η_o and η_w = Coefficients of viscosity of oil and water respectively.
ρ_o and ρ_w = Densities of oil and water, respectively;
and t_o and t_w = Times of flow of oil and water, respectively

Dielectric constant (relative permitivity),ϵ: The dielectric characterization was based on the possibility of using the oils as impregnators in paper capacitors. For this, a parallel-plate capacitance sensor constituted on the Schering's bridge was used to measure the capacitance of paper capacitors with and without impregnated oils. Thus, capacitors of the same specifications were carefully opened up and the strips of paper in between the foils carefully removed. The foils were cleaned properly using acetone and allowed to dry. Thin paper strips of the same dimension and from the same source were used in between the foils as insulators. These in turn, were firmly rolled back into the cylinder and the potential difference (p. d) taken after 45 sec within the temperature range of 26-80°C. The paper strips were then moderately impregnated with the oil sample. p.d. values were taken twice in each case after 45 sec within the temperature range of 26-80°C using a thermostated water bath and a constant current. Attainment of thermal equilibrium was allowed before taking each reading.

Calculations were made based on the relationship,

$$\epsilon = \frac{V_o}{V}$$

derived as follows:
For a given capacitor,
$C = Q/V$ ……(i) (Tareev, 1979; Serway, 1996)
V = The potential difference between the foils.,
where
Q = The operating quantity of electricity = current× time;
V = The potential difference between the foils., and
C = The capacitance of the capacitor.

Given a vacuum capacitor of capacitance C_o. If this capacitor contains a material having relative permitivity ϵ, the capacitance C will increase and reach the value.

$C = \epsilon C_o$, (Tareev, 1979; Serway, 1996)
i.e., $\epsilon = {}^{C}/C_o$ … (ii)

Combining Eq. (i) and (ii):

$$\epsilon = \frac{Q}{V} \div \frac{Q_o}{V_O}$$

Since the same quantity of electricity was used,
i.e., Q = Qo

Hence, $$C = \frac{Qo}{V}$$

Where
ϵ = The relative permitivity of the oil;
Vo = The p.d. value for vacuum capacitor;
and V = The p.d. value for capacitor with the oil.

Surface tension, γ: This was determined at 28.5°C by drop number method (Sharma and Sharma, 1990) and the surface tension of the oil was evaluated from:

$$\underline{\gamma_o}/\gamma_w = \underline{n_w}\ \underline{\rho_o}/n_o\rho_w$$

where

γ_o and γ_w = Surface tensions of oil and water, respectively;

n_o and n_w = Number of drops of oil and water, respectively and

ρ_o and ρ_w = Density of oil and water respectively.

The drop number method did not, however, allow for variations of temperature in the determination of surface tension.

Refractive index, (μ): The refractive index of each of the oil samples was determined at 28°C using an Abbé refractometer.

RESULTS AND DISCUSSION

Table 1 shows the observations of the colour, taste and odour of the oils. The colour of the oils vary from reddish brown to pale greenish yellow. All the oils had essentially bland odour except *Hevea brasiliensis* in which the odour was intensely nutty. Most of the oils were tasteless. *Jatropha curcas,* however, had a mild bitter taste while *Khaya ivorensis* tasted intensely bitter strongly suggesting the presence of alkaloids and resins. All the oil samples were in liquid forms at room temperature, but generally congealed within the temperature range of -1 to 2°C as can be seen from the cooling/heating curves in Fig. 1 and 2, drawn for oils having the maximum and/or minimum solidification/ melting temperatures.

The results of other physical constants of the oils such as specific gravity, viscosity and surface tension/refractive index are presented in Table 2-4. These constants are temperature dependent. The specific gravity and viscosity values of the oils are comparable to those obtained for *Glycine max* (soybean) by Akanni *et al.* (2005).

The specific gravity values for all the samples are less than that of water within the temperature range (30-80°C) investigated. This conforms with the usual values observed for conventional seed oils like groundnut oil. As such, they can also conveniently be used as water evaporation retardants especially in arid regions where acute water shortage is a menace. Since seed oils are prone to faster biodegradation than fossil fuels, there is less fear of possible long-term environmental pollution problems that may arise from their use. However, the water for which the oils may serve as retardants should not be potable as peroxidation of the oils may impart off

Table 1: Colour, flavour and physical state of the oils at room temperature

Oil	Colour	Odour	Taste	State
C. edulus	Light brown	Bland	Tasteless	Liquid
H. brasiliensis	Reddish brown	Nutty	Tasteless	Liquid
H. crepitans	Light brown	Bland	Tasteless	Liquid
J. curcas	Light brow	Bland	Mildly bitter	Liquid
K. ivorensis	Light yellow	Bland	Very bitter	Liquid
C. sinensis	Pale greenish yellow	Bland	Tasteless	Liquid

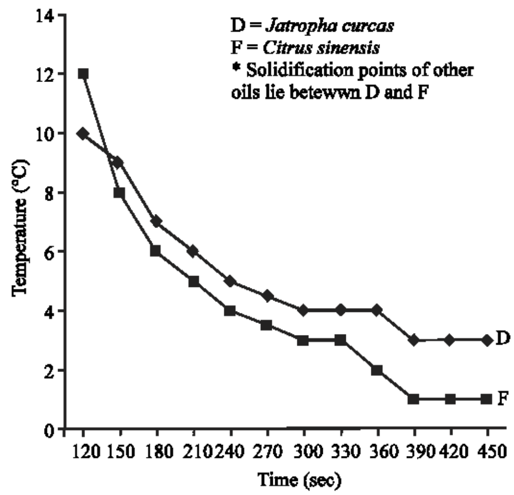

Fig. 1: Cooling curves of the oils

odour of rancid oils to the water as time goes on. In any case, short-term usefulness of this application includes preserving water for moulding blocks, watering seedlings and so on.

The oils have similar viscosity values to that of *Jatropha curcas* (in this work), an oil reported by SPORE (1997) magazine to be in current use by many villagers in Mali for driving stationary engines. Thus, if these oils are used as lubricants in engine parts especially in the tropical countries, there should be no difficulty in starting the engines if left overnight as the solidification temperature of the oils is below the lowest attainable temperature (~10°C) in any season.

The dielectric constant (ϵ) values ranged between 1.63 at 80°C in *Hevea brasihensis* to 3.88 at 30°C in *Khaya ivorensis.* The ϵ-temp relationship is represented by the graph in Fig. 3. According to Tareev (1979), the ϵ value for transformer oil is 2.25. The values obtained for the oils between 26 and 40°C especially showed that some of the oils like *Cucumeropsis edulis*, *Hura crepitans* and *Citrus sinensis* might be suitable alternatives as transformer oils and in the making of capacitors. Although for *Citrus sinensis* oil, the ϵ-temperature relationship pattern was erratic and for *Hevea brasiliensisi* there was a continuous fall in the ϵ-value with increase in temperature, a general fall was, however, observed as from 40°C for the

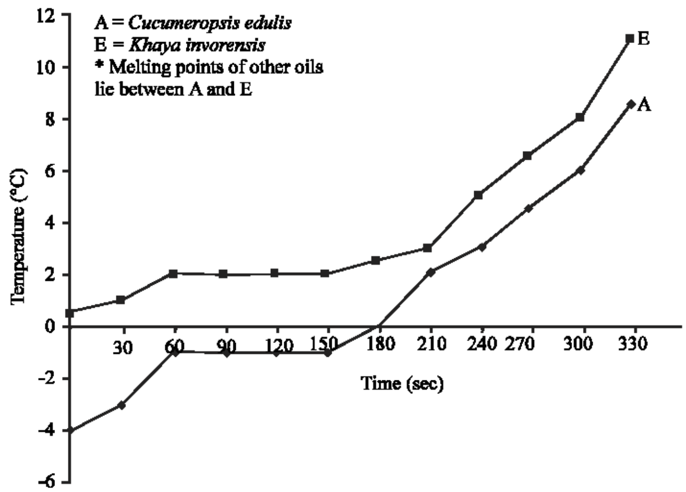

Fig. 2: Heating curves of the oils

Table 2: Specific Gravity (s.g.) measurement[a]

	Temperature (°C)					
Oil	30	40	50	60	70	80
Cucumeropsis edulis	0.9207	0.9186	0.9157	0.9137	0.9190	0.9069
Hevea brasiliensis	0.9200	0.9169	0.9127	0.9101	0.9091	0.9077
Hura crepitans	0.9162	0.9132	0.9096	0.9067	0.9049	0.9053
Jatropha curcas	0.9164	0.9114	0.9082	0.9054	0.9032	0.9033
Khaya ivorensis	0.9214	0.9186	0.9145	0.9126	0.9115	0.9113
Citrus sinensis	0.9125	0.9090	0.9059	0.9028	0.9022	0.9004

[a]Expressed as mean

Table 3: Viscosity measurement (in cp)

	Temperature (°C)					
Oil	30	40	50	60	70	80
Cucumeropsis edulis	40.71	28.89	19.41	14.00	10.85	8.59
Hevea brasilisnsis	42.47	28.64	20.10	14.97	11.74	8.53
Hura crepitans	38.46	27.12	18.11	13.68	9.90	7.50
Jatropha curcas	41.70	27.02	19.20	13.54	10.28	7.70
Khaya ivorensis	60.34	37.27	25.22	17.53	12.82	9.41
Citrus sinensis	38.44	24.21	17.35	12.88	9.90	7.35

Table 4: Surface tension (γ) and refractive index (μ)

	Temperature (°C)	
Oil	γ (Nm^{-1}) at 28.5°C	μ at 28°C
Cucumeropsis edulis	0.03589	1.46671
Hevea brasiliensis	0.03499	1.47072
Hura crepitans	0.03542	1.46573
Jatropha curcas	0.03560	1.46470
Khaya ivorensis	0.03616	1.46570
Citrus sinensis	0.03492	1.46469

remaining oils. This observation leads to the conclusion that there might be optimal temperature for seed oils to be used as dielectrics.

Figure 4 compares the specific gravities of the oils to their corresponding surface tensions at (about) the same temperature. It could be deduced on a general note that there is a correlation between the specific gravity of a given oil and its surface tension at the same temperature. This relationship will be a subject of further investigation.

Gourd *et al.* (1966) reported an empirical equation having a number of advantages over the existing correlations that have been proposed as being successful over a wide temperature range and within normal viscometric accuracy. This equation,

$$H = A + SQ$$

can be used to described the dynamic viscosity-temperature relationship of a large variety of liquids. In the equation,

H = $A + SQ$,
H = $\log (1.20 + \log n)$;
η = The dynamic viscosity (in cp);
A = A constant;
S = The slope index;
Q = $\text{Log}\ (1 + t/135)$;
t = The temperature in °C

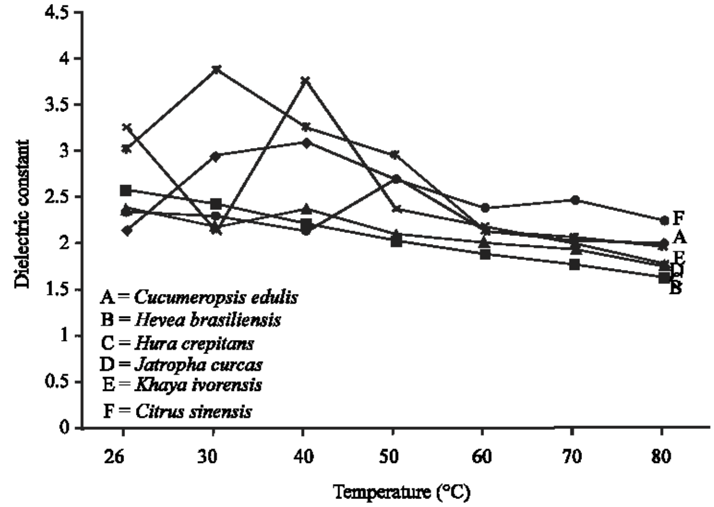

Fig. 3: Dielectric constant-temperature graph of the oils

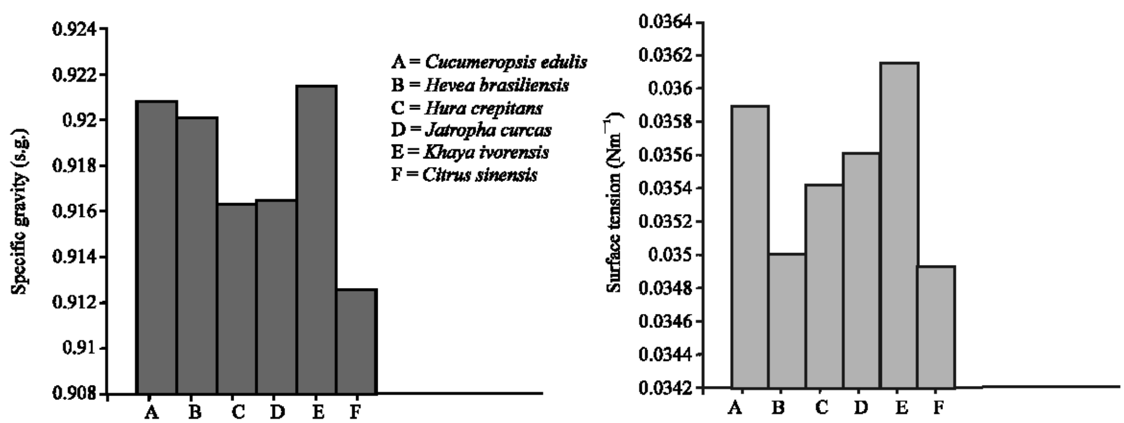

Fig. 4: Comparison among specific gravity and surface tension of the oils at ~ 30°C

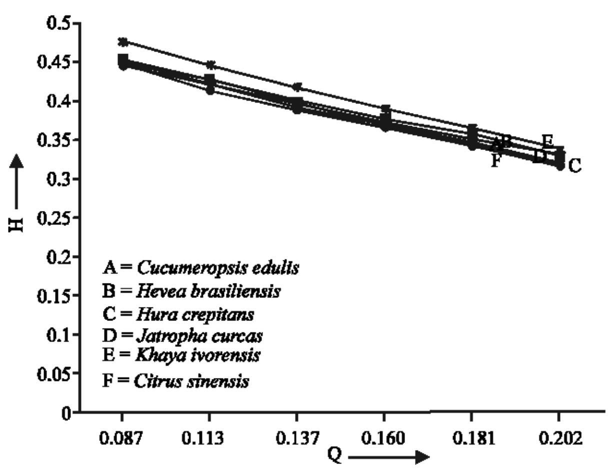

Fig. 5: Results of Eq. H = SQ on oils

One obvious deduction from the Fig. 5. is that it offers an easy way of seeing how closely comparable the viscosity of the oils are. For example, while *cucumeropsis edulis*, *Hevea brasiliensis*, *Hura crepitans* and *Jatropha curcas* oils have quite close viscosity values, those of *Khaya ivorensis* and *Citrus sinensis* are quite divergent.

CONCLUSIONS

From colour, odour and viscosity considerations, most of the oils, if subjected to further refining, could be useful in deep frying, emulsifier formulation, baking activities and as part of short cake and confectionery components. All the oils could serve as grease for engine parts without causing sticking problems any where in the tropics and even at temperatures as low as 5°C in places like the temperate regions because all the oil were still free-flowing liquids at that temperature.

Other physical parameters of the oils as revealed by the study indicate their ability to serve as lubricants, water evaporation retardant agents and suitable alternatives as transformer oils and dielectrics in capacitors.

Based on the specifications reported by Ryan *et al.* (1984), with further investigation, the low viscosity values of the oils studied might justify their usefulness as substitutes for diesel fuels.

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REFERENCES

Adeyeye, A., K. Ajewole and L.O. Onasanya, 1990. Characteristics and Fatty Acid Composition of Jatropha curcas Seed oil. Pak. J. Sci. Ind. Res., 33: 436.

Adeyeye, A. and K. Ajewole, 1992. Chemical composition and fatty acid profiles of cereals in Nigeria. Food Chemistry, England, Great Britain, 44: 41-44.

Ajewole, K. and A. Adeyeye, 1991. Seed oil of white star apple (*Chrysophyllum albidum*)-physicochemical characteristics and fatty acid composition. J. Sci. Food Agric. London, 54: 313-315.

Akanni, M.S., A.S. Adekunle and E.A. Oluyemi, 2005. Physicochemical properties of some non-conventional oilseeds. J. Food Technol. Faisalabad, Pak., 3920: 177-181.

Besbes, S., C. Blecker, C. Deroanne, G. Lognay, N.E. Drira, and H. Attia, 2004. Quality characteristics and oxidative stability of dates seed oil during storage. Food Sci. Technol. Intl., pp: 333-338.

Boelhouwer, C., 1983. Trends in chemistry and technology of lipids. J. Am. Oil Chemists' Soc., 60: 457-462.

Gourd, T.H., J.C. Vulgter and C.J.A. Roelands, 1966. Physical properties of fatty acid methyl esters vi-viscosity. J. Am. Oil Chemists' Soc., 16: 433-434.

Harwood, H.J., 1984. Oleo chemicals as fuel: Mechanical and Economic Feasibility. J. Am. Oil Chemists' Soc., 61: 315-324.

Kaufman, A., 1990. Oleo chemicals-a look at world trends, INFORM, 1: 1034-1048.

Lea, P.J. and R.C. Leegood, 1993. Plant Biochemistry and Molecular Biology (Chister, John Willey), pp: 269.

Mielke, T., 1988. Oil prices on uptrend. J. Am. Oil Chemists Soc., pp: 1066-1075.

Omode, A.A., O.S. Fatoki and K.A. Olaogun, 1995. Physicochemical properties of some underexploited and non-conventional oilseeds. J. Agric. and Food Chem., Washington, 43: 2850-2853.

Ryan, T.W., L.G. Dodge and T.J. Collahan, 1984. The effects of vegetable oil properties on injection and combustion of two different diesel engines. J. Am. Oil Chemists' Soc., 61: 1610-1619.

Serway, R.A., 1996. Physics for Scientists and Engineers, 4th Edn., (Saunders College Pub.), pp: 741-755.

Sharma, K.K. and D.S. Sharma, 1990. An Introduction to Practical Chemistry (Vikas Publishing House PVT Ltd.), pp: 217-226.

Spore, 1997. Technical Centre for Agric and Rural Cooperation CTA-ACP-EU Home Countries, Cotton Research and Development Inst., Ilocos Norte, Philippines.

Tareev, B., 1979. Physics of Dielectric Materials, Mir Pub. Moscow, pp: 90.