Fat Content and Fatty Acid Composition of Oils Extracted from Selected Wild-Gathered Tropical Plant Seeds from Nigeria

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ABSTRACT: As the search for alternative sources of food to alleviate hunger continues, this study was undertaken to determine the fat content and the fatty acid composition of 15 lesser-known wild tropical seeds gathered in Nigeria. Results were contrasted with five tropical soybean varieties (*Glycine max*). The fat content varies from less than 1% *(Pterocarpus santalinoides, Daniellia ogea*) to 59% (*Entandrophragma angolense*). The fatty acid composition of most of the wild and mostly leguminous seeds differed considerably, compared to the composition of tropical soybeans. The oil of *Adansonia digitata, Prosopis africana, Afzelia lebbeck, Enterolobium cyclocarpium,* and *Sesbania pachycarpa* contained high proportions of linoleic and oleic acid as well as palmitic and linolenic acid. Seeds of *Milletia thonningii, Lonchocarpus sericeus,* and *S. pachycarpa* were much higher in linolenic acid and relatively poor in linoleic acid, compared to soybeans. The content of saturated fatty acids was higher than that of soybeans, resulting in lower polyunsaturated/saturated (P/S) ratios (0.83–2.12) than observed in soybeans (P/S = 3.4), with the exception of the composition of *S. pachycarpa* (P/S = 3.15). Some of these less familiar wild seeds could be used as sources for industrial or edible oils, provided that possible toxic constituents could be removed.
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KEY WORDS: Fat content, fatty acid composition, legume seeds, linolenic acid, Nigeria, soybean, tropical seeds.

The main sources of edible and industrial oils in Nigeria, as in other developing countries, are oilpalm (*Elaeis guineensis*), soybean (*Glycine max*), and peanut (*Arachis hypogaea*). These species contain oils of commercial importance and thus have received appreciable research attention. However, with the growing scarcity (increasing population, shortage of fertile land, restrictions on the importation of food) and high prices of these sources of edible and industrial oils in tropical developing countries, interest is being focused toward finding alternatives to prevent hunger and malnutrition (1–3). One way is the exploitation of less familiar plant resources that have been identified, but lack of data on their chemical composition has limited the prospects for their utilization.

In evaluating the nutritional quality of oil, fatty acid composition occupies a special place. Dietary fatty acids modify the plasma lipoprotein profile and the risk of cardiovascular disease, which has been shown in intervention studies, in particular for polyunsaturated and monounsaturated fatty acids (4–6). Saturated fatty acids have a more hyperlipidemic effect than unsaturated fatty acids (7,8). Studies on the evaluation of food value of some tropical plant seeds show that quite a number of them may contain high levels of oils and may prove to be good sources for edible or industrial use (9). Therefore, it is necessary to investigate their fatty acid composition before they can be considered for further evaluation.

EXPERIMENTAL PROCEDURES

Collection of seed samples. Mature seed samples (35–50 kg per specimen) were harvested during the dry period (October–January) from villages around the city of Ibadan with the help of the natives. Collections were taken from several plants to get a representative sample for the Ibadan region. The samples were identified at the Forestry Research Institute, Ibadan. Table 1 provides a short characterization of the tropical seeds analyzed. The soybean samples (*Glycine max*) were provided by The International Institute of Tropical Agriculture, Ibadan, Nigeria, and were analyzed for purposes of comparison with the wild seed samples. The raw seeds were milled to flours in a Wiley mill (Rekord A, Gbr. Jehmlich GmbH, Nossen, Germany) to pass through a 0.5-mm mesh sieve and were stored at 4°C until analysis.

Analytical procedures of seed samples. Lipids were extracted from the seed samples with petroleum ether (boiling point 40–60°C) in a Soxhlet extractor (10). For analysis of the fatty acid composition, an aliquot (10 mg) of the lipid extract was transmethylated with trimethylsulfoniumhydroxide (TMSH) according to Schulte and Weber (11). The fatty acid methyl esters (FAME) were analyzed in a gas–liquid chromatograph (HP 5890, Hewlett-Packard

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TABLE 1
Characterization of Selected Tropical Seeds

Genus and species	Family	Described[a]	Toxicity[b]	Use as food or feed
Adansonia digitata	Bombacaceae	Yes	No	Humans, baobab (i.e., milk of fruits, "gubdi," or soup of leaves, "miyar kuka") (19)
Prosopis africana	Leguminosae	Yes	No	Humans, mesquite, okpiye, condiment prepared by fermentation of seeds (20)
Millettia thonningii	Leguminosae	Yes	Unknown	Ruminants
Gliricidia sepium	Leguminosae	Yes	Yes	Ruminants (leaves)
Albizia lebbeck	Leguminosae	No	No	Ruminants (leaves)
Albizia zygia	Leguminosae	Yes	No	Humans, ruminants
Lonchocarpus sericeus	Leguminosae	No	Yes	Unknown
Daniellia ogea	Leguminosae	Yes	No	Humans
Pterocarpus osun	Leguminosae	No	No	Humans
Pterocarpus santalinoides	Leguminosae	No	No	Ruminants
Enterolobium cyclocarpium	Leguminosae	No	Unknown	Humans (fruits)
Diospyros mespiliformis	Ebenaceae	No	No	Humans
Afzelia bella	Leguminosae	Yes	No	Humans, ruminants
Sesbania pachycarpa	Leguminosae	Yes	No	Humans
Entandrophragma angolense	Meliaceae	Yes	Unknown	Unknown
Glycine max (TGX 1660-15F)[c]	Leguminosae	—	No	Humans
Glycine max (TGX 1740-6F)[c]	Leguminosae	—	No	Humans
Glycine max (TGX 1740-2F)[c]	Leguminosae	—	No	Humans
Glycine max (TGX 1649-11F)[c]	Leguminosae	—	No	Humans
Glycine max (TGX 1681-3F)[c]	Leguminosae	—	No	Humans

[a]Described by Keay (21) in *Trees of Nigeria.*
[b]Personal communication by I.E. Ezeagu (12).
[c]Tropical soybean seed samples analyzed in comparison to the wild seed samples.

GmbH, Waldbronn, Germany), equipped with a flame-ionization detector. A DB-Wax capillary column (30 m × 0.32 mm i.d.; Fisons Scientific, Mainz-Kastel, Germany) with He as carrier gas was used for the separation of FAME. A volume of 1 μL was injected splitless by an autosampler (HP 7673, Hewlett-Packard GmbH). The injector temperature was 255°C, and the detector temperature was 250°C. The following oven temperature gradient program was used: initial oven temperature was 140°C; 140–170°C, ramp 4°C min^{-1}; 170–185°C, ramp 1.5°C min^{-1}; 185–220°C, ramp 4°C min^{-1}, held 33 min. Peak areas were integrated with 3365 Series II ChemStation software (Hewlett-Packard GmbH), and the fatty acids were expressed as percentage of total fatty acids. Fatty acids were identified by comparison of their retention times with those of known standards (Sigma-Aldrich Chemie GmbH, Deisenhofen, Germany). Quantitative data were obtained by using tricosanoate ($C_{23:0}$) as an internal standard and response factors of FAME in comparison to the internal standard. Factors to convert FAME values to fatty acids were based on the molecular weight of each FAME.

The determinations of lipid content and fatty acid composition were done in duplicate. Chemicals were purchased from several suppliers (Sigma-Aldrich Chemie GmbH; Merck KGaA, Darmstadt, Germany; Fluka Chemie AG, Buchs, Switzerland) and were of analytical grade.

RESULTS AND DISCUSSION

Table 2 shows the fat content of the seeds. As usual for the proximate composition in plants, there is a wide variation in fat content (12–14). High fat content was found in seeds of *M. thonningii* (30.7%), *L. sericeus* (33.9%), and *E. angolense* (59.4%). The fat content of *E. angolense* was comparable to that reported for oilseeds with a high oil content, such as peanut (45–55%) or palm kernel (44–58%) (14,15) and promises to be a good oil source from a quantitative point of view.

To our knowledge, this is the first report on the fatty acid composition of these tropical seed samples with the exception of the tropical soybean samples. The fatty acid compositions of the oils of tropical soybean varieties were in the range of those described in the literature (Table 3) (15,16). Typically, high proportions of linoleic and oleic acid, as well as palmitic and linolenic acid, were observed in soybeans. The fatty acid compositions of the oils of *A. digitata*, *P. africana*, *A. lebbeck*, *E. cyclocarpium,* and *S. pachycarpa* were comparable with soybean oil (Tables 4 and 5). Interestingly, the fatty acid composition in the pods of *P. africana* was quite different from that in its seeds. Some of the other legume seeds contained a rather high content of linolenic acid (>20 g per 100 g oil) (*M. thonningii, L. sericeus, S. pachycarpa*) and a relatively low content of linoleic acid (*M. thonningii, L.*

TABLE 2
Fat Content of Selected Tropical Seeds

Seed sample	Fat (% fresh weight)
Adansonia digitata	14.80
Prosopis africana	3.09
Prosopis africana (pods)	0.39
Millettia thonningii	30.66
Gliricidia sepium	23.90
Albizia lebbeck	3.62
Albizia zygia	5.65
Lonchocarpus sericeus	33.88
Daniellia ogea	0.46
Pterocarpus osun	20.27
Pterocarpus santalinoides	0.16
Enterolobium cyclocarpium	10.32
Diospyros mespiliformis	5.46
Afzelia bella	23.17
Sesbania pachycarpa	16.19
Entandrophragma angolense	59.43
Glycine max (TGX 1660-15F)	21.77
Glycine max (TGX 1740-6F)	18.74
Glycine max (TGX 1740-2F)	22.19
Glycine max (TGX 1649-11F)	20.11
Glycine max (TGX 1681-3F)	18.62

sericeus). A high content of α-linolenic acid, ranging from 40 to 63%, has also been determined for cultivated flaxseed, *Linum usitatissimum* (16). Furthermore, some samples contain substantial amounts of behenic (*M. thonningii, A. lebbeck, L. sericeus, P. osun*) and lignoceric acid (*M. thonningii, L. sericeus, D. ogea, A. bella*). The presence of large amounts of long-chain saturated fatty acids is unusual for commonly used vegetable oils. Only peanut oil is known to contain up to 6% long-chain saturated fatty acids (16).

In the nonlegume varieties, high proportions of palmitic (*A. digitata, D. mespiliformis*) or palmitoleic acid (*E. angolense*) were found. Their linoleic and linolenic acid levels meet that of peanut oil (16). Further peculiarities are the high proportion of the $C_{18:1n\text{-}7}$ isomer of oleic acid in seeds of *E. angolense* and the presence of the docosahexaenoic acid in seeds of *D. mespiliformis*. The last-mentioned fatty acid usually occurs in phospholipids of animals but not in plant tissues (17,18). The content of saturated fatty acids was higher or much higher (*G. sepium, P. osun*) than in soybeans, except for *P. santalinoides, S. pachycarpa,* and *E. cyclocarpium*. Oil of *A. bella* contains 48 g of total fatty acids per 100 g of oil as several nonidentified fatty acids (Table 5). With the exception of *S. pachycarpa* [(P/S) = 3.15], generally, much lower polyunsaturated/saturated ratios [(P/S) = 0.83–2.12] were determined for all investigated wild seed samples than for soybeans (P/S = 3.4).

Tables 3–5 show the sum of fatty acids per 100 g oil. Usually, depending on the fatty acid composition of their triglycerides, values between 85 and 92 g of fatty acids are found in 100 g oil. For the soybean varieties and some other samples (*P. africana, G. sepium, P. osun*), the estimated values were in the same range. However, in most of the other investigated seed samples, the fatty acid content was lower than 80 g fatty acids per 100 g oil, and in some samples, the total amount of fatty acids was unusually low (<50 g fatty acids per 100 g oil). This is especially true for seed varieties that contain a low amount of total fat (*D. mespiliformis, P. santalinoides*). It indicates that the raw oils extracted from the seeds contain not only triglycerides or phospholipids but also considerable amounts of lipidic components, such as sterols, waxes and dyes, that were coextracted.

In conclusion, some of the investigated seeds may be exploited for the production of food oils because they are rich in

TABLE 3
Fatty Acid Composition of Selected Tropical Soybean Seed Oils (g fatty acid per 100 g oil)

Seed sample		*Glycine max* TGX 1660-15F	TGX 1740-6F	TGX 1740-2F	TGX 1649-11F	TGX 1681-3F	Mean	± SD
Myristic	$C_{14:0}$	—	—	—	—	—	—	—
Palmitic	$C_{16:0}$	10.49	10.44	9.77	9.64	9.74	10.02	0.37
Palmitoleic	$C_{16:1n\text{-}7}$	—	—	—	—	—	—	—
Hexadecadienic	$C_{16:2n\text{-}4}$	1.96	1.91	1.75	1.80	1.85	1.85	0.08
Stearic	$C_{18:0}$	3.25	3.48	3.56	2.93	3.59	3.37	0.25
Oleic	$C_{18:1n\text{-}9}$	22.32	24.13	22.48	21.21	15.78	21.18	2.86
Oleic (isomer)	$C_{18:1n\text{-}7}$	1.54	1.31	1.23	1.35	1.11	1.31	0.14
Linoleic	$C_{18:2n\text{-}6}$	44.32	38.47	37.42	38.49	43.91	40.52	2.96
Linolenic γ	$C_{18:3n\text{-}6}$	0.46	0.40	0.38	0.40	0.44	0.41	0.03
Linolenic α	$C_{18:3n\text{-}3}$	5.66	5.32	5.13	4.72	6.39	5.45	0.56
Arachidic	$C_{20:0}$	0.33	0.33	0.34	0.37	0.44	0.36	0.04
Gadoleic	$C_{20:1n\text{-}9}$	0.24	0.21	0.21	0.29	0.22	0.24	0.03
Behenic	$C_{22:0}$	0.41	0.37	0.40	0.44	0.53	0.43	0.06
Lignoceric	$C_{24:0}$	—	—	—	0.19	—	—	—
Docosahexaenoic	$C_{22:6n\text{-}3}$	—	—	—	—	—	—	—
Total		91.00	86.38	82.68	81.83	84.02	85.18	3.29
Saturated[a]		14.49	14.62	14.08	13.58	14.31	14.18	0.37
P/S ratio[b]		3.62	3.15	3.17	3.34	3.67	3.40	0.22

[a]Sum of $C_{16:0} + C_{18:0} + C_{20:0} + C_{22:0} + C_{24:0}$.
[b]Polyunsaturated ($C_{16:2} + C_{18:2} + C_{18:3} + C_{22:6}$)/saturated ($C_{16:0} + C_{18:0} + C_{20:0} + C_{22:0} + C_{24:0}$) ratio.

TABLE 4
Fatty Acid Composition of Selected Tropical Seed Oils (g fatty acid per 100 g oil)

Seed sample		*Adansonia digitata*	*Prosopis africana*	*Prosopis africana* (pods)	*Milletia thonningii*	*Gliricidia sepium*	*Albizia lebbeck*	*Albizia zygia*	*Lonchocarpus sericeus*
Myristic	$C_{14:0}$	0.19	—	—	—	—	—	—	—
Palmitic	$C_{16:0}$	15.50	9.15	11.04	4.78	15.13	5.64	13.82	6.64
Palmitoleic	$C_{16:1n\text{-}7}$	0.20	1.19	0.51	—	0.37	0.25	7.71	0.22
Hexadecadienic	$C_{16:2n\text{-}4}$	0.70	1.85	1.07	1.68	1.97	1.36	1.47	1.95
Stearic	$C_{18:0}$	3.12	4.54	3.03	2.69	16.21	2.65	2.67	2.31
Oleic	$C_{18:1n\text{-}9}$	24.69	29.38	8.69	17.90	23.98	11.15	13.44	18.03
Oleic (isomer)	$C_{18:1n\text{-}7}$	0.71	1.74	0.86	0.29	0.66	0.71	4.91	2.76
Linoleic	$C_{18:2n\text{-}6}$	19.11	29.82	26.43	7.66	28.47	15.80	13.58	6.77
Linolenic γ	$C_{18:3n\text{-}6}$	0.39	0.32	0.29	—	0.31	0.19	—	—
Linolenic α	$C_{18:3n\text{-}3}$	1.58	2.01	3.17	23.05	1.43	6.40	2.16	26.50
Arachidic	$C_{20:0}$	0.74	0.92	0.44	1.10	3.20	1.53	0.91	0.97
Gadoleic	$C_{20:1n\text{-}9}$	0.19	0.26	—	1.73	0.22	0.15	0.26	1.19
Behenic	$C_{22:0}$	0.36	0.78	0.31	8.93	1.65	5.21	1.62	8.46
Lignoceric	$C_{24:0}$	0.31	0.64	0.31	2.49	1.27	1.27	0.60	3.20
Docosahexaenoic	$C_{22:6n\text{-}3}$	—	—	—	—	—	—	—	—
Total		67.79	82.59	56.17	72.29	94.87	52.31	63.15	79.00
Sat.[a]		20.03	16.02	15.15	19.99	37.45	16.30	19.62	21.58
P/S ratio[b]		1.09	2.12	2.04	1.62	0.86	1.46	0.88	1.63

[a]Sum of $C_{16:0} + C_{18:0} + C_{20:0} + C_{22:0} + C_{24:0}$.
[b]Polyunsaturated ($C_{16:2} + C_{18:2} + C_{18:3} + C_{22:6}$)/saturated ($C_{16:0} + C_{18:0} + C_{20:0} + C_{22:0} + C_{24:0}$) ratio.

TABLE 5
Fatty Acid Composition of Selected Tropical Seed Oils (g fatty acid per 100 g oil)

Seed sample		*Daniellia ogea*	*Pterocarpus osun*	*Pterocarpus santalinoides*	*Enterolobium cyclocarpium*	*Diospyros mespiliformis*	*Afzelia bella*	*Sesbania pachycarpa*	*Entandrophragma angolense*
Myristic	$C_{14:0}$	—	—	0.20	—	—	—	—	—
Palmitic	$C_{16:0}$	7.47	12.02	7.01	5.45	11.82	2.24	6.91	3.81
Palmitoleic	$C_{16:1n\text{-}7}$	—	—	0.47	0.54	0.35	—	—	10.80
Hexadecadienic	$C_{16:2n\text{-}4}$	1.21	1.39	0.54	0.79	0.52	1.35	1.37	2.75
Stearic	$C_{18:0}$	1.40	5.17	2.94	4.37	3.22	2.25	4.27	10.36
Oleic	$C_{18:1n\text{-}9}$	6.56	18.32	5.62	10.54	7.74	8.08	16.14	1.55
Oleic (isomer)	$C_{18:1n\text{-}7}$	0.24	0.29	0.48	1.58	0.50	0.31	0.42	31.74
Linoleic	$C_{18:2n\text{-}6}$	27.66	27.79	11.49	18.06	8.04	20.42	18.67	11.13
Linolenic γ	$C_{18:3n\text{-}6}$	0.27	0.36	—	0.21	—	—	—	—
Linolenic α	$C_{18:3n\text{-}3}$	0.67	0.62	1.30	5.53	0.63	0.26	20.81	0.20
Arachidic	$C_{20:0}$	0.56	2.35	0.64	1.43	0.63	1.03	0.71	1.18
Gadoleic	$C_{20:1n\text{-}9}$	0.80	1.28	—	0.28	—	1.36	0.32	—
Behenic	$C_{22:0}$	3.30	10.44	1.08	2.44	0.51	4.02	0.85	0.33
Lignoceric	$C_{24:0}$	9.24	2.46	1.31	1.12	0.55	8.33	0.26	—
Docosahexaenoic	$C_{22:6n\text{-}3}$	—	—	—	—	4.65	—	—	—
Unidentified[a]							48.26		
Total		59.38	82.49	33.05	52.33	39.16	97.93	70.72	73.84
Sat.[b]		21.96	32.44	12.97	14.81	16.73	17.88[d]	12.99	15.67
P/S ratio[c]		1.36	0.93	1.03	1.66	0.83	1.23[d]	3.15	0.90

[a]Unidentified fatty acids eluting after 18:2n-6 (1.87 area%), after 20:1n-9 (26.83 area%) and before 20:4n-3 (15.50 area%).
[b]Sum of $C_{16:0} + C_{18:0} + C_{20:0} + C_{22:0} + C_{24:0}$.
[c]Polyunsaturated ($C_{16:2} + C_{18:2} + C_{18:3} + C_{22:6}$)/saturated ($C_{16:0} + C_{18:0} + C_{20:0} + C_{22:0} + C_{24:0}$) ratio.
[d]Without consideration of unidentified fatty acids.

essential fatty acids. But we recognize that information on yield, acceptability, and potentially harmful and toxic constituents in these seeds should further clarify the potential usefulness of these seeds as supplementary energy sources. Further research on these unconventional tropical plant seeds will show if some of the seeds described may be used as an addition to indigenous food supplies.

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