Original Research Article

PHYSICOCHEMICAL PROPERTIES OF *ALCHORNEA CORDIFORLIA, CYPERUS ESCULENTUM* AND *IRVINGIA GABONENSIS* SEED OILS AND THEIR APPLICATIONS

ABSTRACT

The physicochemical properties of oils extracted from three locally available plant seeds in Nigeria namely: *Alchomea cordiforlia*, *Cyperus esculentum* and *Irvingia gabonensis* using n-Hexane were determined. The results of the analysis revealed that their % yield were 37.00, 27.50 and 33.00 for *A. cordiforlia*, *C. esculentum* and *I. gabonensis* respectively. Their odour was non-offensive and their colours were reddish, light yellow and milky white for *A. cordifolia*, *C. esculentum* and *I. gabonensis* respectively, making them bright and attractive. The specific gravity of the oils at 25^{o}c was 0.91, 0.94 and 0.92 for *A. cordiforlia, C. esculentum* and *I. gabonensis* respectively. Their flash points in ^{o}c were also 155, 159 and 229 respectively, indicating that *I. gabonensis* is the most thermally stable oil and suitable for frying. The chemical properties for *A. cordiforlia, C.esculentum,* and *I. gabonensis* respectively were as follows: Acid values in mgKOH/g were 24.67, 5.33 and 3.73. Peroxide values in mEqKg^{-1} were 7.26, 9.86 and 2.96. Saponification values in mgKOH/g were 162.13, 179.52 and 238.43. Iodine values in g/100g were 24.62, 11.68 and 3.38. These results indicate that the three seeds are viable sources of oil based on their % yield. They are good for both domestic and industrial use based on their acid, saponification and iodine values. Their properties in most cases compete favorably with palm kernel oil (PKO) which is currently being used for many domestic and industrial purposes in Nigeria especially for the making of paints, soap, cosmetics, lubricant, and varnishes.

Keywords: Physiochemical Properties, Seed oils, Applications

INTRODUCTION

Palm kernel oil is one of the most commonly used vegetable oils because its properties have been studied and known especially by researchers like Akubugwo and Ugborgu, stating that is good for soap making and the production of cosmetics, paints, varnishes industrially based on its saponification value, iodine value, etc[1]. According to Unilever [2], vegetable oils from plants like oil palm tree, groundnut, olive, beniseed *(sesame)*, soya beans, coconut, castor seed, linseed etc. plays an important role in our diet as a source of fat and oil, a major class of food required for warmth and energy in the body. Besides, some of these oils are used for the production of commodities like soaps, cosmetics, paints, varnishes, lubricants plastics, while others are used for cooking or are prepared and eaten in the form of butter or margarine. Moreover, some vegetable oils are now used as substitutes for petrol or diesel as fuel in automobiles in the form of biodiesel or bio-ethanol [3]. Medicinally, Ihesie have reported that sesame seed oil can be used to treat health problems like chronic constipation in elders, roundworms in children, dysmenorrhea (painful menstruation) in women, amenorrhea, asthmatic symptoms, coughs and hiccoughs, and insufficient flow of breast milk in nursing mothers by the oral intake of the oil up to two teaspoons at a time [4]. Akpe has also studied the physiochemical properties of *Carica papaya, Citrus paradisi*, and *Croton zambesicus* seed oils and reported that they compete favourably with palm kernel oil used for several industrial purposes in Nigeria [5].Thus, oils from plants are used for both domestic and industrial purposes all over the world based on their physical and chemical properties. Nyam and others have also studied the physicochemical properties, and bioactive compounds of oil extracted from bitter melon, Kalahari melon, kenaf, pumpkin roselle seeds and found that the oils were rich in tocopherols, with ɣ-tocopherol as the major component in all the oil samples, they also contain a great number of compounds that have a potential high value as food and for production of non-food products [6]. Neagu and his team have also worked on the physicochemical properties of sunflower oil, corn oil, rapeseed oil, and peanut oil, and reported that their properties were within the requirements of food domain and their density correlated with other properties of edible oils [7]. Kalias and his group have researched the physicochemical properties of soybean, castor, groundnut, cottonseed oils and their blends, and the results showed that higher viscosity and lower acid value of castor oil blends in soybean oil suggest that they can be directly used as an alternative for lubricant for mineral oil based lubricants [8]. Serjouie and his team have also studied the effect of vegetable-based oil blends on physicochemical properties of oils during deep-fat frying and stated that the properties of the oils were significantly influenced by the type and concentration of the component oils [9]. Zahir and his group also investigated the physicochemical properties of edible oils and evaluated their frying quality using FT-IR spectroscopy, and the results revealed that due to the temperature change in the oils, there is a notable difference in the spectral band which showed that the proportions of fatty acids were changed [10]. Angaye and Maduelosi studied the physicochemical properties of some brands of edible oils namely; Turkey, Grand, Gino, Tropical, Power, Mammador, local vegetable oil and raw/locally extracted groundnut oil sold in some supermarkets and open markets in Port-Harcourt, Nigeria, and compare the results with standards and found that oils sold in supermarkets are better protected from light-induced oxidation than those sold in open markets [11]. Based on the facts so far, the importance of vegetable oils to man cannot be over emphasised and their economic value unquantifiable. However, it is observed that the oil plants or crops mentioned above are a small percentage of the several hundreds of plants in nature whose oil potentials have not been discovered, even some that have been identified as oilseed crops are being underutilized because their oil properties and potentials have not been properly studied to ascertain their suitability for use domestically and or industrially. Consequently, this study is aimed at determining the physicochemical properties of oils extracted from *Alchornea cordiforlia* (Christmas bush) which is a shrub belonging to the family *Euphorbiaceae, Cyperus esculentum* (Tiger nut or yellow nutsedge) which is a crop of the family *Cyperaceae* and *Irvingia gabonensis* (Bush, wild or African mango) which is a tree of the family *Irvingiaceae,* all of which are found locally in Obudu Area of Cross River State and many other parts of Nigeria, Africa and some other countries of the world, especially the tropics and have not been properly studied. This is with a view to determining their potentials and properties as sources of vegetable oil for domestic and industrial uses, and also compare their properties with the established properties of palm kernel oil from *Elaeis guinensis* (palm tree) which is popularly in use now.

MATERIALS AND METHOD

Sample collection and preparation: Viable or healthy seeds of *Alchornea cordifolia* (Christmas bush), *Cyperus esculentum* (Tiger nut) and *Irvingia gabonensis* (Bush mango) were collected locally from Obudu Area of Cross River State of Nigeria between February and March, and were taken to the Department of Botany, University of Calabar for identification of botanical names and labeling. The samples were then taken to the Chemistry Department of the same University where they were shelled or de-hauled (where applicable), sun-dried for several days, wrapped in polythene bags and kept for use within one month. Each of the samples was crushed or ground into a paste using a manual grinding machine. 100 g of the paste of each sample was packed in an ashless filter paper and placed in the thimble of a Soxhlet apparatus (extractor) and extracted using N-hexane as the extracting solvent. At the end of the continuous extraction for about 5 to 6 hours, the extracting solvent was evaporated off leaving the oil sample for analysis. The percentage yield of the oil extract of each sample was determined thus:

$$\%\, yield = \frac{weight\ of\ oil}{weight\ of\ sample} \times 100\%$$

Sample analysis: The specific gravity of the oils was determined according to the method reported by Onwuka [12] thus: A 50 mL pycometer bottle was washed with water and detergent, rinsed and dried. The bottle was filled with distilled water and weighed. After drying the bottle of water, it was filled with the oil sample and weighed, at the room temperature of 25^{o}c. The specific gravity was calculated thus:

$$Specific\ gravity = \frac{weight\ of\ 50mL\ of\ oil}{weight\ of\ 50mL\ of\ water}$$

The colour, state at room temperature and the odour were observed and perceived using the human sense organs. The flash point of the oil samples was determined following the procedure reported by Onwuka [12] thus: 10 mL of the oil was poured into an evaporating dish and placed on a source of heat. A thermometer was suspended at the centre of the dish ensuring that its bulb dips inside the oil without touching the bottom of the dish. The temperature of the oil was raised gradually by regulating the source of heat. The point at which the oil began to give off a thin bluish smoke continuously (i.e. smoke point), a flame was applied using a match-stick. The temperature at which the oil started flashing when the flame is applied without supporting combustion was noted as the flash point of the oil.

The acid value was determined following the method of AOAC [13] as reported by Onwuka [12] thus: 1.0 g each of the oils was dissolved in a mixture obtained by mixing 25 mL diethylether and 25 mL ethanol, and titrated with 0.1M NaOH using phenolphthalein as an indicator, shaking till a pink colour end point which persisted for 15 seconds was observed. The acid value and % free fatty acids were calculated as follows:

$$Acid\ Value = \frac{Titre\ volume(mL) \times 56.1 \times M}{weight\ of\ sample}$$

Where, M is the molarity of NaOH (0.1M).

Acid value is expressed in milligram KOH per gram (mgKOH/g).

$$\% \, free \, fatty \, acid = \frac{1}{2} \times Acid \, value$$

The saponification value was determined using the method of AOAC [13] as described by Onwuka [12] thus: 1 gram of the oil was weighed into a round bottom flask and 24 mL of alcoholic potassium hydroxide solution was added. A reflux condenser was attached to the flask and heated on a sandbath for 1 hour shaking frequently. One mL of phenolphthalein (1%) solution was added and titrated while hot with 0.5M HCl to a colourless end point. A blank titration was also carried out the volume at end point recorded. The saponification value was calculated thus.

$$Saponification \, value = \frac{(X - Y) \times 56.1 \, M}{Weight \, of \, sample}$$

Where X = volume (mL) of test solution titration

Y = volume (mL) of blank titration

M = Molarity of HCl (0.5)

The peroxide value was determined using the method of AOAC [13] as described by Onwuka [12] thus: 1 ml of potassium iodide (KI) was added to 20 mL of a solution of mL of (2:1) volumes of glacial acetic acid and chloroform. The result out solution was added to 1.0 g of the oil sample in a clean dry conical flask. The mixture was left in a dark for about 2 minutes and 30 mL of distilled water was added and titrated with 0.02M sodium thiosulphate solution using 5 mL starch as indicator. A blank titration was also carried out. The peroxide value was calculated thus:

$$Peroxide\ value\ =\ (100M\ (Va - Vb)/W$$

Where W = weight of oil sample

Va = volume in Ml of thiosulphate used in test solution

Vb = volume in mL of thiosulphate used in blank solution

M = molarity of sodium thiosulphate (0.02).

The iodine value was determined using Wij's method as described by Onwuka [12] thus: 0.5 g of the oil sample was poured into a beaker and 10ml of carbon tetrachloride was added, 20 mL of Wij's solution was added and a stopper previously moisten with potassium iodide was inserted and allowed to stand in the dark for 30 minutes. 15mL of potassium iodide solution (10%) was added and titrated with 0.1M thiosulphate solution using starch as indicator. A blank titration was also carried out. The iodine value was calculated thus:

$$Iodine\ value\ =\ \frac{(b - a)\ \times 12.69M}{weight\ of\ sample}$$

Where a = volume in mL of test titration

b = volume in mL of blank titration

M = molarity of thiosulphate (0.1)

RESULTS: The results of the physical and chemical properties are presented in Table 1 and 2 respectively

Table 1: Physical properties of *Alchornea cordiforlia, Cyperus esculentum* and *Invingia gabonensis* seed oils.

	% yield	Specific gravity	Flash point (°C)	State at 25°c (Room temperature)	Colour	Odour
Alchornea cordiforlia	37.00±1.50	0.91±0.01	155.00± 2.00	Semi-solid	Reddish	Non-offensive
Cyperus esculentum	27.50± 2.01	0.94± 0.02	159.00± 2.50	Liquid	Light yellow	Non-offensive
Invingia gabonensis	33.00± 2.00	0.92± 0.02	229.00± 2.00	Waxy solid	Milky white	Non-offensive

Values reported in mean ± SD, with N = 3

Table 2: Chemical properties of *Alchornea cordiforlia*, *Cyperus esculentum* and *Invingia gabonensis* seed oils

Seed oil	Acid value in mgKOH/g	% free fatty acids	Peroxide value in $mEqKg^{-1}$	Saponification value in mgKOH/g	Iodine value in g/100g
Alchornea cordiforlia	24.67±1.25	12.34±1.30	7.26± 0.12	162.13± 2.50	24.62± 1.50
Cyperus esculentum	5.33± 0.15	2.67± 0.10	9.86± 0.15	179.52± 3.00	11.68± 1.25
Invingia gabonensis	3.73± 0.13	1.87± 0.11	2.96± 0.02	238.43± 2.50	3.38± 0.15

Values reported in mean ± SD, with N = 3

DISCUSSION

The percentage yield in Table 1 revealed that *A. cordiforlia* (37.00%), *C. esculentum* (27.50%) and *I. gabonensis (33.00 %).* This shows that *A. cordiforlia* has the highest yield, followed by *I. gabonensis* while *C. esculentum* has the lowest % yield. However, these values compete favorably with palm kernel oil with a % yield of 28% as reported by Akubugwo and Ugborgu [1], with *A. cordiforlia* and *I. gabonensis* even better as their values are higher than that of palm kernel oil that is commonly used. Thus, the 3 seed plants can be used as good sources of vegetable oil.

The flash point is the temperature at which volatile evolving from the heated oil will flash but not support combustion. It measures the thermal stability of the oil [12]. It is also an indicator of the suitability of the oil for frying [5]. The results in Table 1 show that the flash points in ^{o}c were 155, 159 and 229 for *A. cordiforlia, C. esculentum* and *I. gabonensis* respectively. These results indicate that *I. gabonensis* oil is a better frying oil and more thermally stable oil than *C. esculentum* and *A. cordiforlia* respectively.

The specific gravity (relative density) values of the oils were 0.91, 0.94 and 0.92 for *A. cordiforlia, C. esculentum* and *I. gabonensis* respectively, all higher than 0.88 reported for palm kernel oil by Akubugwo and Ugborgu [1], which is commonly used industrially. All the oil samples were non-offensive in their odour, *A. cordiforlia* was reddish in colour, *C. esculentum* was light yellow and *I. gabonensis* milky white in colour. This makes the oil attractive and appealing. Their state at room temperature was semi-solid, liquid and waxy solid for *A. cordiforlia, C. esculentum* and *I. gabonensis* respectively. This also competes with palm kernel oil (PKO) which is semi-solid as reported by Akubugwo and Ugborgu [1].

The chemical properties of the studied oils are reported in Table 2. The results showed that the acid values of the oils were 24.67, 5.33 and 3.73 for *A. cordiforlia, C. esculentum* and *I. gabonensis* respectively. Also, the % free fatty acids were 12.34, 2.67 and 1.87 for *A. cordiforlia, C. esculentum* and *I. gabonensis* respectively. All these values are less than PKO with an acid value of 14.04 [1]. Acid value is an indicator for edibility of oil and suitability for use in the paint industry. *C. esculentum* and *I. gabonensis* oil are edible going by their free fatty acid value of less than 3 [14] as cited by Akpe [5]. They can also compete favorably with sesame, soya bean, sun flower and rapeseed oils with acid value of about 4 as reported by Pearson [15]. Thus, the two oils with the least acid values of 5.33 and 3.37 can be consumed directly (i.e. *C. esculentum* and *I. gabonensis* respectively). Besides, these values compete favourably with CODEX Standard Acid values for cold pressed palm oil and virgin palm oil which are 4.0 and 10.0 mgKOH/g respectively, and are consumed directly [16].

The peroxide values of the oils were 7.26, 9.86 and 2.96 for *A. cordiforlia, C. esculentum* and *I. gabonensis* respectively. It is an indicator for the deterioration of oils. Fresh oils have values less than 10 $mEqkg^{-1}$ and rancid oils have values ranging from 20 to 40 [12]. It is also an indicator for longer and shorter shelf life during storage, as fresh oils last longer [17]. Thus, all the 3 seed oils are fresh oils and they compete favourably with 2.12 $mEqKg^{-1}$ reported for PKO by Akubugwo and Ugborgu [1].

The saponification value is an indication that the oils have potential for use in the industry when values are high especially for soap and cosmetics [18]. Its values for the oils were 162.13, 179.52 and 238.43 for *A. cordiforlia, C. esculentum* and *I. gabonensis* respectively. *I. gabonensis* with the highest value has the best potential for industrial use and compete with PKO that has a value of 246.60 [1].

The Iodine values of the oils were 24.62, 11.68 and 3.38 for *A. cordiforlia, C. esculentum* and *I. gabonensis* respectively. These values indicates that all the three oils are non-drying oils because their values are less than 100, those with values between 100 and 150 are semi-drying oils while those greater than 150 are drying oils [19]. This non-drying character qualifies them for use in the paint industry [20]. However, the oils compete favorably with PKO which is also non-drying oil with an iodine value of 18.30 as stated by Akubugwo and Ugborgu [1]. Based on their iodine values, the storage procedure should ensure protection from oxidative rancidity or deterioration as they contain an appreciable level of unsaturated bonds.

Finally, the variations in the physical and chemical properties of the oils were already expected because the plants used to belong to different families or genera. However, the purpose of the study was to determine their oil properties and compare them based on their suitability for domestic or industrial applications, and not the oils generally.

CONCLUSION

At the end of this study, the 3 oilseeds can be classified as high yielding based on the % yield. *C. esculentum* and *I. gabonensis* are suitable for direct consumption by their free fatty acid value. Their iodine and saponification values show they are suitable for the industrial production of soaps, cosmetics, paints etc. Their colours are bright and attractive while their odours are non-offensive. Most of the physicochemical properties of the three seed oils studied compete favorably with palm kernel oil (PKO) and conventional seed oils like groundnut oil, soya bean, rapeseed, castor seed, etc. One can, therefore, recommend that the 3 seed oils have potentials for development and use for domestic and industrial purposes.

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