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A comparison of the proximate, mineral and amino acid composition of some known and lesser known legumes in Nigeria

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The proximate, mineral and amino acid composition of various cultivars of three legumes consumed in Nigeria were compared. They include the African Yam bean (*Sphenostylis stenocarpa* (Hochst ex. A. Rich) Harms.), Pigeon pea (*Cajanus cajan* (L) Millsp.) and Cowpea (*Vigna* spp.). Results showed that, on average, apart from protein and ash, the proximate compositions of all the legumes were similar. The protein content of cowpea was significantly higher ($P < 0.01$) than those of the African Yam bean and Pigeon pea. Cowpea and Pigeon pea had significantly higher values for ash ($P < 0.05$) than the African Yam bean. Two popular cultivars of *Vigna unguiculata* (white and brown) contained lower values of dietary fibre, i.e. about 60% of the amount in the African Yam bean and 48% of that found in the Pigeon pea. Cowpea seemed to have a better mineral pattern than Pigeon pea and the African Yam bean. In terms of amino acid composition, the African Yam bean had a better pattern of essential amino acids (EAAs). All legumes were, however, deficient in cystine and methionine. In addition to these amino acids, Pigeon pea was also deficient in valine and isoleucine. The necessity of combining legumes with cereals is further stressed.

INTRODUCTION

The need for an understanding of the nutrient composition of locally available foods in any community cannot be over-emphasized. In developing countries, such information is very scanty and where available, the data may be obsolete or be based on only the most popular foods. The consequence of this lack of useful information is that nutritionists and survey workers are handicapped by poor knowledge of the composition of available foods in a particular community. This tends to contribute to inconsistencies in dietary intake studies and the interpretation of nutritional results.

In Nigeria, one of the most limiting nutrients in the diet is protein (Oke, 1968), especially among the rural communities and the urban poor. Although this observation was made over 20 years ago, the situation has not changed, especially with the low income level of the majority of Nigerians, exacerbated by inflationary trends and increasingly high cost of animal proteins. Several food intake studies have shown that the protein intake of the Nigerian population falls below recommended allowances (Olusanya, 1980; Nnanyelugo *et al.*, 1985; Mbofung & Atinmo, 1986). It is now clearly shown that increase in protein intake can be achieved by consumption of plant proteins, especially legumes. There is therefore a need to identify legumes with high nutritional potentials.

There is a tendency to rate some legumes as less nutritious than others due to lack of relevant information about their composition and quality. The present study is therefore a contribution to the nutritional knowledge of some locally available plant proteins in Nigeria. They

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include the African Yam bean (*Sphenostylis stenocarpa* (Hochst ex. A. Rich) Harms.); Pigeon pea (*Cajanus cajun* (L.) Millsp.) and two local Cowpea varieties (*Vigna* spp.) known locally as Akidi and Olaludi. Two other cultivars of Cowpea (*Vigna unguiculata*) (L.) Walp.) were incorporated in the experiment for comparison.

MATERIALS AND METHODS

Collection and preparation of sample

A total of 10 samples were used in this study. They included 3 cultivars of the African Yam bean, 3 cultivars of Pigeon pea, and 4 cultivars of Cowpea. The cultivars differed in various morphological characteristics including seed colour. Samples were purchased from Nsukka, Orba and Ibagwa local markets, except for one cultivar of African Yam bean which was purchased from Asaga, Ohafia, in Imo State, Nigeria, where it is most common. The samples were hand-picked in order to remove sand, stones and other impurities. Representative samples were then ground with a laboratory mill and stored in plastic sample containers ready for analysis.

Experimental procedures

The determination of moisture, protein, ash and fat were based on approved methods (AOAC, 1984). The factor 6·25 was used to convert the nitrogen (N) into crude protein in all cases. Total dietary fibre was determined by the method described by Prosky *et al.* (1985). Total sugar (soluble and insoluble) was determined by a colorimetric method (Kaziol, 1981). Starch was by difference. Total carbohydrate was obtained as the sum of sugar and starch.

Mineral analysis was done by dry ashing according to standard AOAC (1984) procedures. Calcium (Ca), Zinc (Zn), Iron (Fe), Potassium (K) and Sodium (Na), were determined in aliquots using a Perkin-Elmer 372 atomic absorption spectrophotometer (AAS) (Perkin-Elmer Ltd, Beaconsfield, Bucks, HP9 1QA, England). Phosphorus was determined by the molybdovanadate method (AOAC, 1984).

Amino acid analysis was done by hydrolysing 25–30 mg of protein with 6 N HCl and incubating at 105°C for 18 h. The branch-chain amino acids were determined as above, but the incubation period was for 72 h. Cystine and methionine were first of all oxidized to cysteic acid and methionine sulfone using performic acid, before acid hydrolysis. The amino acids cystine and methionine were determined on the Beckman amino acid analyser (Model 120C) (Beckman Instrument Int. S.A., Geneva, Switzerland). Tryptophan was determined by alkaline hydrolysis. The hydrolysate was then analysed using a Waters HPLC (WISP 710B with fluorescence detector, Model 420-AC) (Waters Associates, Inc. Milford, Massachusetts, USA). All analyses were done in duplicate. Seed weights were also determined for each sample.

Statistical analysis

Means ± SE were calculated and analysis of variance (ANOVA) and Duncan's multiple range test were used to test the differences among means (Steele & Torrie, 1960).

RESULTS AND DISCUSSION

Table 1 shows the physical characteristics and degree of popularity of the legumes under investigation. Figure 1 also illustrates these legumes. There were highly significant differences between the different legumes ($P < 0{\cdot}01$) for seed weight. The African Yam bean was the heaviest in weight although its weight was not significantly different from that of the *V. unguiculata* cultivars. Akidi and Olaludi were the smallest in size and weight with an average seed weight of 82 ± 14·14 mg/seed.

The proximate compositions of these legumes are shown in Table 2. There was not much variation within each group of legumes. However, when the three groups of legumes were compared statistically, significant differences were found only in the protein and ash contents. The protein content of Cowpea was significantly

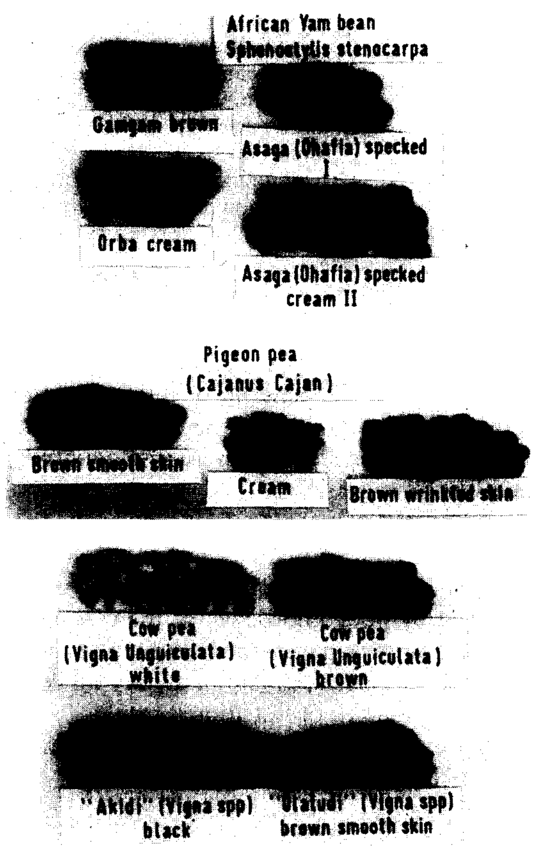

Fig. 1. Legumes under investigation.

Table 1. Characteristics of samples

Sample	Seed colour	Seed shape	Skin characteristic	Seed weight (mg/seed ± SE)	Popularity
African Yam bean (*Sphenostylis stenocarpa*)					
	Cream	Round	Thin and leathery	355 ± 19·2	*
	Brown	Round	Thin and leathery	249 ± 2·50	*
	Brown with black spots (specked)	Round	Thin and leathery	318 ± 9·57	*
				$\bar{X}$ ± SE = 307[a] ± 53·8	
Pigeon pea (*Cajanus cajan*)					
	Cream	Round	Thick and leathery	104 ± 5·48	**
	Brown	Round	Thick and leathery	162 ± 4·47	*
	Brown	Round	Thick, wrinkled and leathery	150 ± 7·07	**
				$\bar{X}$ ± SE = 138·67[b] ± 30·6	
Cowpea (*Vigna spp.*)					
Akidi	Black	Flat	Leathery	92 ± 9·88	**
Olaludi	Brown	Flat	Leathery	72 ± 4·47	
				$\bar{X}$ ± SE = 82·0[b] ± 14·1	*
Cowpea (*Vigna unguiculata*)					
	White	Round	Thin and porous	268 ± 14·8	***
	Brown	Round	Thin, porous and wrinkled	209 ± 12·2	
				$\bar{X}$ ± SE =238·5[a] ± 41·7	***

* Lesser known; ** Slightly popular; *** Most popular. [a,b] Values with different superscript differ significantly, $P < 0·01$.

Table 2. Proximate composition of legumes studied (as per cent dry matter)*

Sample	Dry matter	Protein (N × 6·25)	Ash	Fat	Dietary fibre	Sugar	Starch	Total CHO
Yam bean (*Sphenostylis stenocarpa*)								
Cream	86·38	21·1	2·70	2·30	17·5	5·90	50·5	56·4
Brown	88·97	21·2	3·50	1·90	21·3	6·05	46·0	52·1
Brown spotted (specked)	85·88	22·5	3·10	2·10	18.6	5·67	48·1	53·8
Group mean $\bar{X}$ ± SE	87·08 ± 1·66	21·6[b] ± 0·78	3·10[b] ± 0.40	2·10 ± 0.20	19·1 ± 1·98	5·87 ± 0·19	48·2 ± 2·25	54·8 ± 2·19
Pigeon pea (*Cajanus cajan*)								
Cream	86·69	21·2	4·10	2·30	23·2	6·01	43·2	49·2
Brown smooth	88·50	22·5	4·00	1·70	22·6	4·95	44·3	49·2
Brown wrinkled	88·48	22·5	3·60	1·30	25·7	6·45	40·5	46·9
Group mean $\bar{X}$ ± SE	87·89 ± 1·04	22·1[b] ± 0·75	3·90[a] ± 0·26	1·77 ± 0·50	23·8 ± 1·64	5·80 ± 0·77	42·6 ± 1·96	48·4 ± 1·33
Cowpea (*Vigna spp.*)								
Akidi (black)	87·45	28·0	4·40	1·80	24·0	6·53	35·3	41·8
Olaludi (brown)	85·73	27·8	3·60	1·90	21·1	5·13	40·5	45·6
Cowpea (*Vigna unguiculata*)								
Agwa (white)	89·45	26·5	4·20	2·10	11·8	6·01	49·5	55·5
Agwa (brown)	90·74	24·4	4·00	2·00	11·4	6·62	51·6	58·2
Group mean $\bar{X}$ ± SE	88·34 ± 2·21	26·7[a] ± 1·66	4·05[a] ± 0·34	1·95 ± 0·13	17·1 ± 6·44	6·07 ± 0·68	44·2 ± 7·65	50·3 ± 7·81

* Protein to starch calculated per 100 g dry matter. [a,b] Values with different superscripts differ significantly, $P < 0·01$ for protein and $P < 0·05$ for ash.

higher ($P < 0.01$) than those of African Yam bean and Pigeon pea; while those of African Yam bean and Pigeon pea were equal. The ash content of Cowpea was also high but equal to that of Pigeon pea and both differed significantly from the African Yam bean ($P < 0.05$). In terms of dietary fibre, Pigeon pea had the highest mean value compared with the African Yam bean and Cowpea, but these differences were not significant. Although no significant differences were found in dietary fibre content between the three types of legumes, the two popular cultivars of *V. unguiculata* were significantly lower in this attribute, containing about 60% of the amount in African Yam bean and 48% of that in the Pigeon pea. The differences in total dietary fibre content between the Cowpea cultivars are probably due to the differences in testa structure. The two local varieties of Cowpea (Akidi and Olaludi) have thick-walled, leathery skins compared to the thin and porous testa of the popular cultivars of *V. unguiculata*. The three types of legumes contain similar amounts of fat, sugar and starch ($P > 0.05$).

The mineral compositions of the legumes are presented in Table 3. Pigeon pea had the highest calcium (Ca) mean value, 110 mg/100 g, although statistically equal to Cowpea, 83·6 mg/100 g, and significantly higher than that of the African Yam bean, 46 mg/100 g. Generally, cowpea seemed to have a better mineral pattern than Pigeon pea and African Yam bean, except for potassium, which was very high in Pigeon pea (2112 mg/100 g).

Table 4 shows the amino acid profile of the legumes in question. Using the essential amino acids only, there were no significant differences within group for Cowpea and Pigeon pea. However, there were significant differences for lysine ($P < 0.05$) and threonine ($P < 0.05$) between the African Yam bean cultivars. The brown and brown spotted (specked) African Yam bean cultivars had significantly higher lysine values (LSD.05 = 0·31) than the cream cultivar. On the other hand, the cream cultivar had a significantly higher threonine value (4·14 mg; LSD.05 = 0·32) than the brown and brown spotted (specked). Table 5 shows the differences in essential amino acid patterns of the three legume varieties and soyabean and how they compare with the FAO reference pattern. Generally, the African Yam bean showed a better pattern of essential amino acids compared to Pigeon pea and Cowpea.

It had higher values in all essential amino acids, except for phenylalanine where its value was equal to that of Cowpea (5·62 mg) but significantly lower than that of Pigeon pea (9·72 mg/100 g). The African Yam bean also compares favourably with Soyabean in essential amino acids, except for methione and tryptophan where it was lower. However, the African Yam bean still had more S-amino acids than all the legumes. All the legumes were limiting in the EAAs cystine and methionine, whereas Pigeon pea was slightly limiting in the EAAs valine and isoleucine. It must be noted that although there were no significant differences in the EAA pattern between the Pigeon pea cultivars, the brown smooth cultivar had a better EAA pattern than the other two and was not limiting in valine. However, this cultivar is not the most commonly consumed. Among the non-essential amino acids (NEAA) there were significant differences between legumes, except for alanine (Table 6). The amino acid profiles by some of these legumes have been presented by other workers: African Yam bean by Evans and Boulter (1974) and Nwokolo (1987) and Pigeon pea by Salunke *et al.*, (1986). Most of the values presented in this work are

Table 3. Mineral composition of samples (mg/100 g dry matter)

Sample	Ca	Fe	Zn	P	K	Na
African Yam bean (*Sphenostylis stenocarpa*)						
Cream	41·0	5·08	2·44	267	1430	3·02
Brown	61·0	4·37	3·02	289	1490	3·58
Brown spotted	36·3	4·64	2·44	308	1512	1·62
$\bar{X} \pm$ SE	$46.1^{b} \pm 13.1$	$4.70^{c} \pm 0.36$	$2.63^{b} \pm 0.33$	$288^{c} \pm 20.7$	1477 ± 42·01	2·74 ± 1·01
Pigeon pea (*Cajanus cajan*)						
Cream	155	5·46	3·34	388	1961	1·96
Brown smooth	125	5·54	2·94	319	2262	1·92
Brown wrinkled	50·2	4·06	3·32	358	ND	ND
$\bar{X} \pm$ SE	$110^{a} \pm 54.2$	$5.02^{b} \pm 0.83$	$3.20^{b} \pm 0.23$	$355^{b} \pm 34.8$	2112 ± 213	1·94 ± 0·03
Cowpea (*Vigna spp.*)						
Akidi (black)	71·8	4·91	4·33	474	ND	ND
Olaludi (brown)	74·7	8·16	4·91	379	1271	6·10
Agwa (white)	86·8	8·4	4·82	422	1322	17·8
Agwa (brown)	101	8·18	3·83	468	ND	ND
$\bar{X} \pm$ SE	$83.6^{ab} \pm 13.3$	$7.41^{a} \pm 1.67$	$4.47^{a} \pm 0.50$	$436^{a} \pm 44.2$	1297 ± 35·8	12·0 ± 8·28

$^{a, b, c}$ Values with different superscripts differ significantly, $P < 0.05$.
ND = Not determined.

Table 4. Amino acid profile of the legumes (mg/100 g)

Amino acid	African Yam bean			Pigeon pea			Cowpea			
	Cream	Brown	Brown spotted	Cream	Brown smooth	Brown wrinkled	Akidi black	Olaludi	Cowpea white	Cowpea brown
Lysine	7·40	7·74	7·88	6·38	6·94	6·39	5·92	6·77	6·70	6·91
Histidine	4·08	3·60	4·25	3·29	3·66	3·50	2·79	3·27	2·80	2·51
Arginine	5·28	5·29	5·17	6·05	6·77	6·59	6·70	7·50	8·07	6·88
Aspartic acid	11·6	11·4	11·3	8·87	11·0	9·30	12.1	10·5	12·6	12·2
Threonine	4·14	3·74	3·83	3·45	3·61	3·40	3·71	3·54	3·65	3·80
Serine	5·80	5·82	6·60	4·84	4·27	4·56	5·42	5·43	6·05	5·49
Glutamic acid	15·2	15·3	16·4	20·3	22·9	21·9	18·8	17·6	18·7	18·9
Proline	4·71	4·91	4·45	4·79	4·46	4·43	4·04	3·08	3·41	3·90
Glycine	4·54	4·37	4·96	3·56	3·85	3·44	3·93	3·98	4·30	4·08
Alanine	4.60	4·37	4·74	4·31	4·58	4·33	4·43	4·17	4·30	4·38
Cystine	1·72	1·43	1·93	1·01	1·28	1·26	1·03	1·06	1·01	0·94
Valine	5·43	5·28	4·97	4·02	4·71	4·15	5·13	4·69	4·44	5·40
Methionine	1·17	1·20	1·21	1·09	1·12	1·06	1·14	1·18	1·20	1·25
Isoleucine	4·44	4·63	4·65	3·54	3·92	3·66	4·35	4·36	3·92	4·67
Leucine	7·59	7·70	7·52	7·22	7·26	6·98	7·68	7·35	7·19	7·70
Tyrosine	4·02	4·22	4·05	2·70	2·96	2·73	3·26	3·28	3·13	3·19
Phenylalanine	5·68	5·79	5·38	10·10	8·57	10·50	5·47	5·72	5·63	5·66
Tryptophan	0·92	1·04	1·09	1·15	1·28	1·2	1·01	1·11	1·07	1·06

Table 5. Comparative mean EAA levels of legumes compared with FAO reference pattern

Essential amino acid	Soybean‡	LSD.05	African Yam bean	Pigeon pea	Cowpea	FAO reference pattern
Lysine	7·0	0·74	7·67[a]	6·57[b]	6·58[b]	4·32
Threonine	3·2	0·22	3·90[a]	3·49[b]	3·68[b]	2·88
Cystine	0·8	0·30	1·69[a]	1·18[b]	1·01[b]	2·02
Valine	4·4	0·70	5·22[a]	4·29[b]	4·90[ab]	4·32
Methionine	1·6	0·08	1·19[a]	1·09[b]	1·19[a]	2·30
Isoleucine	3·8	0·46	4·57[a]	3·71[b]	4·33[a]	4·32
Leucine	7·3	0·27	7·60[a]	7·15[b]	7·50[a]	4·90
Phenylalanine	5·1	0·74	5·62[b]	9·72[a]	5·62[b]	2·88
Tryptophan	1·9	0·12	1·02[b]	1·21[a]	1·06[b]	1·44
Total S-amino acids (SAA)§	2·4 (55·6%)		2·88 (66·7%)	2·27 (52·5%)	2·2 (50·9%)	4·32

LSD 0·05—Least significant difference $P < 0{\cdot}05$.
[a,b,c] Values with different superscripts differ significantly, $P < 0{\cdot}01$.
§Values in parentheses represent the percentage of FAO (for SAA) met by the individual legumes.
‡Data from Evans and Bandemor (1967).

comparable to the works cited. The slightly higher values for some amino acids recorded by Evans and Boulter (1974) and slightly lower values recorded by Nwokolo (1987) for some could be due to differences in methodology and the various cultivars used. Cowpea (*V. unguiculata*) has also been worked on extensively. This study, apart from contributing to the amino acid, proximate and mineral composition of the lesser-known legumes, has tried to compare all these legumes. Work is still going on to use other parameters to evaluate these legumes.

The data presented show that apart from protein and ash, the proximate compositions of these legumes are similar. The low ash value for African Yam bean is related to its low mineral values. However, it should be noted that bioavailability of minerals may be affected by other constituents of the food/diet. Thus, the higher content in one legume may not indicate its relative bioavailability when consumed. On the other hand, African Yam bean has a comparable, if not better, pattern of amino acid than Cowpea, Pigeon pea and soyabean. It could then be a good substitute for the most popular legume (Cowpea) since some of its processing and preparation procedures are similar to those of Cowpea.

Table 6. Differences in non-essential amino acids

Non-essential amino acid	LSD.05	Yam bean	Pigeon pea	Cowpea
Histidine	0·48	3·98[a]	3·48[b]	2·84[c]
Arginine	0·81	5·25[c]	6·47[b]	7·29[a]
Aspartic	1·04	11·4[a]	9·69[b]	11·9[a]
Serine	0·64	6·07[a]	4·56[a]	5·60[a]
Proline	0·62	4·69[a]	4·56[a]	3·60[b]
Glutamic acid	0·67	15·6	21·7[a]	18·5[b]
Glycine	0·04	4·62[a]	3·62[c]	4·07[b]
Alanine	0·20	4·57	4·40	4·32
Tyrosine	0·27	4·10[a]	2·80[c]	3·22[b]

[a,b,c] Values with the same superscript in the same row are similar while those with different superscripts are significantly different, $P < 0{\cdot}01$.

Generally, all the legumes studied could be considered nutritious. However, there is a need to encourage the practice of combining legumes with other food sources, e.g. cereals and vegetables, in order to make up for their various deficiencies. Furthermore, since these legumes are typical of selected localities, there is a need to promote them in areas where they are found in order to increase their production and utilization and help solve the problem of malnutrition.

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