Fatty Acid Compositions of Tigernut Tubers (*Cyperus esculentus* L.), Baobab Seeds (*Adansonia digitata* L.), and Their Mixture

E. Eteshola* and A.C.I. Oraedu

Department of Biochemistry, University of Benin, Benin City, Nigeria

ABSTRACT: Fatty acid profiles and iodine values of tigernut tubers (*Cyperus esculentus* L.), decorticated seeds of the baobab tree (*Adansonia digitata* L.), and their mixture (one part of tigernut to three parts of baobab seeds, w/w) were chromatographically and chemically determined. All three samples contained myristic acid as the main saturated acid and oleic acid as the predominant unsaturated acid. Linoleic acid was present in the samples to the extent of 8.8–27.4%, and no other polyunsaturated acids were found. The vegetable oil mixture had the highest level of linoleate, and its possible significance in relation to the intended use in novel food formulation is discussed.
JAOCS 73, 255–257 (1996).

KEY WORDS: *Adansonia digitata* L., *Cyperus esculentus* L., fatty acids/essential fatty acids, mixture of oils, potential in novel food formulation.

Cyperus esculentus L. tubers, commonly known as tigernut or chufa, is a member of the Cyperaceae family. Tigernut grows mainly in the middle belt and in the nothern regions of Nigeria. It is a root crop, which grows widely in wet places as a grass and is sometimes cultivated for its small and sweet tubers. In some parts of Nigeria, the tubers are eaten like nuts or pounded into cakes and served at the end of a meal. It has been reported (1–4) that tigernut oil is of high nutritional value and can be used in food products. Shilenko *et al.* (3) have estimated that human dietary lipid requirements would be satisfied by eating 150–200 g of the tubers per day.

Baobab trees (*Adansonia digitata* L.) form part of a natural vegetation of northern Nigeria, where they grow wild. The leaves, fruit pulp, and seeds have wide and varied uses, especially in the savannah belt of Nigeria (5,6). Chemical analysis of the seeds has shown that they are rich in some essential amino acids and oil (7). Gaydou *et al.* (8) have reported that the oil of baobab seeds may be useful as an alimentary oil.

One of the criteria for the determination of fat quality is the content of the essential fatty acids, for example, linoleic, linolenic, and arachidonic. Many animals, including humans, require some of the essential fatty acids to prevent an essential fatty acid deficiency, which is manifested by skin lesions, poor hair growth, and low growth rates. The primary objective of this study, therefore, was to determine the components of the oils of the individual vegetables and their mixture, especially their content of essential fatty acids. The mixture formulation is intended to serve the same purpose as popular cereal-legume–based beverages such as Incarparina [Institute of Nutrition of Central America and Panama (INCAP), Guatemala City, Guatemala], Pro-Nutro (9) and Soyogi (10). As far as we know, the fatty acid profile of the vegetable mixture has not been reported in the literature.

MATERIALS AND METHODS

Sample preparation. Tigernut and baobab fruits for the study were purchased from a local market in Kano, Nigeria. The content of the dry baobab fruits was removed and crushed in a mortar to free the seeds from the adherent pulp. The tubers and seeds were washed, sun-dried, machine-ground, and sifted with a sieve of 710 μm diameter. The fine-powdered samples obtained were stored in stoppered plastic containers at 0–4°C until needed. The vegetable mixture was prepared by mixing three parts of the ground baobab seeds and one part of the tigernut powder.

Analytical. The oils were obtained from the *C. esculentus* L., *A. digitata* L., and their mixture by direct solvent extraction according to the method of Folch *et al.* (11). The iodine values of the oils were estimated by the Wijs' method (12). The fatty acid composition of the extracted oils was determined by converting aliquots into fatty acid metyl esters (FAME) by transmethylation as described by Feldman *et al.* (13). The FAME were chromatographically analyzed with a Pye Series 104 gas chromatograph equipped with a flame-ionization detector. A 2.1 m × 6 mm glass column (Johns Manville, Waterville, OH) packed with polyethyleneglycol adipate on 80–100 mesh chromosorb was used for the fatty acid analysis. The run was performed isothermally at 180°C with nitrogen as the carrier gas at a flow rate of 35 mL per min. The various fatty acids were identified and quantitated by reference to the authentic standards and peak evaluation by the triangulation method.

*To whom correspondence should be addressed at Department of Biomedical Engineering, TECHNICON, Technicon City, Haifa 32 00, Israel.

TABLE 1
Fatty Acid Composition of Tigernut and Boabab Seeds and Mixtures Thereof[a]

Fatty acids	Tigernut[a]	Baobab Seed[a]	Mixture[a]
Lauric	trace	—	—
Myristic	28.1	38.4	22.0
Palmitic	14.5 (14.1)[b]	19.7 (26.7[e], 27.2[f])	18.4
Stearic	3.4 (2.2)[b]	3.2 (5.8)[e]	3.2
Crotonic	trace	trace	—
Oleic	44.8 (69.0[b]; 73.9[c]; 71.39[d])	22.4 (41.9[e]; 36.8[f])	28.8
Linoleic	8.8 (13.2[b]; 9.5[c]; 6.33[d])	16.2 (20.6[d]; 21.6[f])	11.5
TUFA	53.6	38.6	40.3
TSFA	46.0	61.3	43.6
Ratio of UFA/SFA	~1.2:1.0	~0.6:1.0	~0.9:1.0
Iodine value (Wijs' 30 min)	131.2	127.0	125.1

[a]Results are expressed as percentage of the total fatty acids. TUFA, total unsaturated fatty acids (oleic and linoleic); TSFA: total saturated fatty acids (lauric, myristic, palmitic, and stearic); UFA, unsaturated fatty acids; SFA, saturated fatty acids. [b]Reference 14. [c]Reference 15. [d]Reference 17. [e]Reference 8. [f]Reference 18.

RESULTS AND DISCUSSION

The most abundant saturated fatty acids were myristic and palmitic, whereas the main unsaturated fatty acids present were oleic and linoleic (Table 1). Linolenic acid was not detected in any samples that were analyzed. Trace amounts of lauric and crotonic acids were found in the individual vegetable oils. The baobab seeds had the highest percentage of linoleic acid.

There was a marked difference between levels of most of the fatty acids in the tigernut and the baobab seeds. The stearic and palmitic acid content was virtually the same in both oils. The variation in the fatty acid content of the oils and their mixture ranged from 22.0–38.4% for myristic, 22.4–44.8% for oleic, and 8.8–16.2% for linoleic acids, respectively. The fatty acid compositions of the individual oils obtained in the present investigation were compared with the previously reported observations for the same oils and other oil-rich seeds (Tables 1 and 2). The present study has shown that oleic acid is the major fatty acid in tigernut, just as other investigators have reported (14–17). However, the oleic acid content is about 63% of the reported values. The linoleic acid is also less by about 9%, and the palmitic and stearic acid values are higher by about 3 and 55%, respectively. Other workers (14,15,17) did not find myristic acid in tigernut, whereas the acid constituted about 28.1% of the total fatty acid in the present investigation.

In contrast to the observations of Gaydou *et al.* (8) and Ralaimanarivo *et al.* (18), who did not find myristic acid in baobab seeds, and of A.O. Osagie (University of Benin, Benin City, Nigeria, personal communication), who reported only traces of the acid, the results of the present investigation have shown myristic acid to be present in baobab seeds at a level of 38.4%. These workers found that oleic acid is the major fatty acid in their oil, whereas the present study indicates that myristic acid is the predominant fatty acid.

This observation is surprising because others found either no myristic acid or only traces of it in these vegetables. Although the reason for this discrepancy is not immediately obvious, it is tempting to suggest that it may have arisen either as an artefact, or that the oils used in this study are unusual. The oleic acid content in the baobab seeds we used is 57% of the reported values (8,18). The linoleic acid found is also less (by about 23%) when compared with reported values (Table 1). However, the variability in the fatty acid composition of the oils, as reported by the different investigators, may be due to the age of the tissue analyzed, genetic history, climate, nutrition, temperature, and oxygen tensions, any of which can profoundly alter the composition of the endogenous lipid of a plant (19).

TABLE 2
Comparison of the Data for Tigernut and Baobab Seed and Published Data on the Fatty Acid Composition of Lipid Extract from the Oils of Some Common Seeds[a]

	Saturated fatty acids						Unsaturated fatty acids			
Source of oil	14:0	16:0	18:0	20:0	22:0	24:0	16:1	18:1	18:2	18:3
Tigernut	28.1	14.5	3.4	—	—	—	—	44.8	8.8	—
Baobab seed	38.4	19.7	3.2	—	—	—	—	22.4	16.2	—
Peanut (*Arachis hypogaea*)[b]	—	12.9	4.5	0.7	3.1	1.1	0.2	43.1	32.5	—
Soybean (*Soja hispida*)[b]	—	11.5	3.9	—	—	—	—	24.6	52.0	8.0
Corn (*Zea mays*); germ[b]	—	12.0	2.3	—	—	—	—	28.3	56.6	0.8

[a]Results are expressed as percentage of the total fatty acids. [b]Data from Reference 20.

The present investigation has shown that the vegetable oil mixture has a fairly high level of linoleic acid when compared with the individual oils (Table 1). Linoleic acid (vitamin F) is an unsaturated and essential fatty acid that is needed for growth and tissue repair. The mixture has been observed to promote growth in weanling albino rats (Eteshola, E., and A.C.I. Oraedu, unpublished data). Thus, the relatively high levels of the unsaturated fatty acids (especially oleic) in the samples indicate a nutritive potential for these oils as well as their mixture (see Table 2; Ref. 20). Okladnikov *et al.* (21) have reported that *C. esculentus* L. is a good source of polyunsaturated fatty acids for humans. Whereas up to 100 g of lactogen powder, a commercial baby food, provides 2.4 g of linoleate (nutritional label information; Nestle Nordisk A/S, Copenhagen, Denmark), only about 70 g of the vegetable mixture would be needed to provide the same amount of linoleate. The mixture may thus serve as a better source of this essential fatty acid as compared with lactogen.

The formulation may need fortification with vitamin E to prevent peroxidation, which would otherwise ensue from the presence of excess linoleic acid. However, this may not be necessary because it has been reported that tigernut oil, one of the constituent oils in the vegetable mixture, is rich in vitamin E (15). Vitamin E is a natural antioxidant, which prevents the development of a disagreeable smell and taste in oils due to peroxidation of polyunsaturated fatty acids.

REFERENCES

1. Osman, F. and A.M. Gad, Nutritive Value of *Cyperus esculentus* oil, *Chem. Abstr. 77*:74011r (1972).
2. Gogolewski, M., and J. Mackowiak, A Characteristic of Chemical Components and Utilization Value of Some Varieties of *Cyperus esculentus*, *Ibid. 87*:182864m (1977).
3. Shilenko, M.P., Kalacheva G.S., Lisovski G.M., and I.N. Trubachev, *Cyperus esculentus* L. as a Source of Vegetable Oils in a Closed Life Support System, *Kosm Biol Aviakosm Med 13*:70–74 (1979).
4. Okigbo, B.N., New Crops for Food and Industry: The Roots and Tubers in Tropical Africa, in *New Crops for Food and Industry*, edited by G.E. Wickens, N. Haq, and P. Day, Chapman and Hall, London, 1989, pp. 123–134.
5. Owen, J., The Medico-Social and Cultural Significance of *Adansonia digitata* (Baobab) in African Communities, *African Notes 6*:24–36 (1970).
6. Balogun, A.M., and F. Babatunde, Tannin, Phytin and Oxalate Contents of Some Wild Underutilized Crop-Seeds in Nigeria, *Food Chem. 30*:37–43 (1988).
7. Addy, E.O., and E. Eteshola, Nutritive Value of a Mixture of Tigernut Tubers (*Cyperus esculentus* L.) and Baobab Seeds (*Adansonia digitata* L.), *J. Sci. Food Agric. 35*:437–440 (1984).
8. Gaydou, E.M., A. Ralaimanarivo, and J.P. Bianchini, Oil of the African Baobab: Fatty Acid and Sterol Composition of *Adansonia digitata* L., *Chem. Abstr. 92*:90895x (1980).
9. Orr, E., *The Contribution of New Food Mixtures to the Relief of Malnutrition—A Second Look*, TPI Publication, 1976.
10. Akinrele, I.A., and C.C.A. Edwards, An Assessment of the Nutritive Value of a Maize-Soya Mixture, Soy-Ogi, as a Weaning Food in Nigeria, *Br. J. Nutr. 26*:177–185 (1971).
11. Folch, J.M., M. Less, and G.H.S. Stanley, A Simple Method for the Isolation and Purification of Total Lipids from Animal Tissues, *J. Biol. Chem. 226*:497–509 (1957).
12. Pearson, D., The Chemical Analysis of Foods, 6th edn. J. and A. Churchill, London, 1970, pp. 510–511.
13. Feldman, G.L., H.T. Johnson, T.W. Culp, and R.H. Gowan, Fatty Acid Composition of Embryonic Fat Organ Lipids, *Poultry Sci. 41*:418–469 (1962).
14. Petrov, P., L. Grozdanova, G. Mechenov, P. Krustanov, R. Chobanova, I. Marinchevski, and L. Nedelcheva, Promising Oil Bearing Sources: I. Chemical and Technological Characteristics of Sedge *Cyperus esculentus* L., *Chem. Abstr. 83*:99648r (1975).
15. Chelkowski, I., and K. Leonczuk, Evaluation of Technological Suitability of *Cyperus esculentus* L., *Przem. Spozyw. 32*:468–469 (1978).
16. Matthiesen, R.L., and E.W. Stoller, Tuber Composition in Yellow Nutsedge (*Cyperus esculentus* L.) Variants, *Weed Res. 18*:373–377 (1978).
17. Gad, A.M., and F.A. Osman, Chemical Constitution of Egyptian Chufa, *Chem. Abstr. 56*:8863 (1962).
18. Ralaimanarivo, A., E.M. Gaydou, and J.P. Biachini, Fatty Acid Composition of Seed Oils from Six *Adansonia* Species with Particular Reference to Cyclopropane and Cyclopropene Acids, *Lipids 17*:1–10 (1982).
19. Stump, P.K. (ed.) *Lipids: Structure and Function—The Biochemistry of Plants, A Comprehensive Treatise*, Vol. 4, Academic Press, New York, 1980, pp. 2–261.
20. Hitchcock, C., and B.W. Nichols, *Plant Lipid Biochemistry*, Academic Press, New York, 1971, p. 63.
21. Okladnikov, Yu.N., Ya.B. Vorkel, I.N. Trubachev, N.V. Vlasova, and G.S. Kalacheva, Inclusion of Yellow Nut Grass in the Human Diet as a Source of Polyunsaturated Fatty Acids, *Chem. Abstr. 87*:51992d (1977).

[Received November 29, 1994; accepted November 13, 1995]