Chemical and Physical Analyses of Oils from Four Species of Cucurbitaceae

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The seed oils of *Cucumeropsis mannii*, two varieties of *Lagenaria sicceraria* and *Telfairia occidentalis* were evaluated. The oil contents by mechanical expression were 33.2%, 33.4%, 34.2% and 32.8% from the roasted kernels of *C. mannii*, *L. sicceraria* var. 1, *L. sicceraria* var. 2 and *T. occidentalis*, respectively. Lower oil contents (26.4–28.6%) were obtained from unroasted kernels of the species. The difference in oil yield between the unroasted and roasted kernels was significant ($p \leq 0.05$). Roasting of the kernels did not affect the quality factors of the oils, except for the color. The color of oil from roasted kernels was golden, whereas that from unroasted kernels was pale yellow. The predominant fatty acids were palmitic, stearic, oleic and linoleic. The oils from the varieties of *L. sicceraria* were more unsaturated (80.2–80.3%) than the oils from *C. mannii* (71.4%) and *T. occidentalis* (69.3%). The smoke (149.5–180.1°C) and flash (204.8–291.5°C) points varied considerably among the oils. *Cucumeropsis mannii* and *T. occidentalis* kernel oils failed a cold test, while the oils from *L. sicceraria* passed.

KEY WORDS: Cold test, cucurbit oils, fatty acids, smoke-flash point.

The term "virgin" for fats and oils means that the edible vegetable fats and oils have been obtained by mechanical procedures and the application of heat only, they may have been purified by washing with water, settling, filtering and centrifuging only (1).

The equipment widely used in processing oilseeds over the years include the cage-type press or hydraulic cylinder, the screw press and solvent extraction. Bredeson (2) reported that the mechanical screw press was the principal means of extracting vegetable oilseeds in the United States from the 1930's through the 1950's. The vegetable oil processing industries in Nigeria are limited to a few oilseeds, namely palm fruit, palm kernel, cottonseed, groundnut and, recently, coconut and soybean. These conventional sources of vegetable oil no longer meet the ever increasing demand for vegetable oil for domestic and industrial purposes in Nigeria. Therefore, the need exists to look inward for other sources to supplement the supplies. The seeds of some species of Cucurbitaceae, mainly melon, have been reported by several authors (3–10) as oil sources with oil contents comparable to those from conventional sources. There are also lesser-known species of Cucurbitaceae for which the potential and oil quality have not been studied.

The dual purpose of this study was to compare the oil yield, from unroasted and roasted kernels of some lesser-known species of Cucurbitaceae, obtained by a manually operated cold press, and to assess some of the quality factors of the oils with a view to predicting other uses.

MATERIALS AND METHODS

Source of material and preparation. The dried seeds of white melon [*Cucumeropsis mannii* Naud (Cult.) syn *Cucumeropsis edulis* (Hook. f.)], gourd varieties 1 and 2 [*Lagenaria sicceraria* (Molina) Standley], and fluted pumpkin [*Telfairia occidentalis* (Hook. f.)] used for this investigation were obtained from the local markets at Ogwashi-Uku and Benin City in Bendel State, Nigeria. Morphologically, the seed of *L. sicceraria* var. 1 is flat, dark brown in color, and assumes a rectangular shape with compressed, cotton-like (soft) and serrated edges on the longer, opposite sides. The seed of *L. sicceraria* var. 2 is light brown, long and assumes a hydra-like shape. The seeds were shelled by cracking them with a small iron rod, followed by splitting manually to remove the kernels. The kernels were packed in polyethylene bags which were put into a tin container with a lid, and stored at −20°C until used.

Treatment and extraction. The kernels were roasted and treated as described by Ogunsua and Badifu (11). The flaked kernels (1 kg) were put into a muslin bag and pressed in a manually operated cold press (Hafi Co., Gezang, Amsterdam, The Netherlands). The oils obtained were filtered through a clean, dry, white piece of cloth spread inside a Buckner funnel (Royal Worcester Porcelain, Essex, UK) connected to a suction pump. They were dried after the determination of moisture content, weighed and put in glass containers under nitrogen. They were stored at −20°C. Samples were drawn for studies. The unroasted kernels were treated in the same manner. Data obtained were analyzed statistically (12).

Chemical analysis. Moisture content from using an air-oven at 105 ± 1°C, crude fat, peroxide value, saponification value, refractive index and specific gravity were determined as described by AOAC (13). Acid value and iodine value (Wijs' method) were determined according to the procedure of Pearson (14). The unsaponifiable matter was determined as described by Hudson (15). Smoke and flash points were carried out by the procedure of Mehlenbacher (16). Iron content was determined according to the FAO/WHO Codex Alimentarius Commission (1).

GLC analysis. About 0.300 g of oil sample was weighed and converted into methyl esters by the method of Metcalfe *et al.* (17). The fatty acid methyl esters were analyzed by GLC under the operating conditions previously reported (11).

Color evaluation. Color was determined as described by Badifu (18). The Lovibond Tintometer model E was used. About 3 mL of oil were put into a glass cell (100 OG), which was placed in the light path of the system against a white background. The color of the oil was matched with standard colors on slides and the corresponding values on the slides were recorded.

Cold test. A slight modification of the method described by Dugan (19) was used for cold tests. Ten grams of oil in a glass bottle with a cap were held in an ice-bath (2–3°C) for 7.5 hr. Afterwards, the bottle was removed and immediately cleaned, and the oil was examined visually for any development of cloudy appearance.

RESULTS AND DISCUSSION

Oil yield. The oil yields from the unroasted and roasted kernels are presented in Table 1. The oil yield from roasted kernels was higher than that from unroasted kernels. Analysis of variance showed that the difference was significant at the 5% probability level. Singh and Yadava (20) reported a range of mean values (17.99–34.38%), obtained by solvent extraction, for some fresh seeds of the genus *Citrullus* of the Cucurbitaceae family. However, Chisholm and Hopkins (8) and Ige *et al.* (21) reported oil yields of 51.1% for *L. sicceraria* and 43.7% for *C. edulis*, respectively, as obtained by solvent extraction. Chisholm and Hopkins (8) reported 61.0% oil, by solvent extraction, for *Telfairia pedata* Hook. f. It is generally recognized that the oil yield by solvent extraction is higher than the value obtained by mechanical expression. Roasting reduced the moisture content of the kernel and this led to easily ruptured cell walls. The net effect was the destruction of the natural compartmentalization of oil in spherosomes within the cell. Heating also denatures protein and allows the release of more oil from the kernel (22). The flaking effect of the roller mill improved the flow of oil out of the matrix. These factors likely influenced the observed difference in oil yield between unroasted and roasted kernels.

Badifu (18) reported the oil yield obtained by solvent extraction of these oilseeds to range from 42% to 47%. By comparison, the oil yield obtained by mechanical expression of the same oilseeds was lower. However, mechanical expression of oil from oilseeds can be managed easily by most tropical countries, such as Nigeria. In Nigeria, the cake obtained could be used for food in different consumable forms without toxicity resulting from processing of the kernels. This might be quite unlike solvent extraction, where the technology of removing the residual solvent from the oil and meal could be too expensive.

TABLE 1

Oil Yield (% w/w) of the Kernels of Four Cucurbit Species

Species[a]	Unroasted kernels[b]	Roasted kernels
Cucumeropsis mannii (white melon)	26.9 ± 0.3[c]	33.2 ± 0.3
Lagenaria sicceraria (var. 1) (gourd)	27.2 ± 0.3	33.4 ± 0.3
Lagenaria sicceraria (var. 2) (gourd)	28.6 ± 0.3	34.2 ± 0.3
Telfairia occidentalis (fluted pumpkin)	26.4 ± 0.3	32.8 ± 0.3

[a] Common name in parentheses.
[b] Values are means of four replicate samples.
[c] Mean ± standard deviation.

Chemical analyses. Table 2 shows the fatty acid compositions of the oils from the species studied. The fatty acid patterns are characteristic of most species of Cucurbitaceae. The proportion of the fatty acids *Cucumeropsis mannii* and *T. occidentalis* oils had higher percentages of saturated fatty acids (palmitic and stearic acids) than the other oils. They were lower in linoleic acid than the other species. This could be an advantage in terms of stability of the oils. However, the low linoleic acid content could reduce nutritional quality. *Lagenaria sicceraria* kernel oils were relatively low in stearic acid. The value of palmitic acid for *Lagenaria* species was much lower than the 42.41% reported by Joshi and Shrivastava (23) for *Lagenaria vulgaris* (calabash). In the species studied, *L. sicceraria* var. 2 oil had the highest linoleic acid (73.2%) and lowest oleic acid (7.1%) contents. *Telfairia occidentalis* had the highest oleic acid (29.8%) and the lowest linoleic acid (39.6%) contents. Chisholm and Hopkins (8) reported 76% linoleic acid for *Lagenaria* species. In this study, the total unsaturation of fatty acids (80.2–80.3%) for *Lagenaria sicceraria* varieties 1 and 2 agreed fairly well with 81.9% reported by Sen Gupta and Chakrabarty (24) for the genera *Citrullus* and *Lagenaria*. Linolenic acid was not detected in any appreciable amounts in the species investigated.

Some of the chemical and physical properties of the oils are presented in Table 3. The specific gravity values compared well with the 0.915 value reported by Kamel *et al.* (5) for melon oil. The specific gravity of *T. occidentalis* oil was relatively high. The iodine value was similar in all species except *T. occidentalis*, which had a lower value. Sediac (25) reported ranges of iodine

TABLE 2

Fatty Acid Composition (% Total Methyl Esters) of the Oils

Species	16:0[a]	18:0	18:1	18:2	Total saturates	Total unsaturates
Cucumeropsis mannii	16.2 ± 0.1[b]	12.3 ± 0.2	12.9 ± 0.1	58.5 ± 0.1	28.5	71.4
Lagenaria sicceraria var. 1	13.1 ± 0.1	5.2 ± 0.0	13.6 ± 0.2	66.6 ± 0.2	18.3	80.2
Lagenaria sicceraria var. 2	12.8 ± 0.2	4.9 ± 0.1	7.1 ± 0.0	73.2 ± 0.2	17.7	80.3
Telfairia occidentalis	16.3 ± 0.1	13.5 ± 0.2	29.8 ± 0.0	39.6 ± 0.1	29.8	69.3

[a] The figures indicate chain length and number of double bonds. Values are mean of four replicate samples.
[b] Mean ± standard deviation.

TABLE 3

Chemical and Physical Characteristics of the Oils

Parameter	*Cucumeropsis mannii*	*Lagenaria sicceraria* var. 1	*Lagenaria sicceraria* var. 2	*Telfairia occidentalis*
Peroxide value[a] (meq. peroxide/kg sample)	4.4 ± 1.4	4.5 ± 1.2	4.5 ± 1.1	4.1 ± 1.1
Acid value (mg KOH/g oil)	3.5 ± 1.2	5.4 ± 1.1	5.3 ± 1.2	7.4 ± 1.1
Iodine value (Wijs' method)	110.9 ± 1.1	115.6 ± 1.1	122.9 ± 1.05	96.5 ± 1.1
Saponification value (mg KOH/g oil)	190.4 ± 1.2	190.2 ± 1.2	190 ± 1.1	190.1 ± 1.2
Unsaponifiable matter (% w/w)	1.2 ± 0.1	1.2 ± 0.1	1.2 ± 0.1	1.3 ± 0.1
Specific gravity (25°C/H_2O at 25°C)	0.916 ± 0.0	0.918 ± 0.1	0.910 ± 0.1	0.924 ± 0.0
Refractive index (n_D 25°C)	1.4653 ± 0.0	1.4698 ± 0.0	1.4708 ± 0.0	1.4668 ± 0.0
Smoke point (°C)	180.1 ± 0.1	179.7 ± 0.2	179.6 ± 0.1	149.5 ± 0.2
Flash point (°C)	291.5 ± 0.2	284.1 ± 0.2	283.5 ± 0.2	204.8 ± 0.1
Cold test	–[b]	+[c]	+	–

[a] Values are mean of four replicate samples, mean ± standard deviation.
[b] Failed, i.e., cloudy at test condition.
[c] Passed, i.e., clear at test condition.

values of 44–56, 84–105, 99–119 and 121–142 for palm oil, groundnut oil, cottonseed oil and soy oil, respectively. Some of the values obtained in this study fell within that range of values. Saponification values compared well with the range (189–198) for cottonseed oil but were lower than the range (248–265) for coconut oil reported by the FAO/WHO Codex Alimentarius Commission (1). The peroxide values for the oils were similar. The acid values for the oils were also similar, except for *T. occidentalis* and *C. mannii*. The Codex Alimentarius Commission (1) stipulated a permitted maximum peroxide level of not more than 10 meq peroxide oxygen/kg oil, e.g., soybean, cottonseed, rapeseed and coconut oils. It also stipulated permitted maximum acid values of 10 mg KOH/g oil and 4 mg KOH/g oil for virgin palm oil and coconut oil, respectively. The smoke point values obtained for crude corn (178°C) and soybean oils (181°C) and flash points for crude corn (294°C), linseed oil (287°C) and soybean oils (296°C) reported by Meyer (22) compared well with the values obtained in this study, except for *T. occidentalis* kernel oil. Smoke point is influenced by the amount of free fatty acid (FFA) present in the oil at the time of determination. Mehlenbacher (16) reported the smoke points for soybean oil with 0.01% FFA and corn oil with 0.065% FFA at 228.3°C and 204.4°C, respectively. The smoke point is a criterion of some importance in regard to edible oils and fats, especially those intended to be used for deep frying. It is one of the safety parameters in use for oils obtained by solvent extraction to ensure the absence of residual solvent in the oil. The smoke and flash point values obtained in this study suggest that the oils could be suitable for use in deep frying.

Oils obtained from the kernels of *L. sicceraria* varieties 1 and 2 did not develop a cloudy appearance when kept in an ice-bath (2–3°C) for 7.5 hr. This could be explained by the high amount of unsaturated fatty acids present in the oils. This suggests that oil from the species could be used in making salad oils, mayonnaise and packing oils for canned foods, such as fish. An oil to be used in mayonnaise must pass a cold test to make sure that it would not crystallize and break the mayonnaise emulsion during storage at refrigerator temperature. Also, an oil to be used for packing canned food, such as fish, should be liquid at refrigeration temperature. *Cucumeropsis mannii* and *T. occidentalis* oils showed a cloudy appearance within 4 hr during the cold test, and this could be explained by the high amount of saturated fatty acid content. An acceptable minimum storage time in an ice-bath for salad oil is 5.5 hr (19). Thus, the oils from the kernels of *C. mannii* and *T. occidentalis* would not be suitable for use in mayonnaise, salad oil and packing oil for canned foods.

Table 4 shows the color of oil samples from the unroasted and roasted kernels of the species. Roasting of the kernels did not, by comparison of data, affect the quality factors studied except oil color. The values are presented in the Lovibond Tintometer scale. The oil obtained from roasted kernels was golden in color, while that from unroasted kernels was pale yellow. This

TABLE 4

Lovibond Color Evaluation of the Oils

Species	Unroasted kernel	Roasted kernel
Cucumeropsis mannii	0.2 R + 3.0 Y[a]	0.3 R + 2.9 Y
Lagenaria sicceraria var. 1	0.3 R + 4.0 Y	0.4 R + 4.3 Y
Lagenaria sicceraria var. 2	0.3 R + 4.0 Y	0.4 R + 4.3 Y
Telfairia occidentalis	2.7 R + 28.8 Y	3.0 R + 29.0 Y

[a] R, value on the red slide; Y, value on the yellow slide.

TABLE 5

Iron and Moisture Contents of the Oils

Parameter	*Cucumeropsis mannii*	*Lagenaria sicceraria* var. 1	*Lagenaria sicceraria* var. 2	*Telfairia occidentalis*
Iron (mg/kg)[a]	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1
Moisture (%)	3.4 ± 0.2 (0.5 ± 0.1)[b]	4.5 ± 0.3 (0.9 ± 0.1)	5.1 ± 0.2 (1.3 ± 0.1)	5.2 ± 0.3 (1.6 ± 0.2)

[a] Values are mean of four replicate samples, mean ± standard deviation.
[b] The values in parentheses are for oils from the roasted kernels.

difference in color may be due to the heat-induced oxidation of the α-tocopherol present in the oil cells of the kernel. *Telfairia occidentalis* oil was darkest in color, and this may be due to the presence of relative high β-carotene and probably α-tocopherol contents (18). Color is an essential attribute of oils, particularly in Nigeria, where most traditional dishes are prepared with crude oil.

Table 5 shows the iron and moisture contents of the oils. The iron content of the oils was less than 0.3 mg/kg. This value is less than the maximum level of contaminants stipulated by Codex Alimentarius Commission (1) for virgin coconut and palm oils (5 mg/kg), cottonseed and soybean oils (1.5 mg/kg). The moisture contents of the oils from unroasted and roasted kernels were in the range of 3.4% to 5.2% and 0.5% to 1.6%, respectively. The oil with low moisture content is expected to be more stable during storage than that with a high value.

The presented data show that the kernels of *Cucumeropsis mannii*, *Lagenaria sicceraria* varieties 1 and 2 and *Telfairia occidentalis* contain good quantities of edible oil. The yield of oil from them depends on the pretreatment of the kernels and on the method of extraction. The predominant fatty acids are palmitic, stearic, oleic and linoleic acid. The oil from the varieties of *L. sicceraria* was liquid at refrigeration temperature (2–3°C), but oils from *C. mannii* and *T. occidentalis* were plastic at refrigeration than the oils from *C. mannii* and *T. occidentalis*. Oils from *L. sicceraria* passed a cold test and have high smoke (ca. 180°C) and flash (ca. 284°C) points; hence, they could be suitable for use in salad oils, mayonnaise, frying oils and packing oils for canned foods.

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[Received May 25, 1990; accepted October 30, 1990]