Canarium schweinfurthii Engl.: Chemical Composition of the Fruit Pulp

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Canarium schweinfurthii Engl. (Burseraceae) is a wild tree found mostly in Africa, which produces fruit similar to olives and which is barely used. On a dry matter basis, the fruit pulp from Côte d'Ivoire (the Ivory Coast) was found to contain 5.6% protein, 30–50% fat, 8.2% starch, 11.8% cellulose and 8.3% ash (the highest mineral elements being potassium, 1.2% and calcium, 0.4%). The melting and solidification points of the extracted fat (44.5°C and 35.2°C, respectively) are higher than those of all the commercial and other _Canarium_-species oils. This oil shows low iodine, peroxide and carotene values (36, 17 meq-g and 2 mg, respectively). The fatty acid composition of the oil revealed a high content of oleic (89.4%) or stearic (67.7–84.0%) acids in the liquid, semi-solid and solid forms of the oil. Consequently, the content of these two acids is much higher in _Canarium schweinfurthii_ oil than in any other vegetable oil. The three forms (liquid, semi-liquid and solid) of the oil depend on the maturity of the fruit and these stages will be investigated further in future work.

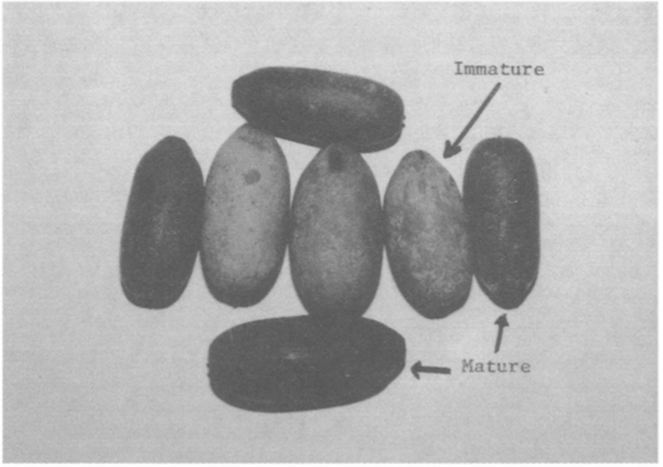

FIG. 1. _Canarium schweinfurthii_ Engl. fruits at different stages of maturity.

KEY WORDS: *Canarium*, composition, fatty acids, oil, properties, state.

Canarium schweinfurthii Engl. (Burseraceae) or Aiélé is a tall tree growing wild in Africa from the West (Sierra Leone) to the East, and to the south of Angola (1). This tree species grows rapidly in open areas. In Côte d'Ivoire (the Ivory Coast) it is also found in the coastal forest and in the semi-forest areas in the center of the country. This tree produces fruit that is similar in appearance to olives (Fig. 1), green in color, becoming red-purple when fully mature. The fruits are ovoid drupes, 3–4 cm long and 1.5–2 cm in diameter (Fig. 1), and contain seeds with a hard, thick endocarp (2.8 cm long and 1.2 cm in diameter). The seed is sub-triangular with three chambers, one of which is fertile. The fleshy pulp of the fruit (2–3 mm thick) is edible (2–6).

This fruit also is found in the Congo and Gabon, where it contains between 68–70% oil (7) and is a traditional food. In Côte d'Ivoire, the consumption of this fruit is practiced only by the Baoulé people of the Didievi area (center of the country), and no scientific work has been reported on this fruit in Africa. The only comment has been from DeMaret, an archeologist (Université Libre de Bruxelles, Belgium) who recently found some of the seeds of *Canarium* in his digs and traced them to the neolithic period in West and Central Africa. He speculated that the hunter-collector Africans of that time became sedentary and tried to plant palm oil and *Canarium* trees, the seeds of which were commonly found among the ancient peoples' food items.

In Côte d'Ivoire, palm oil plays an important role in the economy of the country (world's third largest producer of palm oil), but it is estimated that by 1995 the country will no longer be able to satisfy the national demand for vegetable oils, even if coconut and cottonseed oils are included (8). It is therefore urgent to look for new sources of vegetable oils, and the *Canarium* fruit appears promising because it contains approximately 30–50% oil (9). This study was carried out in order to determine the chemical composition of the fruit pulp and the physicochemical characteristics of the pulp oil, and to compare these properties to those of other vegetable oils.

EXPERIMENTAL PROCEDURES

About 25 kg of fresh fruits were collected at three different levels of maturity from the *Canarium* trees in the Allanikro village, a semi-forest area in Didievi county (central Côte d'Ivoire). The stages of development of these fruits are not well known, but the fruits collected from the different trees of a single collection were combined and submitted to pulp extraction according to the scheme shown in Figure 2.

The collected fruits were soaked in warm water (70°C) for 1–2 hr to soften the pulp, and the pits were removed by hand. The pulp was then dried in a laboratory oven at 70°C for 48 hr. Fat extraction was carried out by the Soxhlet method with hexane as solvent for 18 hr. The extracted fat was dried in a regular laboratory oven at 70°C for 2 hr before weighing. Chemical compositions were determined for the fruit pulp and the pulp residue after oil extraction, but the different physicochemical properties were determined on the extracted oil only.

The dry pulp of the *Canarium* fruit and its defatted pulp residue were analyzed for their chemical composition according to the Bureau Interprofessionnel d'Études Analytiques (B.I.P.E.A.) methods (10). The solidification, melting, boiling (normal atmospheric pressure) and smoke

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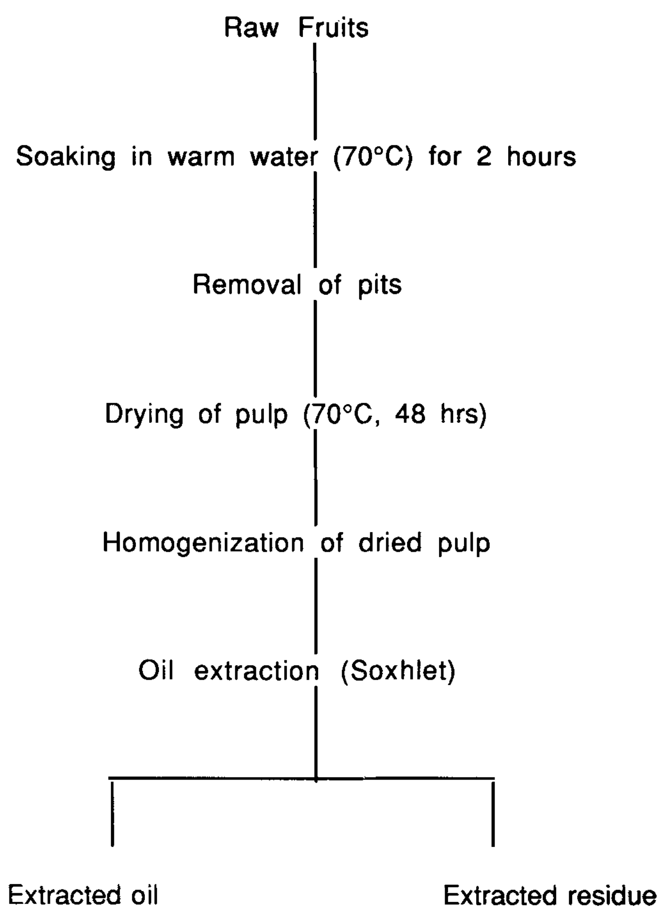

FIG. 2. Diagram of fat extraction from *Canarium schweinfurthii* fruits.

points to one type (solid) of oil extracted from *Canarium* were determined according to Hamilton and Rossel (11). The solid type of the oil was used because it was the most abundant.

Moisture and volatiles were determined by drying the samples in an oven at 103°C to a constant weight (30 min to 1 hr) according to Wolff (12). The refractive index, iodine and carotene values were also determined according to Wolff (12). The free acidity, saponification value and unsaponifiables were determined by B.I.P.E.A. methods (10). The peroxide value was determined according to Cocks (13).

Methylation of the fatty acids was done according to the method of Luddy *et al.* (14). Three drops of methylation solution (a mixture of sodium-free acid methoxide, petroleum ether and diethyl ether) was added to 1 mg of sample, and the mixture was placed in a water bath for 30 seconds at 65°C with shaking. The mixture was heated an extra 90 seconds without shaking before removing it from the bath. After cooling to room temperature, approximately 1 mg of a mixture of calcium chloride and silica gel (50:50) was added with shaking. Finally, 1 mL of hexane was added, and the mixture was then filtered through an organic sep-pak filter. Then 3 μL of the methylated sample was injected into a Hewlett-Packard 5890 Gas Chromatograph (Palo Alto, CA) with a DB 225, 0.25 mm × 15 m capillary column under the following conditions: Oven temperature, 235°C; injection temperature, 295°C; and detector temperature, 300°C. The fatty acid components were identified by comparing them with chromatograms of fatty acid ester standards from Sigma Chemical Co. (St. Louis, MO). The peak areas were measured by triangulation. The percentage of each peak was calculated as the percentage of the total area of all the peaks. The results of the present study are means of triplicate analyses from each *Canarium schweinfurthii* Engl. sample collected.

RESULTS AND DISCUSSION

Physicochemical properties. The moisture content determined on the fresh pulp of the *Canarium schweinfurthii* Engl. fruit was 56.1%. The fat extracted from the dry pulp was a solid with a yellow-golden color. Other forms (liquid and semi-solid) of the oil were also obtained from different fruit samples depending on the degree of maturity. Fat recovery ranged from 30 to 50%, which makes this species of *Canarium* much lower in oil than other *Canarium* species (*Canarium commun*, 62–72%; *C. luzonicum*, 72%; *C. oleosum*, 68%; *C. ovatum*, 74%; *C. pachyphyllus*, 72–74% and *C. polyphyllum*, 69%) (Table 1). These latter oils are obtained from the kernel of their respective fruits, while *Canarium schweinfurthii* oil is obtained from the fruit pulp. Its fruit contains a small kernel in one of the three chambers of a hard and thick endocarp, and this kernel is not suitable for economical oil extraction. *Canarium schweinfurthii* fruit is also lower in oil than peanut (46%), palm (45–50%) and sheanut (40–60%), but

TABLE 1

Physicochemical Characteristics of Oils from Some Species of *Canarium*

Species	Origin	Location of fat	Fat content (%)	Melting point (°C)	Solidification point (°C)	Saponification value (mg/g)	Iodine value	Unsaponifiables (%)
C. schweinfurthii[a]	Côte d'Ivoire	Pulp	40 ± 10	44.5 ± 2.4	35.5 ± 1.5	206.4 ± 2.6	36 ± 3	1.0 ± 0.1
C. luzonicum[b]	Philippines	Kernel	72	29	14	197	55.9–57.1	—
C. oleosum[b]	Malaysia	Kernel	68	—	12.5	197	63	1
C. ovatum[b]	Philippines	Kernel	74	—	—	187–197	55.9–55.6	0.2
C. pachyphyllus[b]	Philippines	Kernel	72–74	—	—	187–193	59.6–61.3	—
C. polyphillum[b]	New Guinea	Kernel	69	30	19–20	188–200	53–59.7	—
C. commun[b]	South India Malaysia	Kernel	62–72	18–28.5	15–20	191–198	59–66	—

[a]Present study.

[b]Mensier (19).

TABLE 2

Physicochemical Characteristics of *Canarium schweinfurthii* Solid Type Oil[a]

Properties	Values
Boiling point	137 ± 3°C
Smoking point	195 ± 2°C
Moisture and volatiles (%)	1.1 ± 0.05
Acidity (% oleic acid)	72.2 ± 0.4
Peroxide value (meq-g/kg)	17.0 ± 0.7
Carotene value (mg/100g)	2.0 ± 0.1

[a]Means of triplicate analyses.

TABLE 3

Chemical Composition of *Canarium schweinfurthii* Pulp and Fat-Extracted Residue (%, D.M.)[a]

Components	Pulp	Residue
Moisture	10.1 ± 0.22	13.0 ± 0.25
Protein	5.6 ± 0.08	7.9 ± 0.10
Fat	40.0 ± 1.0	6.4 ± 0.3
Starch	8.2 ± 0.4	13.4 ± 0.3
Cellulose	11.8 ± 0.3	15.9 ± 0.50
Ash	8.3 ± 0.25	7.0 ± 0.15
Calcium	0.4 ± 0.04	0.5 ± 0.05
Phosphorus	0.08 ± 0.02	0.1 ± 0.02
Potassium	1.2 ± 0.15	2.0 ± 0.2
Sodium	0.02 ± 0.002	0.02 ± 0.002

[a]Means of triplicate analyses.

higher than those of soybean (17.9%), cottonseed (35%) and avocado (14.2%) (15–18).

With the exception of coconut and palm kernel oils (with respective iodine values of 7.5–10.0 and 16–20), *Canarium schweinfurthii* oil had a lower iodine value (36) than oils of other *Canarium* species and other commercial vegetable oils. This low iodine value is consistent with the low peroxide value (17 meq-g/kg), indicating that the solid type of *Canarium schweinfurthii* oil is low in unsaturated fatty acids. Contrary to the iodine value, the saponification value (206.4 mg/g) of *Canarium schweinfurthii* oil is higher than that of the vegetable oils mentioned above, with the exception of coconut (248–265 mg/g) and palm kernel oils (230–254 mg/kg), due to the high level of free fatty acids content (72.2%). The unsaponifiable value of *Canarium schweinfurthii* (1.4%) is higher than that of *Canarium ovatum* (0.2%), *Canarium oleosum* (1%), and peanut (0.2–0.8%) oils, but much lower than that of sheanut (6–8%) oil. It is similar to that of cottonseed (0.2–1.5%), sesame (0.9–2%), soybean (0.5–1.6%) and corn (0.5–2.8%) oils.

The comparative physical properties of the analyzed fat are presented in Table 1. The melting and solidification points obtained (35.2°C and 44.5°C, respectively) are higher than those of all the other *Canarium* species (19) and commercial vegetable oils. The boiling and smoke points of that crude oil are 137°C and 195°C, respectively (Table 2), probably due to the presence of color and gum constituents.

Analysis of the whole fruit pulp (Table 3) shows 5.6% protein, 8.2% starch, 11.8% cellulose and 8.3% ash (potassium is the highest mineral element at 1.2%). The composition of the extracted pulp residue contained 7.9% protein, 13.4% starch, 6.41% oil, 15.9% cellulose and 7% ash (potassium, 2.0%; calcium, 0.6%; phosphorus, 0.1% and sodium, 0.02%). The carotene value (0.02%) obtained was lower than that of red palm oil (0.1–0.2%) (20), indicating that oil from *Canarium schweinfurthii* is a poor source of vitamin A. These results show that *Canarium schweinfurthii* fruits are a good source of oil, cellulose and potassium, but a poor source of protein, calcium, sodium and phosphorus.

The fatty acid composition. The fatty acid composition of the three types of oil products (liquid, Canarium 1; semi-solid, Canarium 2; and solid, Canarium 3) is presented in Table 4. The liquid state (Canarium 1) contained 89.4% oleic acid (C18:1), the semi-solid state (Canarium 2) contained 67.7% stearic (C18:0) and 30.0% linoleic (C18:2) acids; and the solid state (Canarium 3) contained the highest level of stearic (84.0%) acid, and only 14.7%

TABLE 4

Fatty Acid Composition of *Canarium* and Other Vegetable Oils (%, w/w)

Oil origins	$C_{8:0}$	$C_{10:0}$	$C_{12:0}$	$C_{14:0}$	$C_{14:1}$	$C_{16:0}$	$C_{16:1}$	$C_{18:0}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$	$C_{20:0}$	$C_{20:1}$
Canarium 1: Liquid	—	—	—	0.3	0.5	3.8	0.8	3.2	89.4	0.7	1.6	0.3	0.6
Canarium 2: S-liquid	—	—	—	0.4	0.3	0.6	—	67.7	1.1	30.0	—	—	—
Canarium 3: Solid	—	—	—	—	—	1.3	—	84.0	—	14.7	—	—	—
Palm oil[a]	—	—	—	1.0	—	44.3	0.2	4.6	38.7	10.5	0.3	0.3	—
Palm kernel[a]	3.3	3.5	47.5	16.4	—	8.5	—	2.4	15.3	2.4	0.1	0.1	0.1
Coconut[a]	7.8	6.7	47.5	18.1	—	8.8	—	2.6	6.2	1.6	—	—	—
Olive[b]	—	—	—	—	—	12.0	1.0	2.0	72.0	8.0	1.0	—	1.0
Peanut[b]	—	—	—	—	—	10.0	—	2.0	46.0	31.0	—	—	—
Sunflower[b]	—	—	—	—	—	6.0	—	4.0	22.0	66.0	—	—	—
Corn[b]	—	—	—	—	11.0	—	2.0	25.0	57.0	1.0	—	—	—
Cottonseed[c]	—	—	—	0.9	—	23.0	—	2.2	17.7	55.8	—	—	—
Soybean[d]	—	—	—	—	—	11.0	—	4.0	22.0	54.3	7.5	—	—
Avocado[e]	—	—	—	—	—	7.1	2.4	0.4	80.3	8.2	0.8	—	—
Palm Chiriva[f]	—	—	—	—	—	29.0	4.4	1.9	38.6	22.2	3.7	—	—
Palm butia[f]	—	—	—	—	—	33.0	3.6	2.9	32.7	24.6	3.5	—	—

[a]Ref. 20.
[b]Ref. 21.
[c]Ref. 22.
[d]Ref. 23.
[e]Ref. 17.
[f]Ref. 24.

linoleic acid and 1.3% palmitic acid (C16:0). Canarium 1 contains 3.2% stearic (C18:0) and 1.6% linolenic (C18:3) acids as well as traces of myristic (C14:0) and myristoleic (C14:1) acids. Only 1.1% of oleic acid was found in the semi-solid state (Canarium 2), along with traces of myristic and myristoleic acids.

When compared to other common vegetable oils, *Canarium* oils contained the highest oleic (Canarium 1, 89.4%) and stearic (Canarium 2, 67.7% and Canarium 3, 84.0%) acid levels (Table 4). Cottonseed (55.8%), sunflower (66.0%) and soybean (54.3%) oils possess a much higher linoleic acid content than any of the *Canarium* oils. Palmitic acid (0.6–3.8%) is lower in the *Canarium* oils than in most of the vegetable oils compared in this study.

All the above results provide some important scientific information that could be exploited for potential uses of *Canarium schweinfurthii* oil. Further investigations in greater depth will be carried out on fatty acids in order to relate them to the different maturity stages of the fruit and to oil quality.

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