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Comparative Study of the Fatty Acid Composition of Some Seed Oils from Nigeria

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ABSTRACT

The fatty acid composition of 10 different seeds from Nigeria was determined. The data showed that most seeds (except for *Brachystegia eurycoma* and *Dacryodes edulis*) could be placed into one major group; they all contained more unsaturated fatty acids ranging from 55.58 to 79.93% for *Tamarindus indica* and *Monodora myristica*, respectively. Two unsaturated fatty acids, namely oleic (21.97-60.68%) and linoleic (5.73-39.42%) were the principal fatty acids. The two alone accounted for 25.47 to 75.71% of the total fatty acids found in the oils. The oil content of the seeds ranged between 3.77 and 55.05% of the seeds. The composition of the oils is nutritionally significant and the oils have potential for edible purposes.

Keywords: composition, fatty acid, gas chromatography, oilseeds, unconventional

INTRODUCTION

The major component of seed oils is triglyceride. They also contain small amounts of sterols, phospholipids and waxes. The type of fatty acid, its chain length, degree of unsaturation and double bond configuration determine the melting point of the fat or oil (Linscheer and Vergroesen 1985). The composition of the diet is an important determinant of serum lipid concentration in humans (Beynen and Katan 1989). The quantity and quality of lipids in the diet have an important bearing on the manifestation of disease or chronic toxic effects in humans. Cholesterol esters of 18:1 (n-9) density lipoproteins penetrate intimal cells and produce atherosclerosis hence reducing the intake of predominantly saturated fatty-acid-containing oils while increasing the amount of polyunsaturated fatty acids in the diet seems to be the best prophylactic measure to check vascular atherosclerosis (Menon 1989). Polyunsatutared fatty acids and their derivatives are important essential nutritive additives in mammals, especially in humans (Kamal-Eldin and Yanishlieva 2002; Ziboh *et al.* 2002; Stransky *et al.* 2005). Among the common vegetable oils, those of coconut, palm and palm kernel are known to have very low polyunsaturated fatty acid/saturated fatty acid (PUFA/SAFA) ratios somewhat like animal fat whereas those of safflower, soybean, corn, sesame, low erucic rape seed, some types of groundnut and mustard in decreasing order have high PUFA: SAFA ratio (Menon 1989). Arachidonic, linoleic and linolenic fatty acids are commonly referred to as essential fatty acids. They are highly unsaturated fatty acids which cannot be synthesized in the body but have to be ingested directly in the food. A diet rich in linoleic and linolenic acid can be obtained by eating plenty of vegetable seed oils. Arachidonic acid seldom occurs in vegetable oils but animals have no difficulty in synthesizing it from linoleic acid (Atrens 1994).

Plant seeds are important sources of oils of nutritional and pharmaceutical importance. The suitability of oil for a particular purpose is determined by its fatty acid composition (Dagne and Jonnson 1997). No oil from any single source has been found to be suitable for all purposes because oils from different sources generally differ in their fatty acid composition. In addition to nutritional, industrial or pharmaceutical uses of oil, patterns of fatty acid variation in plants have proven to be useful tools in determining the end use of the oil. This necessitates the search for new sources of novel oils. The objective of this work was to carry out a comparative study of the fatty acid composition of 10 seed oils. The seeds are *Adansonia digitata* Linn., *Calophyllum inophyllum* Linn., *Dacryodes edulis* G. Don H. J. Lam., *Monodora monodora* Gaertn. Dunat, *Pentaclethra macrophylla* Benth., *Terminalia catappa* Linn. and *Telfairia occidentalis* Hook f. Such information is important for defining unconventional seed oils that could have potential for possible future domestication and safe for human consumption.

C. inophyllum is exotic and is presently used as an ornamental tree. The mealy portion of *A. digitata* is soaked in water and used as a milk substitute; the leaf is used in making soup by the Hausas in Nigeria. *B. eurycoma* and *M. flagellipes* are used by the Igbos in South-west Nigeria as soup thickeners. *P. macrophylla* is fermented and then used as spice for cooking soup by the Igbos in Nigeria. *T. indica* is used for soup by the Hausas in the Northern part of Nigeria. *M. myrstica* is used as spice for pepper soup by the populace in Nigeria. The pulp of *D. edulis* fruit is boiled and eaten mostly by the Igbos in Nigeria; the seed is discarded. The fruit of *T. catappa* is eaten by both young and old in Nigeria while the seed is discarded. The leaves of *T. occidentalis* are used for cooking soup, the leaf is macerated in water and taken as blood tonic while the seeds are cooked as delicacy by the Igbos of Nigeria.

Although many researchers have worked on a number of these seeds (Ajayi 2004; Alabi *et al.* 2005; Odoemelam 2005; Sudjaroen *et al.* 2005; Amoo and Asoore 2006; Komolafe *et al.* 2006; Okwu 2006; Akubugwu and Ugbogu 2007; Oladele and Aina 2007; Ajayi 2008) there is no literature on a comparative study of the fatty acid of the seed oils under study.

MATERIALS AND METHODS

Plant materials and sample collection

The seeds of *C. inophyllum* and *A. digitata* were collected from the Botanical Garden, University of Ibadan and premises of

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Research Note

Table 1 List of the seeds analyzed, family nameand the abbreviations used.

Name of seed	Family name	Local name	Abbreviation used
Adansonia digitata Linn.	Bombacaceae	Oshe, Muchi, Bokky, Kuka	Ad
Brachystegia eurycoma Harms	Leguminosae-Caesalpiniodeae	Achi	Be
Calophyllum inophyllum Linn.	Guttiferae	-	Ci
Dacryodes edulis (G.Don)	Burseraceae	Ibo pear, Ube	De
Monodora mrystica Gaertn. Dunal	Annonaceae	African nutmeg	Mm
Mucuna flagellipes Hook. f.	Leguminosae-Papilionoideae	Ukpo	Mf
Pentaclethra macrophylla Benth.	Leguminosae-Mimosoideae	African oil-bean, Ugba	Pm
Tamarindus indica Linn.	Leguminosae-Caesalpiniodeae	Tsamiya	Ti
Telfairia occidentalis Hook. f.	Cucurbitaceae	Ugwu	To
Terminalia catappa Linn.	Combretaceae	Fruit	Tc

Table 2 Oil content and fatty acid composition of the analyzed seeds.

Name of seed	Ad	Be	Ci	De	Mf	Mm	Pm	Ti	To	Tc
Oil content [a]	**33.00**	**5.87**	**49.15**	**10.64**	**3.77**	**21.79**	**40.29**	**7.20**	**53.63**	**55.05**
Fatty acids[b]										
$C_{16:0}$	4.43	26.19	14.62	43.16	10.71	5.96	3.83	27.41	27.45	34.82
$C_{18:0}$	3.98	7.47	16.48	4.59	3.39	4.44	0.67	13.36	1.43	6.79
$C_{18:1}$	26.07	31.50	39.82	21.97	60.68	33.15	28.17	24.13	38.17	30.13
$C_{18:2}$	39.42	5.73	27.60	12.63	15.03	35.52	35.76	24.75	25.05	23.44
$C_{20:0}$	2.26	3.47	0.38	11.56	-	9.52	1.47	2.25	0.42	2.31
$C_{20:1}$	4.01	2.40	0.86	0.21	-	2.96	0.74	3.13	0.20	0.47
$C_{20:2}$	2.52	1.59	-	3.212	2.26	5.43	0.88	2.12	0.26	1.00
$C_{20:3}$	1.09	-	-	1.72	-	2.87	4.34	1.45	4.10	1.04
$C_{22:0}$	3.46	4.24	0.24	0.32	1.37	-	3.94	0.39	0.46	-
$C_{22:1}$	-	-	-	0.27	-	-	1.60	-	1.24	-
$C_{22:2}$	-	13.27	-	0.12	-	-	3.71	-	0.94	-
$C_{24:0}$	10.70	4.14	-	0.06	3.85	0.15	12.52	0.51	0.28	-
$C_{26:0}$	2.06	-	-	0.18	2.71	-	2.37	-	-	-

[a]Mean of triplicate result [b]Percentage of dry matter

University of Ibadan campus respectively while *T. indica* and the other seeds were purchased from Sabo and Ojo markets in Ibadan, Oyo State Nigeria. The seeds were identified in the Herbarium Unit of the Botany Department, University of Ibadan, Ibadan, Nigeria where vouchers of each specimen were already deposited. The collection extended from December to September during three consecutive years (1995-1997). 100-150 of each seed sample were collected. All chemicals used were supplied by British Drug House (BDH).

Sample preparation and extraction

The seeds were shelled manually by cracking to remove the kernels inside. The kernels were then ground to powder in a Hammer mill and stored in air tight sample bottle in a refrigerator (4°C) until needed for analysis. Seed oils were extracted with *n*-hexane for 8 h using a Soxhlet extractor. The solvent was removed completely and the oils obtained were used for this study.

Fatty acid analysis

The methyl esters of the crude oils were prepared in the University of Tuebigen, Germany following the method of Ajayi *et al*. (2007). 5 ml of CH_3OH and 1 ml of CH_2Cl_2 were added to 0.10 g of each oil sample. Ice was used to cool the mixture and then 0.6 ml of CH_2COCl was added. 1 ml of the solution was withdrawn into a hydrolysis tube and heated for 1 h at 110°C. The solution obtained was again cooled with ice and discharged into a separating funnel containing 10 ml of 100% NaCl solution. The extraction of the organics in the solution was carried out thrice with 4 ml of hexane; a rotatory evaporator was used to reduce the volume to 0.5 ml after which it was eluted on a silica gel column successively with 5 ml hexane and 4 ml CH_2Cl_2.

A separation was made of the CH_2Cl_2 fraction on a DB5 30 m × 0.25 mm capillary installed on a gas chromatograph (GC Chrompack 900l; J&W Scientific, Koln, Germany) equipped with computer software and mosaic integration. The programming of the temperature was 35°C for 3 min after which it was increased at 20°C/min up to 230°C for 5 min. The internal standard was heptadecanoic acid. The detector used was a flame ionization detector.

RESULTS AND DISCUSSION

The scientific name, family name and the abbreviations of the 10 seeds whose oils were analyzed for fatty acid are presented in **Table 1**. The fatty acid composition of the investigated oils is given in **Table 2**. The carbon chain length found in the samples ranged from $C_{16:0}$ to $C_{26:0}$ including unsaturated fatty acids. Lauric and myristic acids were completely absent in all the oils. Palmitic acid is the main saturated fatty acid in the seed oils; it ranged from 3.83% for *P. macrophylla* to 43.16% for *D. edulis*. All the seed oils contain stearic and arachidic acids; *M. flagellipes* however does not contain arachidic acid. It is now known that diet plays an important role in preventing certain disease. The relationship between dietary fat and certain chronic illness including cardiovascular, neoplastic, endocrine disease and so on is also recognized (Walker and Ball 1993). Consumption of saturated dietary fats has been associated with increased plasma concentration potentially increasing the risk of cardiovascular disease (Npales *et al.* 1996). The hypercholesterolemic effects of dietary saturated fat on plasma lipoproteins, in particular low-density lipoprotein LDL have been well documented (Segster *et al.* 2000). Monounsaturated fatty acids (MUFAs) such as oleic acid are known to reduce blood cholesterol levels in non-hypertrigleceridemic individuals. Because of the importance placed on dietary MUFA, it has been recommended that MUFA intake be as high as half of the total recommended dietary intake of calories from fat as a means for reducing the risk of cardiovascular disease (Nee and Foglia 2000). Recent studies have demonstrated that MUFAs are better contributors to plasma cholesterol lowering effects (Grundy *et al*. 1989).

All the oils except *T. catappa* and *C. inophyllum* contain lignoceric acid which is a long chain fatty acid in the range of 0.06% for *D. edulis* and 13.27% for *B. eurycoma.* Five of the seed oils namely *A. digitata*, *D. edulis*, *B. eurycoma*, *T. indica* and *M. flagellipes* contain cerotic acid which is also a long chain fatty acid. The oils are good sources of oleic and linoleic acids with values between 21.97% in *D. edulis* and 60.68% in *M. flagellipes* for oleic acid and 5.73% in *B. eurycoma* and 39.42% in *A. digitata* for linoleic acid. This

Table 3 Oleic, linoleic, MUFA, PUFA, UFA, SAFA, oleic/linoleic, MUFA/PUFA, SAFA/UFA contents of the analyzed seeds.

Parameters	Ad	Be	Ci	De	Mf	Mm	Pm	Ti	To	Tc
Oleic	26.07	31.50	39.82	21.97	60.68	33.15	27.17	24.13	38.17	30.13
Linoleic	39.42	5.73	27.60	12.63	15.03	35.52	35.76	24.75	25.05	23.44
MUFA[a]	30.08	33.90	40.69	20.45	60.68	36.11	30.51	27.26	39.61	30.60
PUFA[b]	40.03	7.32	27.60	17.68	17.29	43.82	44.69	28.32	30.35	25.48
UFA[c]	73.11	41.22	68.28	40.13	77.97	79.93	75.20	55.58	69.96	56.08
SAFA[d]	26.89	58.78	31.72	59.87	22.03	20.07	24.80	44.42	30.04	43.92
Oleic/Linoleic	0.66	5.50	1.44	1.73	4.04	0.93	0.79	0.97	1.52	1.29
MUFA/PUFA	0.75	4.63	1.47	1.16	3.51	0.82	0.68	0.96	1.31	1.20
SAFA/UFA	0.37	1.43	0.46	1.49	0.28	0.25	0.33	0.80	0.43	0.78

[a]Monounsaturated fatty acids; [b]Polyunsaturated fatty acids; [c]Unsaturated fatty acids; [d]Saturated fatty acids

is in close agreement with the report given by El-Adawy and Taha (2001) for oleic and linoleic acids in watermelon kernel seed oil (18% and 59.6%), pumkin kernel seed oil (20.4% and 55.6%) and paprika oil (14.6% and 67.8%. Jonnala *et al.* (2005) reported of oleic (39.9 to 44%) and linoleic acid (37 to 39%) for genetically modified peanut. Nzikou *et al.* (2006) also reported that the most abundant fatty acids of okra seed oil were oleic, linoleic and palmitic which together composed about 90% of the total fatty acids. The presence of high amounts of the essential linoleic acid suggests that these oils are highly nutritious. None of the oils contain linolenic acid but Longvah *et al.* (2000) reported that *Perilla* seed oil contains linolenic acid. Essential fatty acids are useful in alleviating fatty acid and deficiency syndrome and in preventing coronary heart disease (Gurr 1985; Pritchard and Rossel 1991).

Erucic acid was found in three of the seed oils namely *D. edulis* 0.27%, *T. occidentalis* 1.24% and *P. macrophylla* 1.60%; all these are however within the allowable limit of 5% for edible oil (Ahmed and Young 1982). Iodine value and oleic to linoleic ratio (O/L) are both indicators of oil stability and shelf life (Branch *et al.* 1990; Hansen *et al.* 1992). The oleic to linoleic ratio of six of the oils is greater than 1. The SAFA: UFA ratio of most of the oils is less than 1 (**Table 3**).

The consumption of diets containing high levels of polyunsaturated fatty acids has been reported to be immensely correlated to mortality from certain systemic disease. The evidence that the intake of saturated fatty acids and cholesterol are causally related to atherosclerotic cardiovascular diseases is convincing. The level of unsaturation of 6 out of the 10 oils is high; it ranged from 68.28% in *C. inophyllum* to 79.93% in *M. mrystica*; this is higher than 67.97% reported for canola seed oil (Shen *et al.* 2005) but lower than the 98.8% for *Plukenetia conophora* (Akintayo and Bayer 2002). These oils because of their high level of unsaturated fatty acids are likely to reduce coronary heart disease if consumed (Nielsen *et al.* 1992; Thompson *et al.* 1993). The ability of some unsaturated vegetable oils to reduce serum cholesterol level may focus attention on these seed oils due to their high unsaturated fatty acid content.

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