Food Chemistry **32** (1989) 109–116

β-Carotene Content and Some Characteristics of Under-Exploited Seed Oils of Forest Trees in Nigeria

A. I. Essien,* B. L. Fetuga‡

Division of Nutritional Biochemistry, Department of Animal Science, University of Ibadan, Ibadan, Nigeria

&

O. Osibanjo

Department of Chemistry, University of Ibadan, Ibadan, Nigeria

(Received 6 May 1988; accepted 8 July 1988)

ABSTRACT

The β-carotene contents of twenty-one seed oils of forest trees were determined. Values ranged from 11·97 μg/100 g oil for Berlinia auriculata *to 684 μg/100 g for* Lonchocarpus caprium. *Six of the seed oils (from* B. monandra, T. tetraptera, P. osun, L. caprium, T. scleroxylon *and* V. africana*) were identified as useful sources of Vitamin A activity based on their carotene content. β-Carotene values of these seed oils were generally much higher than those for palm kernel oil, beniseed oil and corn oil. Some physical and chemical characteristics of thirteen of these seed oils were also investigated. The refractive index averaged 1·467 ± 0·005 while the mean values for iodine value, saponification value, and per cent unsaponifiable matter were 77·8 ± 4·7, 158 ± 6·2 and 1·17 ± 0·12, respectively. Values for volatile matter, moisture, peroxide value and free fatty acid are also discussed. Generally, these seed oils exhibited characteristics similar to those reported in the literature for other oils.*

Present addresses: * Department of Agriculture, Animal Science Division, University of Cross River State, Uyo-Akwa Ibom State, Nigeria. ‡ Glaxo (Nig) Limited, Agbara Industrial Estate, Agbara, Ogun State, Nigeria.

INTRODUCTION

In the search for new industrial oils, Earle *et al.* (1960) conducted studies on 158 species of plants representing 52 families and 23 orders. In their investigation, both the physical and chemical characteristics of the oils were determined. Those with high oil content and fatty acid composition, thought to be sufficiently different from those of the commercial vegetable oils, were scheduled for more intensive study.

In Nigeria, the major sources of vegetable oil at present consist of seeds of annual plants such as groundnut, soyabean, cottonseed, beniseed and melon seed, and those of oil-bearing trees of which the oil palm and coconut are most important. Presently, there is a shortfall in the production of edible oil from these conventional sources, leading to the importation of vegetable and industrial oils with its attendant huge foreign exchange costs and high consumer prices. Studies on some aspects of the seeds of lesser known, unconventional plants have received attention in recent times. While Amubode & Fetuga (1983, 1984) and Balogun & Fetuga (1986) have published information on the protein and amino acid composition of some forest seeds, Balogun & Fetuga (1985*a*,*b*) have analysed some of the seeds for per cent oil content and oils for their fatty acid profiles. As a follow up to an earlier work done in our laboratory, it was intended that some of these seed oils of forest origin be analysed for their β-carotene contents and some of the constants employed in the characterisation of seed oils. The results are reported in this paper.

MATERIALS AND METHODS

Source of seeds and seed oils

The forest tree seeds used in this study were obtained from different sources including the Forestry Research Institute of Nigeria (FRIN), Ibadan, Nigeria, and the University of Ibadan Botanical Garden. The oils were extracted from these seeds by the Soxhlet method (AOAC, 1975).

The four conventional vegetable oils used in this study (palm kernel oil, red palm oil, beniseed oil and corn oil) were obtained from the Food Laboratory of the Department of Chemistry, University of Ibadan.

β-Carotene analysis

The method used for β-carotene analysis of the oil samples was based on the Report of the Vitamins (Fat Soluble) Panel, a Sub-committee of the

Analytical Methods Committee (1964). The unsaponifiable matter extracted from portions of the oil samples using light petroleum after refluxing with ethanolic potassium hydroxide was chromatographed on a column of neutral alumina and rechromatographed on a column of magnesium oxide to separate the β-carotene. The absorbance of the eluate collected was measured over the range 440 to 450 nm using a spectrophotometer.

Physical and chemical characteristics of oils

The different physical and chemical characteristics of the seed oils used in this study (refractive index, per cent volatile matter, moisture, iodine value, saponification value, per cent unsaponifiable matter, peroxide value and free fatty acid) were determined by methods of the American Oil Chemists Society (1975).

RESULTS AND DISCUSSION

The results of the β-carotene determination of twenty-one seed oils of trees of forest origin and four conventional oils are shown in Table 1. β-Carotene values for the under-exploited seed oils ranged from as low as 11·97 μg/100 g for *Berlinia auriculata* to 684 μg/100 g for *Lonchocarpus caprium*. Apart from the *Berlinia auriculata* seed oil, the average value for the other three members of the Caesalpinaceae family was 159·5 μg/100 g ± 42·35 which was higher than the mean for seed oils of the Melliaceae family but lower than that for the two oils of the Mimosaceae family (175·4 μg/100 g). When compared with the values obtained for three of the conventional vegetable oils used in this study (palm kernel oil, beniseed oil and corn oil), β-carotene values of the seed oils of forest trees were much higher (151·1 μg/100 g ± 38·99 v 13·15 μg/100 g ± 4·72). While the β-carotene values for *Berlinia auriculata* (11·97 μg/100 g) and *Enthandrophragma angolense* (13·59 μg/100 g) were similar to the value obtained for beniseed oil (11·54 μg/100 g), seed oils of *Gliricidia sepium* (25·00 μg/100 g), *Blighia sapida* (26·20 μg/100 g), *Lophira alata* (20·90 μg/100 g) and *Pycnanthus angolense* (25·21 μg/100 g) had β-carotene values in the same range as that of palm kernel oil (22·00 μg/100 g). However, when these values are based on the classification of the vitamin A activity of certain oils and foods by Pyke (1975), seed oils of *Bauhinia monandra, Tetrapleura tetraptera, Pterocarpus osun, Triplochiton scleroxylon, Voacanga africana*, and *Lonchocarpus caprium*, whose β-carotene values range from 22·4 μg/100 g to 680·0 μg/100 g, can be referred to as useful sources of vitamin A. The value of 87 881 μg/100 g obtained for red palm oil, a conventional vegetable oil used in this study, is similar to the value of

TABLE 1

Mean[a] β-Carotene Values of some Under-exploited Seed Oils compared with those of some Conventional Vegetable Oils (μg/100 g)

Source of seed oil	*Family*	*β-carotene content*
A. Under-exploited seed oils		
Bauhinia monandra	Caesalpiniaceae	222·4
Berlinia auriculata	Caesalpiniaceae	11·97
Cassia nodosa	Caesalpiniaceae	177·1
Daniella oliverii	Caesalpiniaceae	78·90
Carapa procera	Melliaceae	54·99
Cedralla odorata	Melliaceae	91·74
Enthandrophragma angolense	Melliaceae	13·59
Khaya senegalensis	Melliaceae	47·02
Lovoa trichilloides	Melliaceae	40·90
Adenanthera pavonina	Mimosaceae	122·8
Tetrapteura tetraptera	Mimosaceae	227·9
Gliricidia sepium	Papilionaceae	25·00
Pterocarpus osun	Papilionaceae	272·3
Terminalia glucausens	Combretaceae	34·57
Adansonia digitata	Bombaceae	43·36
Blighia sapida	Sapindaceae	26·20
Lonchocarpus caprium	Leguminosae	684·0
Lophira alata	Ochnaceae	20·90
Pycnanthus angolense	Myristicaceae	25·21
Triplochiton scleroxylon	Sterculiaceae	478·0
Voacanga africana	Apocynaceae	490·9
B. Conventional vegetable oils		
Palm kernel oil		22·00
Red palm oil		87 881
Beniseed oil		11·54
Corn oil		5·90

[a] Average of duplicate analyses.

88 500 μg/100 g for the *tenera* variety of palm oil reported by Sannoh (1978). β-Carotene values either lower or higher than that reported in this study for palm oil have been obtained by other workers and this has been attributed to differences in extraction methods and varietal differences of the fruit. The values of some physical and chemical characteristics of 13 forest seed oils and four conventional vegetable oils are presented in Table 2. The mean refractive index for the forest tree seed oils was $1{\cdot}467 \pm 0{\cdot}005$ and $1{\cdot}465 \pm 0{\cdot}005$ for the conventional seed oils. These values are close to the mean ($1{\cdot}469 \pm 0{\cdot}001$) reported by Earle *et al.* (1960) for seed oils of 160 trees. The refractive index values obtained in this study are lower than the mean of

TABLE 2
Some Physical and Chemical Characteristics of Seed Oils of Under-exploited Forest Trees (duplicate analyses)

Source of seed oil	*Refractive index* (n_D *40°C*)	*Volatile matter (%)*	*Moisture (%)*	*Iodine value*	*Saponification value (mg KOH/g)*	*Unsaponifiable matter (%)*	*Peroxide value*	*Free fatty acid (%)*
Cassia nodosa	1·460	14·01	15·03	82·9	135·2	1·13	12·61	8·91
Carapa procera	1·464	3·11	4·71	60·6	164·4	1·34	4·58	9·95
Enthandrophragma angolense	1·475	3·08	3·67	86·5	145·6	2·02	3·25	16·08
Lovoa trichilloides	1·475	3·09	0·40	122·7	167·8	1·30	12·15	10·08
Gliricidia sepium	1·465	1·12	1·93	72·0	156·5	1·51	11·20	11·19
Terminalia glucausens	1·464	2·82	4·41	73·5	158·8	0·73	8·89	15·59
Adenanthera pavonina	1·465	1·30	1·57	86·8	150·0	0·83	21·80	1·21
Tetrapleura tetraptera	1·467	3·54	4·27	78·8	155·0	1·46	14·60	2·73
Voacanga africana	1·475	2·69	3·17	80·3	148·3	1·66	7·42	3·62
Adansonia digitata	1·468	1·65	2·08	85·2	157·1	0·82	1·86	15·53
Blighia sapida	1·460	6·91	7·48	58·7	136·6	0·60	7·76	12·44
Lophira alata	1·465	2·87	3·40	60·4	158·0	0·91	4·07	3·82
Pycnanthus angolense	1·471	1·03	3·77	63·5	225·3	0·88	8·41	23·75
Palm kernel oil	1·454	1·56	3·93	16·3	204·7	1·80	11·63	8·44
Red palm oil (unrefined)	1·462	1·84	1·37	55·7	171·0	0·73	8·57	21·30
Beniseed oil (unrefined)	1·470	1·02	1·12	110·8	159·1	0·93	9·43	9·51
Corn oil (refined)	1·475	1·61	0·83	71·1	161·9	1·03	21·38	0·51

1·475 reported by Ali & McKay (1982) for different varieties of rapeseed and mustard seed oils. This difference in refractive index could be related to the differences in fatty acid profile since higher values have been associated with increase in length of the hydrocarbon chains and the number of double bonds in the chains. Balogun & Fetuga (1985*a*,*b*) reported a higher proportion of the C16–C18 fatty acids for some of the oils used in the present study while Ali & McKay (1982) obtained a higher fraction of the C20–C24 fatty acids. Within the Melliaceae family, differences in refractive index between *Carapa procera*, *Lovoa trichilloides*, and *Enthandrophragma angolense* could be directly related to their fatty acid composition published by Balogun & Fetuga (1985*b*). Values for the two members of the Mimosaceae family, *A. pavonina* and *T. tetraptera*, were, however, very similar.

Percentage volatile matter changed in the same direction as percentage moisture with moisture being consistently higher.

The mean iodine value for the under-exploited seed oils was $77{\cdot}8 \pm 4{\cdot}7$, indicating a lower degree of unsaturation when compared to most plant oils (Earle *et al.*, 1960; Itoh *et al.*, 1973; Ali & McKay, 1982). The comparatively higher iodine value for *Lovoa trichilloides* (122·7) can be related to a correspondingly higher proportion of the unsaturated fatty acids (84·88%) than other seed oils used in this study as reported by Balogun & Fetuga (1985*a*). Results in this study reveal that, within the same family, variations do exist in the iodine values, confirming earlier observations by Earle *et al.* (1960) who reported values of 151 and 79 for two seed oils of the Apocynaceae family and values ranging from 100 to 211 for four members of the Euphoribiceae family.

The saponification values for the seed oils of forest trees ranged from 135·2 for *Cassia nodosa* to 225·3 for *Pycnanthus angolense*, averaging $158{\cdot}4 \pm 6{\cdot}2$ which is less than $174{\cdot}2 \pm 10{\cdot}5$, obtained for the four conventional oils, implying that the average molecular weight of the fatty acids constituting the fats in seed oils of forest origin was greater than that for the conventional oils used in this study. The values are, however, lower than those reported by Itoh *et al.* (1973) for nineteen conventional vegetable oils and Ali & McKay (1982) for rapeseed oils.

The unsaponifiable matter ranged from 0·60% for *Blighia sapida* to 2·0% for *Enthandrophragma angolense*. These values are within the range reported for some seed oils by Earle *et al.* (1960) but higher than those of Itoh *et al.* (1973) for some unrefined vegetable oils.

The peroxide value of the seed oils ranged from 1·86 for *Adansonia digitata* to as high as 21·8 for *Adenanthera pavonina*. The range for the conventional oils used alongside this study was from 8·57 for palm oil to 21·38 for corn oil. The values obtained in this study were generally high with respect to peroxide values of good quality oils. The comparatively lower peroxide value of the seed oil of *T. glucausens* (8·89) than that of *A. pavonina* (21·8) is a possible reflection of the degree of unsaturation in both oils. Percentage proportions of total unsaturated fatty acids reported for *T. glucausens* and *A. pavonina* by Balogun & Fetuga (1985*a,b*) are 59·8% and 77·2%, respectively. Apart from the degree of unsaturation in fats, which enhances the addition of oxygen at the double bond, thereby forming peroxides, the other factor which affects peroxide values of fats is the presence of a single methylene group between two double bonds.

The percentages of free fatty acids obtained for oils in this study were generally high and suggestive of the extent of hydrolysis that must have occurred in the course of storage prior to the analysis of each sample.

ACKNOWLEDGEMENT

The authors hereby express their gratitude for the technical assistance of Mr Philip Aigberua of the Food Laboratory, Department of Chemistry, University of Ibadan.

REFERENCES

Ali, A. & McKay, J. E. (1982). The chemical and physical characteristics and fatty acid composition of seed oils extracted from cruciferous species cultivated in Pakistan. *Food Chem.*, **8**, 225–31.

American Oil Chemists' Society (AOAC) (1975). *Official and Tentative Methods.* (3rd edn), revised AOCS, Champaign, Illinois.

Amubode, F. O. & Fetuga, B. L. (1983). Proximate composition and chemical assay of the methionine, lysine and tryptophan concentrations of some forest seeds. *Food Chem.*, **12**, 67–72.

Amubode, F. O. & Fetuga, B. L. (1984). Amino acid composition of seeds of some lesser known tree crops. *Food Chem.*, **13**, 299–307.

Analytical Methods Committee (1964). *Analyst*, **89**, 7–17.

Association of Official Analytical Chemists (AOAC) (1975). *Official Methods of Analysis*, AOAC, Washington, DC.

Balogun, A. M. & Fetuga, B. L. (1985*a*). Fatty acid composition of seed oils of some members of the Melliaceae families. *J. Am. Oil Chem. Soc.*, **62**, 529–31.

Balogun, A. M. & Fetuga, B. L. (1985*b*). Fatty acid composition of seed oils of some members of the Leguminosae family. *Food Chem.*, **17**, 175–82.

Balogun, A. M. & Fetuga, B. L. (1986). Chemical composition of some under-exploited leguminous crop seeds in Nigeria. *J. Agric. Food Chem.*, **34**, 189–92.

Earle, F. R., Glass, C. A., Geisenger, C., Wolf, A. & Jones, Q. (1960). Search for new industrial oils. *J. Am. Oil. Chem. Soc.*, **37**, 440.

Itoh, T., Tamura, T. & Matsumoto, T. (1973). Sterol composition of 19 vegetable oils. *J. Am. Oil Chem. Soc.*, **50**, 122–5.
Pyke, M. (1975). In *Success in Nutrition*. John Murray Publishers, London, 127–33.
Sannoh, W. (1978). The Bleachability and Chemical Composition of Nigerian Palm Oil. PhD thesis, University of Ibadan, Nigeria.