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Comparative Study of the Physicochemical Properties and Fatty Acid Composition of Some Indigenous Spices in Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author CUON carried out the experimental design conducted the experiment and wrote the first draft of the manuscript. Author FUI carried out the statistical analysis and corrected the final format and author KOO provided the literature search. All authors read and approved the final version of the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

Aim: This study evaluates the physicochemical properties and fatty acid composition of "Gbafilo" *(Uapaca guineesis)*, "Omilo" *(Parinari excelsa)*, "Country onion" *(Afrostyax lepidphyllus)*, and "Taiko" *(Zanthoxyllum zanthoxylloids)*.
Methods: The oil was extracted using n-hexane in a soxhlet apparatus and evaluated for their physical and chemical properties. Fatty acids profile was determined by Gas Chromatography (GC).
Results: The Refractive Index, Specific gravity and Oxidative stability values range between 1.44-1.46, 0.930-.0970, 40-72hr, respectively; While Iodine, Acid, Ester and Saponification values range between 94.14-105.20 I_2/100g, 2.58-19.25mgKOH/g, 164.28-231.14mgKOH/g and 170.92-

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233.72mgKOH/g, respectively. Oleic acid was the predominant fatty acid in Omilo (92.98%) and Country onion (72.73%); While palmitic acid was predominant in Gbafilo (30.45%) and Taiko (28.09%). Linoleic acid was present only in Country onion (12.84%) and Omilo (2.04%).
Conclusion: These results suggest that the oil from these spices have potentials for use as food supplements and industrial raw materials in addition to their traditional use as condiments.

Keywords: Physicochemical properties; fatty acids; indigenous spices; n-hexane.

1. INTRODUCTION

Edible plants have been reported to provide oils especially the ∝-linolenic acid and several mono and polyunsaturated fatty acids. Oil extracted from plants are important both for their application as nutrients in foods and as industrial raw materials [1]. The characteristics of oils from different sources depend mainly on their compositions and since no oil from a single source can be suitable for all purposes [2], the study of their constituents becomes important. Despite numerous studies carried out on the nutritional and medicinal properties of spices [3,4,5] as well as changes in their physicochemical composition [6,7,8], more researches are required especially with some under utilized spices known to be rich in a wide variety of fauna and flora and are commonly found around the Niger Delta region of Nigeria. This is necessary as most of these indigenous spices could become extinct if not adequately explored, utilized and documented. The indigenous spices namely "Omilo" (*Parinari excelsa*), "Country onion" (*Afrostyax lepidophyllus*), "Gbafilo" (*Uapacca guineeasi*) and "Taiko" (*Zanthoxyllum zanthoxyloides*) are common rain forest trees commonly found in Gabon, Tanzania, Senegal, Cameroon, Uganda, France, Liberia, Ghana and in Nigeria. A brief description of these spices is shown in Table 1 below. The present study evaluates the physicochemical properties and fatty acid profile of the oil extracted from these spices.

2. MATERIALS AND METHODS

2.1 Material Preparation

The spices were obtained from the herb shop at Mile 3 Market in Port Harcourt, Rivers State, Nigeria. Samples were sundried. The dried samples were separately ground in a Kenwood food processor, Mode 967, England, then sieved to 300mm mesh. The sieved spices were placed in an airtight container and stored in a desiccator at a temperature of about 25ºC until ready for analyses.

2.2 Lipid Extraction

Oil was extracted from the sieved samples in a soxhlet apparatus with n-hexane for 8hrs. The oil was then recovered by evaporating the solvent using rotary evaporator [13]. The oil obtained was stored in an amber bottle and the percentage yield was calculated as:

$$Oil\ content\ (\%) = \frac{Volume\ of\ the\ oil}{Weight\ of\ sample} \times 100\%$$

2.3 Physicochemical Analysis

2.3.1 Physical parameters

2.3.1.1 Colour

The colour of the oil was determined using a Lovibond tintometer. A clear molten liquid was poured into a beaker on a steam bath and warmed to 60ºC. The liquid was stirred with the thermometer until the sample showed colour [14].

2.3.1.2 Oxidative stability (Hrs)

The oxidative stability index, defined as the time required for oil sample to develop measurable rancidity, was determined using a Racimat instrument (Metrohm Ltd. Herisau, Switzerland) following the American method Cd 12b – 92 [14]. Oxidation was carried out at 100ºC with an air flow rate of 20 litres/hour.

2.3.1.3 Refractive index

The refractive index of the spices oil at a temperature of 28ºC was determined using Carl Zeiss 110849, West Germany. The oil drop was placed on the slide and directed towards a source of light. It was then observed through the lens after adjustment had been made to give a semi-circle on the glass prism in the refractometer. The reading was then taken.

Table 1. Brief description of the spices

Botanical name	Common name	Origin	Family	Uses
Uapacca guineensis	*Gbafilo Nderite* Sugar Plum Red cedar *Rikio* Paleturier rivier	Delta, Nigeria Ikwerre, Nigeria English English Liberia French	*Euphorbiaceae (phyllanthaceae)*	- Seeds are used as condiments - Roots are used for treatment of impotency in men. Stem bark, leaves and roots relieves headache and general pain. The root bark can also treat leprous sores and taken as tonic by women who have just given birth [9].
Parinari excels	Guinea plum Mobola plum	English English	*Chrysobalanceae*	- Treatment of malaria - Epilepsy, diarrhea [12]
Aprostyrax lepidophyllus	Country onion	English	*Hauceae*	- Seeds are used as spice in the traditional African cuisine and for medicinal purposes [11].
Zanthoxyllum zanthoxyloides	Toothache bark Candle wood Tagra jaaune	English Senegal French		- The root is commonly used as chewing stick. The root and stem bark are used for malaria treatment, fever and sickle cell anaemia. - Seed used as condiments [10]

2.3.1.4 Smoke point (ºC)

Smoke point was determined by placing 20ml of oil sample into a stainless steel crucible. A thermometer was inserted in the oil sample and the crucible with the oil was heated under strict temperature regulation using a thermostat - equipped hot plate.

2.3.1.5 Specific gravity

Oil samples (10cm^3) was measured in a pre-weighed measuring cylinder. The weight of the cylinder and oil were measured, the weight of the oil was then obtained by subtracting the weight of the cylinder from the weight of the oil and cylinder. The specific gravity of oil was obtained using the relationship:

$$Specific\ gravity = \frac{Density\ of\ water\ used}{Density\ of\ oil\ used}$$

2.3.2 Chemical Parameters

The chemical parameters namely; Free fatty acid, percentage oil yield as well as acid, peroxide, saponification, esterification and iodine values were determined using standard methods [15].

2.4 Fatty Acid Profile

Fatty acid profile of the seed oil of these spices was determined using NUCON series 5700 gas chromatography equipped with the flame ionization detector and stainless steel packed column, having internal diameter 2 mm and length 2.0 cm. About 0.1 ml of the oil was converted to the methyl ester by using the boron-trifluoride and extracted in 1ml hexane before being injected into the gas chromatography. The detector temperature was programmed from 70ºC to 200ºC with the increasing rate of temperature 6ºC/min. Nitrogen was used as the carrier gas. Hydrogen and air flow used were 40ml/min and 60ml/min respectively. The peak was identified by measuring the retention time of the samples and comparing it with the standard under the same operating conditions.

2.5 Statistical Analysis

All data were analyzed using the analysis of variance. When analysis of variance revealed a significant effect, means were separated using Duncan's new multiple range test [16].

3. RESULTS AND DISCUSSION

3.1 Physicochemical Analysis

Table 2 reports the physical properties of the seed oil of these indigenous spices. The refractive index values obtained for the spices range from 1.44 (Country onion) to 1.46 (Omilo), the values did not show any significant ($P \geq 0.05$) difference. The high refractive index of these oils confirms the high number of carbon atoms in their fatty acids [8]. Refractive index values corroborates the report of Justyna [17] as reported for conventional oils from soybean (1.466) and Palm kernel (1.449). The specific gravity for Omilo (0.932) and Country onion (0.930) were significantly ($P \leq 0.05$) different from the values obtained for Gbafilo (0.960) and Taiko (0.970). However, there was no significant ($P \geq 0.05$) difference observed for Gbafilo and Taiko. The values for Omilo and Country onion are closer to 0.939 as reported for neem seed [18]. The values obtained for refractive index and specific gravity showed that Omilo and Country onion can be classified as a semi drying oils. A drying oil is an oil that hardens to a rough, solid film after a period of exposure to air. Such oils are easily oxidized and are often unstable for cooking as well as being susceptible to becoming rancid due to autoxidation (the process by which fatty foods develop off flavours). Drying oils are key components of oil paints and some varnishes [19]. The smoke point value for Omilo (148ºC) and Country onion (147ºC) does not differ significantly ($P \geq 0.05$). There was a significant ($P \leq 0.05$) difference between Gbafilo (132ºC) and Taiko (140ºC) as well as with the other spices. The smoke point of these spices is lower when compared with the report of Justyna [17] for groundnut oil (213.5ºC). The oxidative stability which is the time required for the oil samples to develop measurable rancidity was significantly ($P \leq 0.05$) different for all spices. However, longer times were observed for all spices compared with that of soybean oil and are comparable to that of *Carica papaya* [20]. Considering the smoke point and the oxidative stability values for Omilo and Country onion, their oils may not be very suitable for deep frying in spite of their acceptable nutritional qualities. But Gbafilo and Taiko can be recommended for deep frying [19]. The spices maintained light yellow to yellow colour.

The oil yield and chemical properties of these seed oil are reported in Table 3. The percentage oil yield for Omilo was significantly ($P \leq 0.05$) higher than the other spices. The high oil content found in Omilo seed may be economically attractive for industrial extraction. The free fatty acid content reported for the spices were significantly ($P \leq 0.05$) different. The amount of free fatty acid recorded for Taiko (10.24%) was higher than the rest. FAO/WHO [21] reported that the lower the free fatty acid content, the higher the smoke point. This statement conforms to the results obtained for these spices. The spices have high iodine value ranging from 94.14 (Taiko) to 105.20 I_2/100g (Country onion). These values agree with the level of unsaturation present in the various seed oils. The values compared favourably to iodine value of seed oil of *Telfaria occidentalis* [22] and white and red *Sesamum indicum* seed [23] as well as seed oil of *Jatropha curcas L*. [24]. The iodine values obtained from these oil seeds can serve in industries as control method for hydrogenation, biodiesel production and in assessing oxidative stability. The saponification value range from 170mgKOH/g (Country onion) to 233.72mgKOH/g (Omilo) and these values differ significantly ($P \leq 0.05$). The high saponification values of these spices indicates high content of triacylglycerol and is consistent with the high esterification values (164.28 – 231.14 mgKOH/g). These values indicate that the seed oils have potential to be used in the cosmetic industry for soap making. The low acid value observed for Omilo (2.58mgKOH/g) and Country onion (3.69mgKOH/g) indicates that the triacylglycerols have not been hydrolyzed, a sign of good stability. The acid values for these seed oils differ significantly ($P \leq 0.05$). The values fell within the acceptable range of 0.00 to 4.00mg/KOH/g [22]; Therefore, these seed oils are suitable for consumption contrary to Gbafilo and Taiko with high acid values. The high acid value corresponds to high free fatty acids recorded for both Gbafilo and Taiko. The peroxide value is an index of rancidity. Thus, the peroxide value for Omilo (9.42 $mEqO_2$/kg) is within the acceptable value of 10$mEqO_2$/kg [25]. Oil seeds of Gbafilo and Taiko had high peroxide values, suggesting that these oils will be prone to rancidity. The percentage oil yield for Omilo was significantly ($P \leq 0.05$) higher than the rest. The high lipid content found in Omilo seed may be economically attractive for industrial extraction.

Fatty acids composition of Omilo, Country Onion, Gbafilo and Taiko are presented in Table 4. The major fatty acid in Omilo (92.98%) and country onion (72.73%) is oleic acid. While Gbafilo (39.45%) and Taiko (28.09%) showed high content of palmitic acid. Linoleic acid was present only in Country onion (12.84%). High content of monounsaturated fatty acids was found in the oils of Omilo and Country onion. The fatty acid composition of both Omilo and Country onion showed high content of oleic acid like those of olive oil (71%) and Carica papaya oil that have 71% and 71.3% respectively [22]. Recent evidence suggests that diets rich in monounsaturated fatty acids can lower Total and LDL-cholesterol levels when substituted for saturated fatty acids in the diet [26]. Therefore, consumption of monounsaturated fatty acids may play a preventive role in the battle against coronary heart disease. Monounsaturated fatty acid are slower to undergoing drying because the allylic radical intermediates are less stable compared with polyunsaturated fatty acids which are susceptible to oxidation [19,27]. Gbafilo and Taiko are moderately rich in saturated fatty acids and may not be good sources of dietary fat since saturated fatty acids in the diet raise blood cholesterol and LDL-cholesterol levels [26].

Table 2. Physical properties of the seed oils

Physical Parameters	Values for oil			
	Omilo	**Country onion**	**Gbafilo**	**Taiko**
Refractive index at 28ºC	$1.46^{a} \pm 0.00$	$1.44^{a} \pm 0.01$	$1.45^{a} \pm 0.00$	$1.45^{a} \pm 0.00$
Specific gravity at 28ºC	$0.932^{a} \pm 0.01$	$0.930^{a} \pm 0.00$	$0.960^{b} \pm 0.01$	$0.970^{b} \pm 0.00$
Smoke point (ºC)	$148^{c} \pm 1.22$	$147^{c} \pm 0.42$	$132^{a} \pm 2.14$	$140^{b} \pm 1.31$
Oxidative stability (hrs)	$72^{c} \pm 1.14$	$63^{b} \pm 0.00$	$40^{a} \pm 0.00$	$42^{a} \pm 0.00$
Colour	Light yellow	Yellow	Light yellow	Yellow

Values are means ± SD of triplicate determinations. Means in the same row not followed by the same superscript differ significantly ($P \leq 0.05$).Note: a is the least value, increases via b to the highest c

Table 3. Chemical properties of the seed oils

Chemical Parameters	Values for oil			
	Omilo	**Country onion**	**Gbafilo**	**Taiko**
Iodine value (I_2/100g)	$103.40^{b} \pm 1.14$	$105.20^{b} \pm 0.00$	$96.12^{a} \pm 2.22$	$94.14^{a} \pm 1.24$
Saponification value (mg KOH/g)	$233.72^{d} \pm 0.00$	$170.92^{a} \pm 2.19$	$222.40^{c} \pm 2.00$	$216.45^{b} \pm 1.99$
Esterification value (mg KOH/g)	$231.14^{d} \pm 0.12$	$164.28^{a} \pm 1.14$	$209.73^{c} \pm 1.19$	$197.20^{b} \pm 0.98$
Acid value (mg KOH/g)	$2.58^{a} \pm 0.00$	$3.69^{a} \pm 0.04$	$12.68^{b} \pm 1.03$	$19.25^{c} \pm 1.01$
Peroxide value (mEqO_2/kg)	$9.42^{a} \pm 0.00$	$9.62^{a} \pm 0.10$	$33.94^{b} \pm 0.06$	$39.02^{b} \pm 0.02$
Free fatty acid (%)	$2.46^{a} \pm 0.02$	$6.25^{b} \pm 0.00$	$10.24^{d} \pm 0.11$	$8.49^{c} \pm 0.00$
Oil content yield (%)	$61.12^{c} \pm 1.40$	$9.71^{a} \pm 0.00$	$12.37^{a} \pm 0.98$	$21.36^{b} \pm 0.00$

Values are means ± SD of triplicate determinations. Means in the same row not followed by the same superscript differ significantly ($P \leq 0.05$). Note: a is the least value, increases via b,c to the highest d

Table 4. Fatty acid profile

Fatty Acids	Relative Percentage (%)			
	Omilo	**Country onion**	**Gbafilo**	**Taiko**
Caprylic acid (8.0)	ND	1.12 ± 0.11	2.68 ± 0.41	7.44 ± 0.22
Capyric acid (10.0)	ND	4.55 ± 0.72	4.19 ± 0.11	10.64 ± 1.02
Lauric acid (12.0)	2.95 ± 0.31	3.13 ± 0.42	5.38 ±1.14	7.46 ± 0.36
Myristic acid (14.0)	0.41 ± 0.01	ND	ND	ND
Myristoleic acid (14.1)	1.65 ± 0.03	5.73 ± 0.78	35.68 ± 1.14	20.99 ± 1.13
Palmitic acid (16.0)	ND	ND	39.45 ± 1.16	28.09 ± 1.02
Palmitoleic acid (16.1)	ND	ND	ND	12.06 ± 1.02
Oleic acid (18.1)	92.98 ± 2.40	72.73 ± 1.17	12.67 ± 0.00	13.14 ± 0.03
Linoleic acid (18.2)	2.04 ± 0.31	12.84 ± 0.02	ND	ND
TSF	3.36	8.80	51.70	53.63
TUSF	96.67	91.30	48.35	46.19

Mean value ± standard deviation (n=3). TSF → Total Saturated Fatty acids, TUSF → Total Unsaturated Fatty acids

4. CONCLUSION

The study of the seed oil of these spices showed that the spices had moderate to high oil contents. The physicochemical properties of Omilo and Country onion are similar to those of conventional seed oils. The high proportion of unsaturated fatty acids observed for Omilo and Country onion make these oils acceptable substitute for other highly unsaturated fats. Omilo and Country onion can, therefore, be used as food supplements for edible oils besides their uses as condiments whereas Gbafilo and Taiko can serve both for deep frying as well as primary sources for oil paints and varnishes.

COMPETING INTEREST

The authors have declared that no competing interest exist

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