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Fatty Acid Composition of Seed Oils of Some Members of the Leguminosae Family

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ABSTRACT

Seed oils of ten leguminous tree crops were investigated for their fatty acid composition. Saturated acid components of the leguminous seed oils analysed revealed that low molecular weight acids (capric and lauric) did not commonly occur. On average, palmitic acid (19·4 ± 10·6) was the only major saturated acid present. However, within the subdivision Mimosoideae stearic acid content was slightly higher than in the subdivision Caesalpinoideae. Two members of the subdivision Mimosoideae—Tetrapleura tetraptera (*13·9%*) *and* Parkia clappertoniana (*19·7%*)—*showed unusually high levels of behenic acid (22·0). Lignoceric acid (24·0) was not detected in any of the oils analysed.*

The major unsaturated acids in the seed oils of the leguminous crops investigated were oleic and linoleic acids, both comprising about 68·3% of the component acids. All members except P. africana (*Mimosoideae*) *and* Pterocarpus osun (*Papilionaceae*) *were richer in linoleic acid than in oleic acid. Linoleic acid even comprised more than 50% of the component fatty acids in the seed oils of* Adenanthera pavonina, T. tetraptera, D.

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oliverii *and* Bauhinia monandra. *Very low levels of linolenic acid were detected in all the leguminous seed oils investigated. The nutritional implications of the component fatty acids are discussed.*

INTRODUCTION

The value of edible legumes as a source of cheap quality proteins for both humans and animals has long been recognised. Most dry leguminous seeds grown in Nigeria possess exceptional grain qualities, including excellent palatability, high content of good quality proteins and large seed size.

Nigeria has several grain legume species that combine different characteristics of direct importance for specific situations and needs (Onochie, 1972). These legumes include groundnut (*Arachis hypogea*), cowpea (*Vigna unquiculata*), soybean (*Glycine max*), Limabean (*Phaseolus lunatus*) and African locust bean (*Parkia filicoidea*). Whilst most of these species have been essentially important for their immense contribution of protein to the Nigerian diet, groundnut and soybean have received considerable attention because of their high oil content, as well as high protein content—hence their classification as oilseeds. These two species contain oils of worldwide commercial importance; therefore, their fat characteristics and fatty acid components have been extensively investigated (Smouse & Chang, 1967; Howells *et al.*, 1972).

However, recent studies (Balogun, 1982) have revealed that some underexploited leguminous seed crops contain appreciable amounts of oil which could warrant their screening for increased edible oil production in Nigeria. In this respect, seeds of *Adenanthera pavonina*, *Prosopis africana*, *Parkia clappertoniana*, *Daniela oliverii* and *Pterocarpus osun*, among others, contain between 16% and 27% of oil. It is therefore necessary to investigate the fat characteristics and fatty acid composition of these oils if their nutritional desirability is to be established.

As an initial step in achieving these goals, the present study reports the fatty acid composition of some of these hitherto neglected leguminous crop seeds.

MATERIALS AND METHODS

The leguminous seeds used in this study were: *Adenanthera pavonina*, *Prosopis africana*, *Parkia clappertoniana*, *Tetrapleura tetraptera*,

Daniela oliverii, *Bauhinia monandra*, *Detarium microcarpum*, *Berlinia auriculata*, *Cassia nodosa* and *Pterocarpus osun*.

Matured seeds of these species were collected from the Forestry Research Institute of Nigeria (FRIN), Ibadan, Nigeria, They were ground in a laboratory mill to pass through a BS 60 mesh sieve and stored in a kilner jar at −4 °C.

Milled samples were extracted for their oils by the Soxhlet method (AOAC, 1975). Extracted oils were methylated according to the procedure described by Metcalfe & Schmidt (1960) and the dry heptane solution of the methyl esters was then used for the fatty acid analysis. The dry heptane solution was injected directly through a microsyringe into a Packard 419 Becker gas chromatograph.

Operating conditions

Model	Packard 419 Becker gas chromatograph
Detector	Flame ionisation
Stationary phase	Polyethylene glycol succinate (PEGS)
Support	Chromosorb W 80-120 mesh
Column length	1·30 m
Type of column	Coiled glass column
Detector temperature	210 °C
Injector part temperature	210 °C
Column temperature	180 °C
Carrier gas	Nitrogen
Chart speed	10 mm/min
Flame producer	Hydrogen and air (oxygen)
Solvent	*n*-heptane (chromatographically pure)

The newly prepared column (10% of PEGS on support) was conditioned at 20 °C above the operating temperature with the carrier gas running overnight. The detector apparatus was then adjusted to the operating temperature with the carrier gas flowing and the baseline recorded to check the stability of the instrument. A small quantity of methyl ester solution (between 3 and 5 μl) was introduced onto the column. The pressure change that occurred was registered in the detector and came out as a solvent peak from which the retention times of the components were measured on the chart.

TABLE 1
Fatty Acid Composition of Oils of Some Members of the Leguminosae Family

	Mimosoideae					*Caesalpinoideae*										
	Prosopis africana	Adenanthera pavonina	Tetrapleura tetraptera	Parkia clappertoniana	*Mean*	*SD*	Daniela oliverii	Detarium microcarpum	Bauhinia monandra	Berlinia auriculata	Cassia nodosa	*Mean*	*SD*	Pterocarpus osun (*Papilionaceae*)	*Mean for Leguminosae*	*SD*
Capric acid	—	—	—	—	—	—	0·2	—	0·1	—	—	0·06	—	—	0·03	—
Lauric acid	—	—	0·7	0·5	0·30	—	—	0·2	—	4·4	—	0·92	—	—	0·58	—
Myristic acid	—	1·8	6·5	0·1	2·10	—	0·30	—	1·4	0·4	—	0·42	—	0·3	1·08	—
Palmitic acid	15·4	11·8	4·0	20·6	13·0	6·1	14·2	10·9	23·1	44·6	25·3	23·6	11·8	23·9	19·4	10·6
Stearic acid	6·2	4·2	1·9	11·5	5·95	3·5	3·1	3·0	6·4	3·2	2·0	3·54	1·48	3·8	4·53	2·73
Palmitoleic acid	0·9	—	—	—	0·24	—	0·2	—	0·1	0·5	—	0·16	—	—	0·97	—
Oleic acid	39·4	24·3	16·9	11·8	23·1	10·4	15·6	36·1	18·1	17·7	25·3	22·6	7·54	35·7	24·1	9·32
Linoleic acid	35·2	50·7	54·7	32·4	43·4	9·54	55·5	38·0	50·4	27·3	45·3	43·3	9·86	33·1	42·3	9·72
Linolenic acid	1·7	2·8	0·9	0·5	1·8	0·85	1·3	2·4	0·2	1·3	0·9	1·18	0·73	1·4	1·32	0·77
Gadoleic acid	—	—	—	—	—	—	—	—	—	0·15	—	0·02	—	—	—	—
Arachidic acid	0·8	1·8	0·6	2·9	1·53	0·93	1·1	0·7	0·4	0·8	1·3	0·86	0·31	1·8	1·22	0·72
Behenic acid	0·4	2·4	13·9	19·7	9·10	7·99	8·5	8·6	—	—	—	3·42	—	—	5·35	3·22
Total saturates	22·8	22·0	27·6	55·3	31·9	13·6	27·4	23·5	31·4	53·4	28·6	32·8	10·6	29·8	32·2	11·5
Total unsaturates	77·2	78·0	72·4	44·7	68·1	13·7	72·6	76·5	68·6	46·6	71·4	67·1	10·6	70·2	67·8	11·5

Identification of fatty acids and measurement of peak areas

The chromatograms of known esters and their mixtures, which included the components assumed to be present in the sample mixtures, were first run to calibrate the instrument.

The retention distance of each component was measured on the trace between the air peak at the start of the chromatograms and the apex of the component peak. The retention time was calculated for each ester by dividing the retention distance by the chart speed (Heyes, 1963). The fatty acids were then identified by their relative retention times compared with those of known esters. The area of each peak was determined using the triangulation method (half base × perpendicular height). The percentage of each area of all peaks was calculated as the percentage of each component.

RESULTS AND DISCUSSION

The results of fatty acid analysis for the seed oils of ten members of the Leguminosae family are presented in Table 1. Saturated acid components of the seed oils revealed that low molecular weight acids (capric and lauric acids) did not commonly occur in all species investigated. Of the four species containing lauric acid, *Berlinia auriculata* had the highest level at 4·4%. Myristic acid was detected in eight species and, of these, *Tetrapleura tetraptera* contained the highest level of 6·5%. The palmitic acid content ($23{\cdot}6 \pm 11{\cdot}8\%$) was higher in the subdivision Caesalpinoideae than in the Mimosoideae ($13{\cdot}0 \pm 6{\cdot}1\%$) whilst the stearic acid content was slightly higher in the latter than in the former. Comparably low levels of arachidic acid were detected in members of both subdivisions. The seed oil of *Pterocarpus osun* (the only member of the subdivision Papilionaceae studied) had palmitic acid as the only major saturated acid with very low levels of stearic and arachidic acids.

It is thus evident from these results that the seed oils of all members of the Leguminosae studied contained, on average, palmitic acid as the only major saturated acid. The only exception was the oil of *T. tetraptera* with behenic acid (22·0) as the major saturated acid. It must, however, be noted that all members of the subdivision Mimosoideae contained behenic acid, with the oil of *Parkia clappertoniana* containing the highest level, and that

only the seed oils of two members of the Caesalpinoideae family (*D. oliverii* and *D. microcarpum*) contained appreciable levels of the same acid.

The results of the present study with respect to saturated acids validate the earlier reports of Hilditch & Williams (1964). Sengupta & Basu (1978) reported that members of the subdivision Mimosoideae contain, in addition to palmitic acid, considerable amounts of higher molecular weight saturated acids. However, the presence of behenic acid in only two members of the Caesalpinoideae subdivision contradicts the report of Hilditch (1956) that several members of this subdivision contain minor components of higher saturated acids (20·0–24·0). It is therefore possible, based on the present results, that there are genetic differences in the saturated acid components of members of this subdivision. Fatty acid levels greater than 22·0 were not detected in the seed oils of any member of the Leguminosae investigated. This is in contrast to the earlier report by Bailey (1951), who found 20–25 % lignoceric acid (24·0) in the seed oil of *Adenanthera pavonina*; but in agreement with the results of Adeyeye (1978), who failed to detect lignoceric acid in the seed oil of a Nigerian species of *A. pavonina*. The differences in these results could be ascribed to differences in analytical techniques, as adduced by Sengupta & Basu (1978) for the oil of *Entada phaseolides* (Mimosoideae). These workers contended that results based on gas–liquid chromatography give a better indication of the fatty acids than earlier methods, based on ester fractionation, for saturated acids content. Also, they would be caused by differences in the ecological and geographical zones where the seeds were collected, as suggested by Aaes-Jorgensen (1961).

The major unsaturated acids in the ten members of the Leguminosae seed oils were oleic and linoleic acids, both comprising, on average, 68·4 % of the component acids. However, seed oils of most of the species, with the exception of *Prosopis africana* (Mimosoideae) and *Pterocarpus osun* (Papilionaceae) were richer in linoleic, than oleic, acid. In fact, in the seed oils of *A. pavenina* and *T. tetraptera* (both Mimosoideae) and *D. olivarii* and *B. monandra* (both Caesalpinoideae), linoleic acid comprised more than 50 % of the total component acids. The seed oils of all leguminous members contained very low levels of linolenic acid. Trace amounts of palmitoleic acid were detected in *P. africana*, *B. auriculata* and *B. monandra* seeds oils. From the average figures presented, it appears that there are no major differences in the linoleic acid contents of the members of the subdivisions Mimosoideae ($43{\cdot}3 \pm 9{\cdot}5\,\%$) and

Ceasalpinoideae (43·3 ± 9·9 %) analysed in this investigation. This is also true of oleic acid content.

Thus, as far as unsaturated fatty acid content is concerned, the present work is supported by previous work by Hilditch & Williams (1964) and Sengupta & Basu (1978). Both groups of workers contended that the unsaturated fatty acid contents of Leguminosae seed fats resemble each other closely and that the chief components are oleic and linoleic acids (together forming 62–80 % of the total component acids).

The very low levels of linolenic acid in all ten members of the Leguminosae studied also confirm the genetic classification of Hilditch & Williams (1964) that linolenic acid is either entirely absent from, or present in only very small amounts in, most Leguminosae seed oils. The poor flavour stability of soybean oil has been attributed to the presence of 7–8 % linolenic acid whilst, in more stable oils, such as corn oil, there is usually less than 1 % linolenic acid (Smouse & Chang, 1967; Howells *et al.*, 1972). Oils rich in oleic and linoleic acids, according to Bailey (1951), are the most adaptable of all oils and are excellent edible oils. In this respect, with high levels of oleic and linoleic acid and with correspondingly low levels of linolenic acids, most of the leguminous seed oils investigated in this study could serve as sources of excellent edible oils in Nigeria. The only exceptions are the oils of *T. tetraptera*, *P. clappertoniana*, *D. microcarpum* and *D. oliverii*, all of which contain appreciable levels of behenic acid. Hilditch *et al.* (1951), Hilditch & Williams (1964) and Balogun (1982) have indicated that oils with high levels of behenic acid may be difficult for digestive enzymes (in humans and animals) to deal with. Thus, Hilditch & Meare (1944) suggested that the presence of behenic acid in some seed oils may have serious implications for their nutritional utilization.

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