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A Comparative Study of Selected African Edible Oils and Their Potential Domestic and Industrial Applications

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A comparative study on the physical and chemical characteristics. Melon seed oil (*Colocynthis Citrullus* L.), African oil bean oil (*Penta celethra, macrophylla*) and Avocado pear oil (*Perse, Americana*) was undertaken to assess their potential domestic and industrial applications. This study focussed on the percentage oil content, individual odour (aroma), specific gravity, refractive index, relative viscosities, smoke points, acid values, free fatty acid contents (%), iodine values, and ester values. The iodine values obtained for these oils were: 151.72 (melon seed); 113.00 (African oil bean oil); 43.30 (Avocado oil). The same oils showed free fatty acid contents as 2.38%; 0.97% and 0.37% respectively, whereas acid values recorded were 4.76 (melon); 1.65 (African oil bean oil) and 0.82 (Avocado pear oil).The saponification values were 197.56 (melon), 185.08 (African oil bean oil) and 246.70 (Avocado pear oil) and the individual Ester values were 192.81 (melon), 183.63 (African oil bean oil) and 241.50 (Avocado per oil). Melon seed, African oil bean seed and Avocado pear gave 57.40%; 42.07% and 15.13% of oil following the extraction procedures outlined in the project.The potential domestic and industrial applications of the oils under study have been discussed in line with their physical and chemical characteristics.

Key words: Edible oils, Dielectric constant, Relaxation time, Viscosity, Loss factor.

Introduction

Fats and oils are indispensable food factors (Tooley 1971), they are also extensively used for nutritional cosmetic, domestic and industrial purpose (Tooley 1971; Berdick 1972). Sources of fats and oils include animal fats e.g. whale oil and shark oil and vegetable oils such as coconut oil, groundnut oil, plm oil, palm kernel oil, rubber seed oil, African oil bean oil, avocado pear oil, melon seed oil etc.

Oils and fats constitute a class of compounds referred to as lipids which are either simple or complex triglycerides. Their existence as fats or oils depends on their state at room temperature (fats are solids and oils are liquids (Gurr and James 1972).

Fats and oils enjoy a wide range of applications such as:

i) For making food products such as enrobing and coating fats in confectionery, shortenings; margarine; salad oil and in compounding of many other food products.

ii) For delivering fat soluble vitamins as carriers and contributing flavours to food (Masson 1981).

iii) For supplying essential fatty acids like lineoleic; linolenic; archidonic acids (etc) which are not made by the body but are required by the body (Triebold and Aurand 1963).

iv) For making soaps and detergents

v) For producing drug dispersants in therapeutics (Ngoddy and Ihekoronye 1964; William 1966; Oyolu 1971).

The three oil, seeds which were selected for the study are abundantly available in Nigeria and their oils can be processed on a large scale at moderate costs.

The melon belongs to the *cucurbitaceae* family and is widely cultivated within the tropics in places like Nigeria, Cameroon, Ghana etc for its seeds and oil. The yield is reported as 51-53% (Oyolu 1971). The fatty acid composition as 12.18% palmitic acid, 12.77% stearic acid, 16.62% Oleic acid, 58.79% linoleic acid.

The Avocado pear (family *Lauruceae*) showing equivalent spread within the tropics (Nigeria, Cameroon) as well as other countries like the United States of America (Kochhar 1981), has up to 30% digestible fats. The fatty acid composition is 42.605% palmitic acid, 3.81% palmitoleic acid, 49.47% oleic acid and 4.10% linoleic acid.

The African oil bean grows luxuriantly and widely in the Eastern part of Nigeria and tribes in this area (Ibos) enjoy it as a delicious food (Ikediobi 1981). The seed is rich in oil containing of 0.48% lauric acid, 1.80% stearic acid, 5.20% palmitic acid, 73.00% linoleic acid, 15.60% oleic acid and trace amount of myristic acid (Triebold and Aurand 1963).

A compartive study of the various qualities of fats and oils from different sources was undertaken. The results obtained are matched against well established oils that are enjoying industrial and domestic application world wide (Soya bean oil; Sun flower oil; Corn oil; Cotton seed oil; Groundnut oil etc are examples of these oils).

Experimental

The samples of melon seeds, African oil bean seeds and Avocado fruit were purchased from a local market (Oregbeni market in Benin City). The chemicals used were supplied by Aldrich Chemical Company USA.

Sample preparation. The samples for the melon seeds and African oil bean seeds were prepared similarly. The dried seeds (after removing the external covering/husks) were ground with an electronically operated blender into fine powdery particles. The fleshy mesocarp of the Avocado fruit was used after blending (electric) to a watery paste. The physical and chemical characterisatics observed are presented in Table 1-2.

Extractions. 1. Melon seeds and African oil bean seeds. Extraction of both the seeds was carried out similarly in a Soxhlet apparatus using methanol as the solvent. Extraction was continued until methanol in the Soxhlet became colourless. The oil obtained, after distilling off the methanol, was stored in labelled flask. 100g of ground samples was extracted with 200ml of methanol.

2. Avocado pear. The watery pasty mass after blend crushing of the fleshy mesocarp of the Avocado fruit was extracted with chloroform. 50g of the sample was poured into a reasonable volume of water and shaken with 300ml of chloroform in a conical flask. The contents of the flask were transferred into a separatory funnel and allowed to stand for 1 h and then separated (oil in the chloroform layer). Extraction process in this case was done five times using the same sample (Ernest-Bernadine 1978). Chlorofom was distilled off and the oil left behind was collected in a stoppered labelled flask.

Odour. This was assessed by olfactory evaluation.

Refractive index. The refractive index was determined by a refractometer using an oil smear and taking the corresponding readings for the individual oils. For this determination, the refractometer was first calibrated with distilled water whose value corresponds to the standard value for the refractive index of water. The refractive index of each oil was taken at 25°C.

Specific gravity. Specific gravity was determined for the oils applying Trieblod and Aurand method (Triebold and Aurand 1963) using the equation:

$$\text{Specific gravity } 28°C = \frac{\text{Wt of bottle + Oil - Wt of dry bottle}}{\text{Wt of bottle + Water - Wt of dry bottle}}$$

Relative viscosity. Relative viscosity was determined by an Oswald U - tube viscometer immersed in a water bath thermostated at 40°C. The oil sample and bath were allowed to equilibrate for 1/2h. The water and oil were introduced similarly into the instrument and their time of flow between the same marks was equally determined. The relative viscosity was determined as:

$$\text{Relative viscosity} = \frac{\text{Time required by oil}}{\text{Time required by water}}$$

Smoke point. 5 ml of each oil was separately taken in 10 ml Pyrex beakers and heated over a burner while light from a 60W bulb was directed onto the oil. The temperature was noted from a thermometer (thermometer bulb submerged in the middle of the oil) when smoking started and was taken as the smoke point.

Free fatty acid. The determination was made by AOCS (American Oil Chemist Society) method (Link 1977). Equal volumes of diethylether and ethanol were mixed and 0.1M KOH solution added until a permanent pink colour was maintained on addition of phenolphthalein indicator. 0.5g of each oil was separately added to the mixture and titrated with 0.1 M NaOH using 4 drops of phenolphthalein as indicator. A persistent pink colour (10-15 sec) was taken as the end point. The percentage free fatty acid was calculated using the equation (Devine and William 1961).

$$\text{\% Free fatty acid} = \frac{V \times C \times M}{100\ W}$$

Where V = Volume of standard NaOH used
C = Concentration of NaOH

Table 1
Physical characteristics of extracts

	Melon seed	African oil bean	Avocado pear
Colour	Yellow	Yellow	Yellow
Odour	Sweet smell	Pleasant	Nutty
Specific gravity	0.9196	0.9225	0.9185
Refractive index	1.4680	1.4650	1.4620
Relative viscosity	356×10^{-3} poise	362×10^{-3} poise	348×10^{-3} poise
Smoke point	175°C	233°C	177°C

Table 2
Chemical characteristics of extracts

	Melon seed	African oil bean	Avocado pear
Free fatty acid content	2.38%	0.79%	0.37%
Saponification value	197.57	185.08	246.70
Iodine value	151.72	113.00	43.30
Acid value	4.76	1.65	0.805
Ester value	192.81	183.63	241.50

M = Molecular weight of dominant fatty acid (in this case oleic acid = 282)

W = Weight of oil sample (g)

Saponification value. 2 g of each oil was added to alcoholic potassium hydroxide (20 ml), refluxed for 1.5 h with frequent shaking and titrated against 0.5 M HCl using 6 drops of phenolphthalein indicator. A blank titration was done using water in place of the oils. Saponification value (S. V.) was obtained from the relation

$$S.V = \frac{(b-a)\,28.05}{\text{Wt. of sample}}$$

a = Volume of acid used for oil

b = Volume of acid used for blank

Iodine value. This was determined using the A.O.C.S method (Link 1977). A known weight of oil sample (0.5 g) was taken into a glass stoppered flask then 5 ml of chloroform and Wiji's solution (5 ml) was added to the oil sample (chloroform). Potassium iodide solution was added and the set up allowed to stand in the dark for 1/2 h. 5 ml of 10% KI solution and distilled water (20 ml) was added and reaction conducted with proper mixing.

The mixture was titrated with 0.1 N standard sodium thiosulphate solution with starch indicator (added close to the end point). The end point was noted when the starch turned colourless. The blank was done in a similar fashion but water was substituted for oil samples.

The iodine value was calculated following the relation

$$\text{Iodine value} = \frac{(b-a)\,1.269}{\text{Wt. of sample}}$$

Where a = Volume of 0.1 N sodium thiosulphate used for oil sample

b = Volume of 0.1 N sodium thiosulphate used for the blank

Acid value. (A measure of degree of esterification). 0.5 g of oil was dissolved in 5 ml of chloroform and titrated with 0.1 M NaOH solution (using phenolphthalein indicator). The acid value was calculated with the expression (Cocks and Rede 1966; Gunstone 1967 and 1969).

$$\text{Acid value} = \frac{M \times C \times V}{W}$$

M = Molecular weight of alkali

C = Concentration of alkali

V = Volume of alkali

W = Weight of oil sample

Ester value. This was obtained from the calculation, Ester Value = Saponification value - Acid value.

Yield. The yield obtained from each oil was calculated from:

$$\text{Percentage yield} = \frac{\text{Wt of concentrated oil extract}}{\text{Wt of sample material}}$$

The yields for melon seed, African oil bean and Avocado pear oil were 57.40%; 42.07% and 15.13% respectively.

Results and Discussion

Melon seeds gave the highest yield of oil 57.40% higher than that obtained using the same solvent and method (Oyolu 1971). The iodine value of melon seed (151.72) was higher than those of the African oil bean and Avocado pear. Since the iodine value measures unsaturation in the fats/oils the melon seed oil is more unsaturated, more than the other two oils (African oil bean and Avocado pear) and more susceptible to rancidity by oxidation if unprotected by antioxidants. The iodine value (151.72) is also higher than that reported for Soya beans (130.00). However, it is comparable with that reported for Sunflower seed oil (140.15) (American Oil Chemists Society OCS 1947-1957). It may not be a good substitute for industrial or domestic vegetble oil. (Soya bean and Sunflower oil) because of its high level of unsaturation however it may be used against Coronary theart diseases (Expert panel 1981; Ikediobi 1981).

The acid value of melon seed oil 4.76 is greater than those of the Avocado pear oil (0.802) and African oil bean (1.65). It is also higher than those for /Sunflower oil (0.80) and Soya bean oil (1.00), it is however greatly lower than that of the rubber seed oil (15.45). Melon oil contains more free fatty acid than Avocado oil and African oil been oil respectively. Free fatty acids indicate the possible hydrolytic degradation of the oil and the acid value is employed to ascertain the quality (condition) and edibility of the oils. Higher acid values are diagnostic indications of rancidity, which may be caused by enzymatic (Lipase) action.

The free fatty acid value of melon (2.38%) is higher than African oil bean (1.05%) and Avocado pear oil (0.79%) showings a low level of contamination by lipase secreting microbes (Free fatty acid value is an indication of lipase activity (Ukhun 1986). Fatty acid (%) has been calculated based on the molecular weight of the dominant acid. In most oils oleic acid is used as the basis of the calculation of FFA (except for palmitic and lauric acid which dominates in palm oil and the latter on palm kernel and coconut oil) (Triebold and Aurand 1963; Cocks and Rede 1966). More than 5% FFA in any oil indicates spoilage or deterioration of the oil (Berk 1976).

The melon seed oil is good for deep fat frying but its use in this regard is limited because of its high level of unsaturation.

The saponification value of the Avocado pear oil (246.70) is higher than that recorded for melon seed (197.57) and African oil bean (185.08). Saponification value measures the amount of free fatty acid present in any oil sample. The Avocado pear oil on account of its high saponification value is useful for soap production. The high ester value (241.50) is an indication of high level of ester in the oil. Specific gravity and refractive index 0.9185 and 1.4620 Avocado pear oil respectively are comparable of with these of Melon seed oil and African oil bean oil and also with that of rubber seed oil (90.925) and (1.4675).

Since the African oil bean oil has the highest smoke point, (233°C) of the three oils investigated, it can stand high temperature up to 233°C. It is therefore a very good for commercial frying operations (Smoke point). This smoke point is also higher than that of rubber seed oil (205°C). The smoke points of melon and Avocado pear 175°C and 177°C are also good for frying but of lower grade than African oil bean oil. The African oil bean seed is widely eaten in Nigeria. It has yellow colour and a pleasant flavour. Its relative viscosity is the highest of the three oils studied. This oil can be used as a lubricant especially in sewing machine components and also as body cream.

The free fatty acid value and acid value for the African oil bean (0.79%, 1.65) are the lowest of the oils studied which implies that it is the least contaminated by lipase secreting enzymes and is the best. It has higher unsaturation than Avocado pear oil but lower than melon seed oil. The iodine values are 113.00, 151.72 and 34.30 for African oil bean seed, melon seed oil and Avocado pear oil respectively, the value for the African oil bean falls within the range for corn oil, 103-178 and cotton seed oil, 99-133.

These oils showing free fatty acids lower than 5% are suitable edible oils because the lower the free fatty acids, the more appealing the oil is to smell (Annon 1963). Avocado pear oil will give harder soap than the other two oils because it has the low unsaturation (lowest iodine value).

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