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The Composition of the Pindó (*Arecastrum romanozoffianum*) Fruit

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ABSTRACT

The pulp and kernel composition, lipid classes, fatty acid composition and distribution of triglycerides and triglyceride composition of kernel fat from Arecastrum romanozoffianum *palms grown in Nigeria have been studied. The kernel has a moderate fat content. Lauric acid was the dominant fatty acid in whole kernel fat, in kernel triglycerides and also in the 2-monoglycerides derived from triglycerides by pancreatic lipase hydrolysis. All the fatty acids in kernel triglycerides exhibited a preference for the combined 1,3-positions except for lauric acid which exhibited a specificity for the 2-position. The trisaturated triglycerides were the dominant glyceride type and the fatty acid compositions of the various glycerides fractions from* $AgNO_3$*-TLC suggested a paucity of simple (monoacid) triglycerides and completely unsaturated triglycerides.* Arecastrum romanozoffianum *pulp consisted mainly of carbohydrate.*

INTRODUCTION

The palm *Arecastrum romanozoffianum*, variously known as queen's palm, plummy coconut or pindó palm, is indigenous to the south-eastern part of South America (Ruddle *et al.*, 1978). The palm is monotype, has an erect solitary, slender trunk, 10–15 m long, and large pinate leaves. It is a palm of both the tropical and subtropical forest and has an annual flowering and fruiting season. The cultivated *Arecastrum romanozoffianum* palm is a popular ornamental and street palm in tropical and subtropical regions. (Ruddle *et al.*, 1978). The wild palm is utilised for its stem starch (sago) and

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palm heart (cabbage). The felled palm is a source of coleoptera larvae (sago grub) (Ruddle *et al.*, 1978). Recently, Balick (1979) has listed the palm in a review of Amazonian palms with potential as economic crops.

The *Arecastrum romanozoffianum* palm bears, annually, three or four bunches which contain numerous oval shaped fruits which are of dietary significance (Ruddle *et al.*, 1978). The fruit consists of a slimy, sweet and fibrous pulp, enclosing a hard shell. The shell encloses a hard fatty kernel (seed). Previous authors have given analytical data for whole fruit, kernel and kernel oil (Pulley & von Loesecke, 1941; Earle & Quentin, 1962; Rodenstein & Cattaneo, 1975; Opute, 1979). However, such information has been either inadequate from the point of view of utilisation or obscure.

The present investigation was undertaken to provide information on the chemical composition of the Nigerian grown *Arecastrum romanozoffianum* fruit pulp, kernel and kernel fat as a basis for their utilisation.

MATERIALS AND METHODS

Fruits

Mature *Arecastrum romanozoffianum* fruits were obtained from the Palmatum of the Nigerian Institute for Oil Palm Research (NIFOR). The fruits were dried in a ventilated oven for 1 week at 40°C. The pulp was peeled off manually and the fruits were shelled to release kernels. Pulp for proximate analysis was further dried at 100°C to constant weight.

Extraction of fat

The kernels were first broken up into large pieces in a mortar. The pieces were then pulverised in a Christy laboratory mill. Dried pulp was blended in a laboratory blender. Pulverised kernel or blended pulp (20 g) was extracted for 6 h with analytical grade hexane in a Soxhlet apparatus. Solvent was removed in a rotary evaporator and the weight of the extracted fat was determined. Results were calculated as % fat (wet basis) in the original kernel and % fat (dry basis) in the original pulp.

Analysis of pulp and kernel fat

Moisture, protein, crude fibre and ash contents were determined according to *Official Methods* (AOAC, 1975). Carbohydrate was calculated by difference. Saponification value, iodine value and slip point were determined according to Cocks & van Rede (1966).

Lipids of *Arecastrum romanozoffianum* kernel fat were separated by

preparative chromatography on thin layer plates (0·75 mm thickness, 20 × 20 cm, coated with silica gel G, Merck). The plates were developed vertically in an 80/20/1 mixture of petroleum ether (40–60°C)/diethyl ether/acetic acid (Sanders, 1980). The lipid classes were identified through the use of authentic samples, spraying with specific reagents (Dittmer & Lester, 1964; Beiss, 1964) and by reference to R_f values. The various bands were located under iodine vapour, the iodine evaporated, the bands scraped into small chromatographic columns and eluted exhaustively with diethyl ether. The ether was evaporated completely and the lipids weighed on a Mettler balance.

The composition of fatty acids at the 2-position of *Arecastrum romanozoffianum* kernel triglycerides was determined by lipolysis with pancreatin according to the method of Tan *et al.* (1981) with modification. A mixture of 40 mg triglycerides, 60 mg enzyme, 2 ml ammonia buffer (pH 9), 0·3 ml 22% $CaCl_2$ and 0·1 ml of a 10% solution of sodium taurocholate was agitated vigorously for 10 min at 40°C. The reaction was stopped by adding 0·5 ml 6N HCl. Hydrolysis products were extracted with diethyl ether. The extract was washed with distilled water, dried over anhydrous sodium sulfate, concentrated, and dissolved in chloroform for thin-layer chromatography. The hydrolysis products were separated by vertical development in petroleum ether (40–60°C)/diethyl ether, 60/40 v/v, containing 1·6% formic acid according to Luddy *et al.* (1964).

Triglycerides were separated on preparative $AgNO_3$-TLC (20 × 20 cm plates, silica gel G, 0·5 mm thick incorporating 12% $AgNO_3$) using a volume mixture 60/40/0·5/0·5 of carbon tetrachloride/chloroform/acetic acid/ethanol. The triglycerides were made visible by spraying with 0·1% 2,7-dichlorofluorescein in ethanol and viewing under uv light. Quantitation of resolved triglyceride was by gas–liquid chromatography using heptadecanoic acid as internal standard according to the method of Barret *et al.* (1963).

Whole fat, triglycerides, and 2-monoglycerides were converted to their corresponding methyl esters by acid catalysed methanolysis according to the procedure of Urakami *et al.* (1976). The esters were extracted with analytical grade hexane, washed with distilled water, dried over anhydrous Na_2SO_4, concentrated and injected into the gas chromatograph (Pye Unicam 104, equipped with a flame ionization detector). Gas chromatography of methyl esters was at an oven temperature of 180°C using a 1·82 m × 2·4 mm id glass column packed with 10% polyethylene glycol adipate (PEGA) on 100/200 mesh Diatomite C–AW. The flow rate of the nitrogen carrier gas was 35·5 ml/min. For gas chromatographic determination of ethanol, oven temperature was 80°C, using a 1·82 m × 2·4 mm id steel column packed with 10% polyethylene Glycol 600 (PEG 600) on 80/120 mesh celite.

RESULTS AND DISCUSSION

Arecastrum romanozoffianum kernel and pulp compositions and characteristics of kernel oil are presented in Table 1. Average fresh fruit weight was 12·8 g made up of a slimy, sweet, and fibrous pulp enclosing the kernel. Average kernel weight was 1·5 g or 11·7% of fruit. Pulley & von Loesecke (1941) gave a kernel content of 8% and a fruit weight of about 6·0 g. *Arecastrum romanozoffianum* pulp consisted mainly of carbohydrate (84·2%); crude protein, crude fibre and ash were each less than 7·0% of dried, defatted pulp. Oil content of dried pulp was 3·7%. *Arecastrum romanozoffianum* pulp could therefore be a good source of carbohydrate, but a poor source of fat and protein. A mash of fresh pulp left to ferment overnight gave 1·26% ethanol, indicating that *Arecastrum romanozoffianum* pulp could be a good source of fermentable carbohydrate. However, pulp carbohydrate composition was not examined.

TABLE 1

(a) *Arecastrum romanozoffianum* Pulp and Kernel, and *Elaeis guineensis* Kernel Compositions

	Arecastrum romanozoffianum				E. guineensis *kernel*[d]
	Fruit coat[a]	*Present work*	*Pulley & von Loesecke*[b]	*Earle & Quentin*[c]	
Moisture	—	6·0	—	—	8·0
Crude protein	5·9	6·6	—	16·7	8·5
Crude fat	—	33·0	32·2	64·7	49·0
Crude fibre	6·3	3·1	—	—	5·8
Ash	3·9	1·7	—	—	1·8
Carbohydrate	84·2	49·6	—	—	26·9

(b) Gross Composition of Fruit (%wt)

	Present work	*Pulley & von Loesecke*[b]
Pulp	—	23
Shell	—	69
Kernel	11·7	8
Fruit weight, average (g)	12·8	
Kernel weight, average (g)	1·5	

[a] Dried and defatted, dried pulp contained 23·7% fat.
[b] Pulley & von Loesecke (1941).
[c] Earle & Quentin (1962).
[d] Haliday (1972).

On a fresh weight basis about 50% of *A. romanozoffianum* kernel consisted of carbohydrate. Soxhlet extraction of the kernel gave 33% fat. This was lower than the fat content of the African oil palm (*Elaeis guineensis*) kernels (Table 1) and lower than values given by Pulley & von Loesecke (1941) and Earle & Quentin (1962) for *A. romanozoffianum* kernels. However, our result agrees with that given by Opute (1979), who used material from the same source as that used in this study. The differences in fruit weight, kernel/fruit ratio and kernel oil content suggest possibilities for improvement of desirable traits through breeding of *A. romanozoffianum* palms.

A. romanozoffianum kernels were richer in carbohydrate and mineral matter than the *E. guineensis* kernels. In addition, they have a lower fibre content. The *E. guineensis* kernel cake is currently utilised as an energy source in livestock feed (Haliday, 1972). The lower fibre content (which should enhance digestibility of cake), the higher carbohydrate content, higher mineral matter and an adequate protein content make the *A. romanozoffianum* kernel more attractive than the *E. guineensis* kernel as a source of kernel cake for use as an energy additive in livestock feed.

Soxhlet extraction of *A. romanozoffianum* kernels gave a pale yellow fat with a nutty aroma. General analytical characteristics, fatty acid composition and carotenoid content of kernel fat are presented in Table 2. Included for comparison are similar parameters for palm kernel and coconut oils. Lauric acid formed more than 50% of the total fatty acids. The fatty acid composition agreed with that given by Opute (1979) and followed

TABLE 2

Fatty Acid Composition (%wt) of *A. romanozoffianum* Fat Palm Kernel Oil and Coconut Oil

Fatty acid	A. romanozoffianum	*Palm kernel*[a]	*Coconut*[b]
8:0	1·7	3–4	5–10
10:0	2·0	3–7	4–15
12:0	55·5	46–52	37–51
14:0	20·4	14–18	7–19
16:0	6·6	6–9	2–11
18:0	1·7	1–3	1–3
18:1	10·2	10–19	5–8
18:2	1·7	0·5–1·5	1–3
Slip point (°C)	27·0	26–29	23–26
Iodine value	13·6	14·5–19·0	7·9–9·5
Saponification value	237·0	246–249	254–258
Carotenoids	9·0	—	—
Consistency at room temperature	solid	liquid	liquid

[a] Williams (1966*a*).
[b] Williams (1966*b*).

the general trends for palmae seed fats: high, 12:0; moderate, 14:0; low, 18:1 and 18:2, and low, 16:0, 18:0 and 10:0 contents (Hilditch & Williams, 1964*a*). The fatty acid composition and general analytical characteristics of *A. romanozoffianum* kernel fat were similar to those of palm kernel oil but differed from those of coconut oil in the amount of short chain fatty acids (10:0 and 8:0) and in the amount of unsaturated fatty acids (18:1 and 18:2).

TABLE 3

Lipid Composition, Total Fatty Acid, Triglycerides and Derived 2-monoglycerides in Fatty Acid Composition of *A. romanozoffianum* Kernel Fat

(a)

Lipid classes[a]	TG	DG	MG	FFA	ST	SE/HC	PL
Lipid composition (%)	95·1	1·5	0·3	1·6	0·4	0·7	0·4

(b)

	Fatty acid composition (% mole)							
	8:0	10:0	12:0	14:0	16:0	18:0	18:1	18:2
Whole fat	2·1	2·1	58·3	18·7	6·3	2·1	8·3	2·1
Triglyceride	2·2	2·2	57·6	24·0	4·4	8·1	7·8	—
2-monoglyceride[b]	0·9	1·3	76·8	12·8	1·9	—	6·3	—
Proportion in 2-position[c]	13·6	19·7	44·4	17·8	14·4	—	26·9	—
Proportion in 1,3-positions[d]	86·4	80·3	55·6	82·2	85·6	—	73·1	—

[a] TG, triglycerides; DG, diglycerides; MG, monoglycerides; FFA, free fatty acid; ST, sterol; SE/HC, sterol esters/hydrocarbons; and PL, polar lipids.

[b] Derived from triglycerides by pancreation lipolysis of triglycerides.

[c] Proportion in 2-position of triglycerides $= \dfrac{\%\text{ mole fatty acid in 2-position} \times 100}{\%\text{ mole fatty acid in triglycerides} \times 3}$

[d] Proportion in 1,3-position of triglycerides = 100 − Proportion in 2-position.

Evidence from fatty acid composition indicates that *A. romanozoffianum* fat could be a better source of medium chain fatty acids (12:0 and 14:0) than either palm kernel oil or coconut oil. The low carotenoid content of kernel fat was in keeping with its light colour.

A. romanozoffianum kernel lipid and fatty acid compositions are presented in Table 3. Also shown are the fatty acid compositions of *A. romanozoffianum* triglycerides and 2-monoglycerides derived from them by lipolysis with pancreatic lipase. The triglycerides were by far the dominant lipid species, accounting for 95·1% of whole fat. Lipids of other classes made up

less than 5% of kernel fat. *A. romanozoffianum* triglyceride fatty acid composition was similar to that of whole fat. However, linoleic acid was absent in triglycerides. Lauric was the major fatty acid in derived 2-monoglycerides. Its relative amount in this position was higher than in whole fat or triglycerides. In contrast, the relative amounts of other fatty acids in the 2-position were lower than in the triglycerides. The 2-position was devoid of stearic and linoleic acids.

Under a strict random distribution, the experimentally determined proportions of fatty acids at the 2 or any other position in triglycerides would be 33·3% (mole). None of the fatty acids at the 2-position of *A. romanozoffianum* triglycerides satisfied this condition. Thus, they did not follow a random distribution. The experimentally determined proportion of lauric acid (44·4% mole) at the 2-position was considerably higher than the 33·3% (mole) predicted by random theory, indicating a specificity of this fatty acid for the 2-position of *A. romanozoffianum* triglycerides. The other fatty acids exhibited a specificity for the combined 1,3-positions. Thus, the *A. romanozoffianum* kernel was characterised by a moderate to high fat content consisting of a high 12:0 and low 18:1 and 18:2 content and a specificity of 12:0 for the 2-position and a specificity of 8:0, 10:0, 14:0, 16:0, 18:0 and 18:1 for the combined 1,3-positions of its triglycerides. Litchfield (1970) has reported a direct correlation between fat content, fatty acid composition of triglycerides and the positional distribution of fatty acids in triglycerides and the botanical subfamilies within the plant family palmae. According to Litchfield (1970), palmae species belonging to the cocoideae subfamily exhibit a high fat content, a high triglyceride content (>90%), high 12:0 levels and low 18:1 and 18:2 levels in fat and appreciable esterification of 12:0 at the 2-position of kernel triglycerides. The moderate to high fat content in its kernel, high, 12:0, low, 18:1 and 18:2, in its kernel fat and the specificity of 12:0 for the 2-position of its kernel triglycerides strengthen current evidence that the *A. romanozoffianum* palm belongs to the cocoideae subfamily of the palmae family. This subfamily includes the principal commercial palms, the oil palm (*Elaeis guineensis*) and the coconut palm (*Cocos nucifera*).

A. romanozoffianum kernel triglycerides were separated on $AgNO_3$-TLC according to numbers of double bonds. The proportions of the various $AgNO_3$-TLC fractions and their fatty acid compositions are presented in Table 4. As is characteristic of palmae kernel fats (Hilditch & Williams, 1964*b*), the trisaturated triglycerides were the major glyceride type, accounting for 76·7% (73·1% of whole fat) of total triglycerides. The mono-unsaturated fraction accounted for 7·9% and the diunsaturated, 10·2%, of *A. romanozoffianum* triglycerides. Fraction 4, containing three or more double bonds, accounted for 5·2% of total triglycerides. The trisaturated

TABLE 4
Triglyceride Fractions from $AgNO_3$-TLC and their Fatty Acid Composition (%wt)

Fraction	1		2		3		4	
Double bonds	0		1		2		3 or more	
% weight	76·6		7·9		10·2		5·2	
Fatty acid	%wt	%mole	%wt	%mole	%wt	%mole	%wt	%mole
8:0	0·6	0·8	—	—	—	—	—	—
10:0	2·8	3·4	1·9	2·6	2·8	3·8	2·6	3·4
10:1	—	—	7·7	10·6	7·7	10·7	12·6	16·9
12:1	62·0	65·0	18·6	22·2	16·2	19·3	20·4	23·3
14:0	25·7	23·7	12·2	12·7	8·3	8·6	10·0	10·1
16:0	7·2	5·9	25·1	23·1	28·4	26·4	24·2	21·7
18:0	1·7	1·3	4·4	4·0	4·4	3·8	4·4	3·7
18:1	—	—	29·5	24·8	28·9	24·5	20·1	16·3
18:2	—	—	—	—	3·3	2·9	5·7	4·6
Saturated	100	100	62·9	64·6	60·1	61·9	61·6	62·2
Monounsaturated	—	—	37·1	35·4	36·6	37·7	32·7	33·2
Diunsaturated	—	—	—	—	3·3	5·7	5·7	4·6

fraction was made up mainly of lauric and myristic acids. On a %mole basis the fatty acid composition of this fraction shows that lauric acid accounted for about two-thirds of its total fatty acids. Thus each mole of triglyceride consisted of two moles of lauric acid in combination with one mole of another fatty acid. The myristic acid content (23·7%) of this fraction indicates that dilauromyristin was present in considerable quantity, with smaller amounts of dilauropalmitin (16:0 = 5·9%), dilauro-caprin (10:0 = 3·4%), dilaurostearin (18:0 = 1·3%) and dilaurocaprilin (8:0 = 0·8%). The fatty acid composition of this fraction indicates a paucity of trilaurin. These results agree with findings for coconut and palm kernel oil trisaturated triglycerides from fractional crystallization studies (Collin & Hilditch, 1928). Almost two-thirds of the fatty acids in each of the other fractions was made up of saturated fatty acids, indicating a paucity of triunsaturated triglycerides in agreement with previously published results for other palmae kernel fats: coconut and palm kernel (Collin & Hilditch, 1928), babassu (Jackson & Longnecker, 1944), and areca (Pathak & Mathur, 1954) from fractional crystallization studies.

Kernel and kernel oil characteristics indicate that the *A. romanozoffianum* palm has potential as a commercial source of high lauric vegetable fat and high carbohydrate kernel cake. *A. romanozoffianum* kernel cake could be of use as a high energy additive in livestock feed while the kernel fat could be exploited in much the same way as the *Elaeis guineensis* kernel fat, i.e. for frying, in margarine blends, as a source of sharp melting fat for confectionery and as a source of medium chain fatty acids for oleochemicals.

The sweet pulp (fruit coat) of the *Arecastrum romanozoffianum* fruit appears to be a good source of fermentable carbohydrate. Improvement of fruit yield and characteristics through agronomic studies coupled with the exploitation of its fruit coat carbohydrate resource could serve to enhance the economic position of the *Arecastrum romanozoffianum* palm.

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