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Amino Acid Composition of Seeds of Some Lesser Known Tree Crops

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ABSTRACT

The amino acid composition of seeds of twenty-six species were determined by column chromatography. Total nitrogen was initially determined by the Kjeldahl procedure. Chemical scores were calculated for the different species using FAO amino acid patterns. Crude protein ($N \times 6{\cdot}25$) ranged between 8·8% in Afzelia bella *(calyx) and 33·2% in* Parkia clappertoniana. Afzelia bella *(calyx) had the highest values of valine (8·9 g/16 gN);* iso-*leucine (12·5 g/16 gN); leucine (16·8 g/16 gN) and phenylalanine (7·1 g/16 gN).* Parkia clappertoniana, Afzelia bella *(seed),* Irvingia gabonensis, Monodora tenuifolia, Pterocarpus osun *and* Cedrella odorata *had the highest values of lysine (8·0 g/16 gN); histidine (6·3 g/16 gN); methionine (1·9 g/16 gN); tyrosine, (9·1 g/16 gN); tryptophan (2·5 g/16 gN) and cystine (3·6 g/16 gN), respectively. The proportion of total nitrogen derived from essential amino acids (E/T_N ratio) varied from 1·0 in* Carapa procera *to 4·2 in* Afzelia bella *(calyx). Chemical score ranged between 22·4 in* Afzelia bella *(calyx) and 64·7 in* Khaya ivorensis.

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INTRODUCTION

There is an ever widening gap between food supplies and population growth, particularly in the Third World countries. This food shortage is particularly serious when per capita protein intake is considered. There are several wild nuts and seeds that have found use as condiments and spices in several areas, where potentials have not been explored and whose uses in diets are fast disappearing with increasing urbanization. Results from preliminary analyses (Amubode & Fetuga, 1983) indicated that some of these seeds and nuts show considerable promise as protein sources. Since the nutritional value of a protein depends, to a large extent, on the concentration of its essential amino acids, the present study was designed to provide further information on the total amino acid composition of these sources to permit an assessment to be made of their potential contribution to the diet mixtures in which they are used.

MATERIALS AND METHODS

The seeds used in this study were partly collected from villages where natives use them and partly from the forest zone of southwestern Nigeria. The undehulled seeds from each tree crop were pooled and dried at 55 °C for 72 h. A 1000 g sample from each tree crop was milled to a powdery fine mesh in a small laboratory milling machine. The milled samples were homogeneously mixed and further dried to constant weight at 105 °C (AOAC, 1975). Nitrogen was determined by the Kjeldahl procedure (AOAC, 1975). The total amino acids of the seeds were determined in duplicate as described by Fetuga *et al.* (1974), after hydrolysing 100 mg of sample with 100 ml 6N-HCl in an atmosphere of nitrogen, using an electric glass mantle heater for 24 h. The Technicon automated sequential multi-sample analyser was used for elution. Cystine was measured as cysteic acid while methionine was measured as methionine sulphone following performic acid oxidation according to Moore (1963). Tryptophan was hydrolysed from the tree crop seeds by mixing 0·5 g of each sample with 15·4 g of barium hydroxide octahydrate $Ba(OH_2)\cdot 8H_2O$, followed by autoclaving at 1·1 kg/cm^2 for 7 h. After neutralising the cold hydrolysate with 6N HCl, tryptophan was colorimetrically estimated at 590 nm using anhydrous sodium sulphate (Na_2SO_4), charcoal and dimethylaminobenz-aldehyde in concentrated hydrochloric acid and sodium nitrite as described by Miller (1967). The chemical scores for the seeds were calculated from determined total amino acid composition using FAO (1973) data as the reference standards. The content of each essential amino acid in either of these protein sources (A_x) was first expressed as a ratio of total essential amino acid (E_x) in them. These ratios were then expressed as percentages of the standard amino acid pattern in the FAO (1973) Table. The lowest of all these percentages were recorded as the chemical scores for the seeds. Methionine plus cystine and phenylalanine plus tyrosine were taken together in calculating the chemical scores.

RESULTS AND DISCUSSION

Table 1 shows the total amino acid content of twenty-six tree crop seeds and whole hen's egg. The independent duplicate analyses gave similar results; hence, the means of the duplicates are presented in this Table. Tryptophan ranged between 0·9 g/16 gN for *Cassia sieberiana* and 2·5 g/16 gN for *Pterocarpus osun*. The values of 2·0, 1·9, 1·9, 1·8 and 1·8 g/16 gN in *Afzelia bella* (seed), *Carapa procera*, *Khaya senegalensis*, *Monodora tenuifolia* and *Tectrapleura tetraptera* were similar to the 1·8 g/16 gN reported (Mba *et al.*, 1974) for groundnut cake while the tryptophan concentrations in *Mansonia altissima*, *Kleinhovia hospita*, *Cassia siamea* and *Afzelia pachyloba* were not different from the value of 1·6 g/16 gN in whole hen's egg. The recovery of pure added tryptophan was 81·3 %. When this precision was used as a correction factor for all the seeds, only the seeds of *Afzelia bella* and *Pterocarpus osun*, respectively attained concentrations of 2·0 and 2·5 g/16 gN. Generally, the values obtained suggest that tryptophan is likely to be adequate in most forest seeds studied when compared with the value for hen's egg or several other conventional plant foods. Five tree crop seeds—*Cedrela odorata*, *Cassia siamea*, *Delonix regia*, *Enterolobium cyclocarpum* and *Parkia clappertoniana*—contained more than 6·0 g lysine/16 gN. The lysine values of 2·1 g/16 gN for *Afzelia bella* (calyx), 1·0 g/16 gN for *Carapa procera* and 2·7 g/16 gN for *Monodora tenuifolia*, which were particularly low, suggest that such seeds could not be expected to be of value in augmenting conventional food sources in which lysine is limiting. It should be indicated that the initial drying temperature of 55 °C was lower than the temperature zone above 80 °C which seemed (Mauron, 1972) to be critical in model assays where Maillard reactions increased very rapidly. The

TABLE 1
Amino Acid Composition of Seeds of Some Lesser Known Crops

Tree crop seeds	*%CP*	*Trp.*	*Lys.*	*His.*	*Arg.*	*Asp.*	*Thr.*	*Ser.*	*Glu.*	*Pro.*	*Gly.*	*Ala.*	*Val.*	*Met.*	*Cys.*	*Ile.*	*Leu.*	*Tyr.*	*Phe.*
		Amino acids (g/16 gN)																	
Irvingia gabonensis	35·5	1·3	4·9	3·4	10·9	12·1	3·5	3·9	18·8	5·0	5·3	5·3	5·5	1·8	2·4	6·3	7·5	3·8	5·0
Abrus precatorius	22·4	1·5	5·7	3·0	4·2	4·6	1·1	1·9	8·0	0·1	2·6	2·9	3·4	1·5	1·7	3·5	5·8	4·9	4·5
Afzelia bella (calyx)	8·8	1·6	2·1	1·7	4·0	34·8	7·0	6·5	28·5	12·4	9·9	8·4	8·9	1·0	1·2	12·5	16·8	7·3	7·1
Afzelia bella (seed)	15·8	2·0	4·0	6·3	4·2	6·0	1·6	3·0	10·3	5·3	3·9	4·5	3·3	1·5	1·9	3·2	5·8	3·2	3·7
Afzelia africana	19·8	1·2	3·7	1·5	3·8	5·5	1·9	2·4	9·4	4·8	4·3	3·3	3·6	0·8	1·3	4·0	5·5	3·5	2·8
Afzelia pachyloba	12·2	1·7	5·6	3·7	11·3	3·5	1·6	3·1	11·7	5·0	9·1	4·9	2·4	0·8	1·2	3·4	7·5	2·5	3·1
Adenanthera pavonina	17·6	1·6	5·6	3·0	9·7	6·7	2·7	2·2	12·5	4·7	9·9	3·4	6·0	0·8	1·8	4·0	7·4	3·9	3·2
Amphimas pterocarpoides	15·4	1·9	4·2	2·0	4·0	2·4	2·7	5·9	6·2	6·8	3·5	2·0	3·0	0·6	1·1	3·5	6·4	3·8	3·2
Antiaris africana	30·1	1·0	4·1	3·0	6·8	9·6	2·9	5·3	11·3	10·3	4·4	3·5	3·8	1·7	2·5	4·3	10·0	5·0	4·7
Azadiracta indica	12·8	1·0	4·8	4·1	13·0	19·8	3·2	4·3	19·7	7·6	7·3	8·2	5·6	0·5	2·6	5·8	6·9	1·9	5·2
Cedrela odorata	29·3	1·1	4·6	1·8	0·7	0·8	1·1	1·6	22·8	0·7	3·2	2·0	1·9	0·9	3·6	2·0	3·8	0·8	0·5
Cassia nodosa	16·0	1·1	5·6	3·1	9·0	9·3	4·1	2·5	20·9	3·2	3·5	4·2	5·5	1·3	2·2	3·5	7·9	4·0	4·7
Cassia sieberiana	20·2	0·9	4·0	1·5	8·7	5·6	3·1	2·9	13·6	4·3	4·4	3·3	3·4	0·8	1·8	2·5	4·0	2·6	3·2

Carapa procera	18·2	1·9	1·1	1·9	1·2	2·4	0·7	0·9	11·9	0·3	1·5	0·9	2·3	1·0	2·0	0·8	1·5	0·9	1·1
Delonix regia	20·2	1·5	6·1	2·6	14·6	12·3	3·2	5·0	24·9	7·6	8·1	5·9	6·1	1·0	1·4	4·0	7·4	3·3	4·9
Enterolobium cyclocarpum	24·7	1·2	6·8	3·1	3·2	6·4	1·4	1·7	7·5	3·0	3·3	2·2	3·1	0·5	1·6	2·9	5·2	3·0	3·2
Jatropha curcas	23·6	1·2	4·7	4·2	1·5	3·7	2·4	3·4	13·1	5·7	4·8	3·4	7·5	0·4	1·5	5·1	6·1	2·6	4·0
Khaya ivorensis	10·1	1·1	3·5	1·8	14·2	12·1	2·4	3·0	9·7	5·5	4·1	3·7	4·9	1·0	1·8	3·6	5·1	3·3	3·8
Khaya senegalensis	13·9	1·9	5·6	1·7	18·5	4·4	1·1	1·2	11·9	4·1	6·2	2·9	2·6	0·9	2·2	2·4	4·0	3·8	3·1
Kleinhovia hospita	17·1	1·7	4·0	1·4	7·0	1·3	2·1	1·8	11·7	2·1	2·2	2·1	1·2	0·2	0·9	1·2	3·5	1·9	3·1
Mansonia altissima	18·2	1·8	5·3	2·3	10·9	0·6	1·6	1·9	10·9	3·1	5·2	3·2	2·4	0·4	1·2	4·2	7·8	2·2	3·7
Monodora tenuifolia	17·4	1·8	4·7	1·7	2·8	5·4	1·8	1·6	6·9	4·5	3·4	2·9	9·6	2·3	1·6	2·5	4·6	9·1	3·2
Parkia clappertoniana	33·2	1·0	8·0	4·4	10·9	3·9	1·8	2·7	11·2	5·2	4·0	3·1	4·5	0·6	1·6	4·9	6·1	3·3	4·3
Pterocarpus osun	32·4	2·5	4·6	3·6	5·3	2·8	1·6	1·5	4·3	3·1	2·3	1·7	2·2	0·2	1·7	2·4	3·9	2·1	2·1
Tectona grandis	9·2	1·5	3·4	1·9	9·9	2·6	2·2	3·8	14·9	5·5	6·4	6·4	3·3	0·9	1·1	3·7	6·1	4·0	4·5
Tectrapleura tetraptera	18·2	1·8	5·3	2·4	5·5	11·4	1·2	2·9	12·4	5·1	4·2	2·5	3·4	0·5	2·1	3·8	7·8	4·5	4·1
Whole hen's egg	38·3	1·6	7·0	2·4	6·1	9·0	5·1	7·7	12·7	5·2	3·3	5·9	6·9	3·4	6·3	8·8	4·2	5·6	2·4

CP = Crude protein; Trp. = Tryptophan; Lys. = Lysine; His. = Histidine; Arg. = Arginine; Asp. = Aspartic acid; Thr. = Threonine; Ser. = Serine; Glu. = Glutamic acid; Pro. = Proline; Gly. = Glycine; Ala. = Alanine; Val. = Valine; Met. = Methionine; Cys. = Cystine; Ile. = *Iso*-leucine; Leu. = Leucine; Tyr. = Tyrosine; Phe. = Phenylalanine.

question of lysine destruction in a protein by any Maillard reaction might not have occurred in this assay since any lysine bound as a Schiff base or as glycosylamine was most likely to be recuperated by the strong acid hydrolysis. Although Maillard reactions may reduce the nutritive value of a protein due to loss in lysine availability, the low values encountered in a few seeds under total lysine determination appeared to be quantitatively representative of these samples. The calyx of *Afzelia bella* contained 7·0 g threonine/16 gN while *Irvingia gabonensis, Azadiracta indica, Cassia nodosa, Cassia siamea* and *Delonix regia* contained between 3·5 and 5·1 g/16 gN. The remaining seeds contained between 0·7 g threonine/16 gN in *Carapa procera* and 3·1 g/16 gN in *Cassia sieberiana*. All the seeds were very deficient in methionine compared with whole hen's egg. *Parkia clappertoniana*, with 33·2 % crude protein, contained a value as low as 0·6 g/16 gN. The values of 1·9 g/16 gN for *Irvingia gabonensis*, 1·5 g/16 gN for *Abrus precatorius* and *Afzelia bella* (seed), 1·7 g/16 gN for *Antiaris africana* and 1·3 g/16 gN for *Cassia nodosa* were, however, higher than the value of 1·1 g/16 gN reported (Oyenuga & Fetuga, 1975) for soybean meal. *Iso*-leucine concentration varied from 1·2 g/16 gN for *Kleinhovia hospita* to 12·5 g/16 gN for *Afzelia bella* (calyx). Apart from *Azadiracta indica* which had a phenylalanine level (5·2 g/16 gN) similar to those of egg (5·6 g/16 gN), soybean (5·8 g/16 gN) and African oil bean meal (5·0 g/16 gN) and *Afzelia bella* (calyx) with a higher value (7·1 g/16 gN), the other seeds contained between 2·8 and 5·0 g phenylalanine/16 gN. These values are in the range reported for several conventional food and feed sources (Oyenuga, 1968; Mba *et al.*, 1974).

The amino acid pattern, expressed as milligrams of amino acid per gram of total essential amino acid (*A*/*E*), the proportion of the total nitrogen derived from the essential amino acids (*E*/*T* ratio) and the chemical scores (CS) for the seeds studied are presented in Table 2. The *E*/*T* ratio ranged between 1·3 for *Kleinhovia hospita* and 4·2 for *Afzelia bella* (Calyx). Most values except that for *Afzelia bella* were lower than the *E*/*T* ratio of 3·2 reported for whole hen's egg. The *E*/*T* ratio for *Irvingia gabonensis* (2·8), *Adenanthera pavonina* (2·6), *Antiaris africana* (2·7), *Azadiracta indica* (2·6), *Cassia nodosa* (2·7), *Delonix regia* (2.6), *Jatropha curcas* (2·5), *Monodora tenuifolia* (2·5) and *Parkia clappertoniana* (2·5) were similar to an *E*/*T* ratio of 2·7 reported (Oyenuga & Fetuga, 1975) for soybean meal.

Chemical scores ranged from 19·9 in *Afzelia bella* (calyx) to 74·0 in *Cassia sieberiana*. Only *Adenanthera pavonina* (61·3), *Antiaris africana*

TABLE 2
Amino Acid Pattern and Chemical Score of Seeds of Some Lesser Known Crops Amino Acids (mg/g Total Essential Amino Acid)

Tree crop seeds	*Trp.*	*Lys.*	*Thr.*	*Val.*	*Met.*	*Cys.*	*Ile.*	*Leu.*	*Tyr.*	*Phe.*	E/T_N	*CS*
Irvingia gabonensis	29	109	79	122	38	48	144	168	77	99	2·83	71·2
Abrus precatorius	41	155	31	92	36	45	96	157	126	113	2·29	27·9
Afzelia bella (calyx)	23	30	105	133	15	17	185	249	95	95	4·23	19·9
Afzelia bella (seed)	55	110	43	93	35	47	88	159	78	90	2·27	38·7
Afzelia africana	39	124	65	118	24	39	134	182	106	87	1·86	58·6
Afzelia pachyloba	50	167	48	71	21	33	100	224	66	79	2·10	43·2
Adenanthera pavonina	39	140	68	147	18	44	100	183	92	74	2·51	61·3
Amphimas pterocarpoides	58	129	83	93	19	32	108	196	111	93	2·04	52·6
Antiaris africana	23	94	67	90	34	55	101	231	107	100	2·68	60·4
Azadiracta indica	24	115	77	135	10	51	138	165	39	106	2·60	62·9
Cedrela odorata	45	271	46	79	37	140	79	158	30	18	1·52	41·4
Cassia nodosa	26	130	93	130	27	44	82	186	85	102	2·69	73·2
Cassia siamea	45	202	123	101	22	35	75	132	75	132	2·28	58·8
Cassia sieberiana	33	145	110	122	29	64	93	145	93	116	1·72	74·0
Carapa procera	124	68	53	147	63	137	53	95	63	74	0·95	45·0
Delonix regia	35	147	77	147	27	35	97	178	81	116	2·59	64·0
Enterolobium cyclocarpum	37	203	77	96	14	48	87	154	91	96	2·08	64·0
Jatropha curcas	29	118	60	190	12	36	129	153	65	100	2·48	49·5
Khaya ivorensis	34	109	74	153	30	54	109	158	104	119	2·02	66·7
Khaya senegalensis	64	191	38	93	22	76	82	137	148	109	1·83	34·2
Kleinhovia hospita	79	189	98	58	8	45	53	167	91	144	1·32	42·0
Mansonia altissima	53	161	49	73	15	34	127	239	68	112	2·05	44·1
Monodora tenuifolia	45	66	43	233	58	39	62	109	222	78	2·50	38·7
Parkia clappertoniana	26	198	43	111	16	40	119	150	83	103	2·53	38·7
Pterocarpus osun	84	156	54	75	5	59	81	129	161	70	1·86	48·6
Tectona grandis	45	104	69	103	29	34	113	186	123	137	2·04	62·2
Tectrapleura tetraptera	49	144	30	95	13	56	104	212	121	108	2·31	27·0
Whole hen's egg	31	135	99	133	65	46	124	170	80	108	3·23	
FAO (1973) pattern	27	151	111	138	97		111	196	169			

Trp. = tryptophan; Lys. = lysine; His. = histidine; Thr. = threonine; Val. = valine; Met. = methionine; Cys. = cystine; Ile. = *iso*-leucine; Leu. = leucine; Tyr. = tyrosine; Phe. = phenylalanine; E/T_N = essential amino acid/total nitrogen; CS = chemical score.
____, First limiting amino acid.

(60·4), *Azadiracta indica* (62·9), *Delonix regia* and *Enterolobium cyclocorpum* (64·0) had chemical scores comparable with the value of 61·0 reported for soybean meal (Oyenuga & Fetuga, 1975) whilst *Irvingia gabonensis* (71·2), *Cassia nodosa* (73·2) and *Cassia sieberiana* (74·0) had distinctly higher values.

CONCLUSION

Threonine and methionine appeared to be the most limiting amino acids in the seeds studied, whilst lysine, valine and leucine were first limiting in a few cases. This apparent limitation of the amino acid profiles of the seeds studied in threonine and methionine would suggest that they would be no better than conventional protein sources, such as the legumes and oil seeds, which have these two amino acids as their main limiting amino acids. Judicious combinations of the various seeds may, however, produce mixtures of desirable amino acid balance. The extent to which the associated amino acids will be utilized will, however, depend on the variety of non-nutrient and other nutrient components that have been shown to affect amino acid availability and utilization. These are yet to be studied in these seeds.

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