Chemical Composition of Some Underexploited Leguminous Crop Seeds in Nigeria

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A total of 16 wild underexploited leguminous crop seeds (belonging to the subdivisions Mimosoideae, Caesalpinoideae, and Papilionoideae) were investigated for their proximate composition and mineral content with the hope of establishing their potential as sources of feed for livestock and their possible industrial uses in Nigeria. Members of the leguminoseae studied were fairly good sources of protein. Mean protein content was 21.83 ± 6.80%. Most members of the subdivision Mimosoideae contained high amounts of protein. These are typified by *Acacia senegal* (38.89%), *Parkia clappertoniana* (29.40%), *Prosopis africana* (25.74%), and *Tetraptera tetrapleura* (25.47%). *Pterocarpus osun* (Papilinoideae) contained a crude protein level of 28.08%. Ether extract, crude fiber, and ash levels for these wild species were fairly high. Generally, these leguminous seeds appeared to be good sources of calcium, phosphorus, and potassium. They however contained low levels of sodium. Wide variability existed in both the zinc and manganese contents among the species investigated.

INTRODUCTION

The search for novel high-quality but cheap sources of protein and energy has continued to be a major concern of government and bodies charged with the responsibility for food and nutrition in many parts of the developing world. However, it has been suggested that, more than anything else, lack of information on the composition and utilization of the many and varied protein and energy sources indigenous to the tropics is the major problem rather than a real shortage.

The formulation of feeds for either livestock or fish implies an accurate knowledge of the nutrient composition and feeding value of the available feedstuff resources. The availability of such information would lead to more judicious use of some more commonly known sources and perhaps step up the use of hitherto neglected sources.

The aspiration of developing countries to be industrially self-sufficient has demanded huge financial spending in agriculture and the search for locally utilizable raw materials among the neglected agricultural crops. However, before such crops could be used, information is needed on their chemical characteristics.

Data have accumulated in literature (Oyenuga, 1968) on the proximate composition and the mineral content of the more commonly used legumes and oilseeds. The work reported here was aimed at providing basic information on the proximate and mineral composition of some underexploited and underutilized leguminous crop seeds in Nigeria.

MATERIALS AND METHODS

Mature seeds of 16 members of the family leguminoseae belonging to three subdivisions (Mimosoideae, Caesalpinoideae, Papilionoideae) were used in this study. A list of species investigated is presented in Table I. The seeds were collected from the seed collection and processing unit of the Forestry Research Institute, Ibadan, Nigeria, which collected the seeds from various locations in the savannah (semi-arid) region of Nigeria during the fruiting season. The leguminous seeds were identified by the methods of Polhill and Raven (1981), Duke (1981), and Hopkins and Stanfield (1966).

About 5 kg of seeds for each species was milled in a laboratory mill to pass through a BS60 sieve and stored in Kellner jars at −4 °C. Samples were withdrawn as required for chemical analysis. All analyses were carried out on duplicate samples.

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Table I. Species of the Leguminoseae Investigated

species	subdivision
A. pavonina	Mimosoideae
A. senegal	Mimosoideae
P. africana	Mimosoideae
P. clappertoniana	Mimosoideae
P. chilensis	Mimosoideae
T. tetrapleura	Mimosoideae
A. nilotica	Mimosoideae
D. oliveri	Caesalpinoideae
B. monandra	Caesalpinoideae
A. africana	Caesalpinoideae
T. indica	Caesalpinoideae
B. auriculata	Caesalpinoideae
C. nodosa	Caesalpinoideae
D. microcarpum	Caesalpinoideae
C. siebberiana	Caesalpinoideae
P. osun	Papilionoideae

Analytical Methods. Proximate composition was determined by the official methods of the Association of Official Analytical Chemists (1970): moisture (AOAC, 22.2003), ash (AOAC, 22.010), nitrogen (AOAC, 22.034), ether extract (oil content) (AOAC, 22.033), and crude fiber (AOAC, 22.040). Percent protein was calculated as % N × 6.25. Nitrogen-free extract (total digestible carbohydrate) was determined by subtracting the sum of crude protein, ether extract, crude fiber, ash and moisture from 100. The moisture was determined for dry-matter estimation. All constituents were therefore expressed on dry-matter basis.

Mineral analysis was determined by the digestion of the sample on a mixture of 4 mL of 60% perchloric acid and 25 mL of concentrated nitric acid (Perkin-Elmer Corp., 1971). The mineral constituents were then determined by atomic absorption spectrophotometry using a Perkin-Elmer 560 instrument except for phosphorus. Phosphorus was determined colorimetrically by the phosphovanadomolybdate method (AOAC, 1970).

RESULTS

The proximate composition of 16 members of the leguminoseae is presented in Table II.

Crude protein values varied between 12.87% in *Tamarindus indica* and 38.89% in *Acacia senegal*, with a mean value of 21.83 ± 6.80%. Most members of the subdivision Mimosoideae had their crude protein higher

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Table II. Percentage Proximate Composition[a] (Dry Matter Basis) of Some Members of the Leguminoseae Family

species	subdivision	crude protein	ether extract	crude fiber	ash	nitrogen-free extract (total digestbl carbohydr)
A. pavonina	Mimosoideae	21.06	27.84	18.88	5.88	26.34
A. senegal	Mimosoideae	38.89	10.00	20.56	5.00	25.55
P. africana	Mimosoideae	25.74	20.00	15.76	2.94	35.56
P. clapertoniana	Mimosoideae	29.40	16.93	13.04	4.92	35.71
P. chillensis	Mimosoideae	25.86	5.24	12.65	3.78	52.47
T. tetrapleura	Mimosoideae	20.16	14.66	10.66	5.24	49.28
A. nilotica	Mimosoideae	25.47	6.45	12.85	4.00	51.23
mean		26.65	14.45	14.91	4.54	39.45
D. oliverii	Caesalpinoideae	14.75	24.50	16.51	2.33	41.91
B. monandra	Caesalpinoideae	24.68	18.25	17.33	4.65	35.09
A. africana	Caesalpinoideae	19.63	7.02	12.97	3.78	56.60
T. indica	Caesalpinoideae	12.87	11.10	15.78	5.00	55.25
B. auriculata	Caesalpinoideae	14.58	22.48	7.22	5.00	50.72
C. nodosa	Caesalpinoideae	13.49	15.96	18.09	6.38	46.08
D. microcarpum	Caesalpinoideae	19.42	22.76	9.84	4.81	43.17
C. siebberiana	Caesalpinoideae	15.13	4.32	20.00	5.41	55.14
mean		16.82	15.80	14.72	4.67	47.99
P. osun	Papilionoideae	28.08	25.29	10.00	4.25	32.38
mean for Leguminoseae		21.83 (6.80)[b]	15.80 (7.75)	14.51 (3.83)	4.59 (1.50)	43.28 (9.63)

[a] Average of duplicate analysis. [b] Mean and standard deviation in brackets.

than the average obtained for the family in this investigation. These species in addition to *A. senegal* are typified by *Parkia clappertoniana* (29.40%), *Prosopis africana* (25.74%), *Prosopis chilensis* (25.86%), and *Acacia nilotica* (25.47%).

Adenanthera pavonina, *Tetraptera tetrapleura*, *Afzelia africana*, and *Detarium microcarpum* had fairly high crude protein content with the following values: 21.06%, 20.16%, 19.63%, and 19.42%, respectively. Among the members of the subdivision Ceasalpinoideae, *Bauhinia monandra* had the highest crude protein content of 24.68%. *Pterocarpus osun* (the only member of the Papilionoideae investigated) had crude protein content of 28.08%. The mean ether extract value for the family was 15.80 ± 7.75%. Noticeably high values were obtained in *A. pavonina* (27.84%), *P. africana* (20.00%), *Daniella oliverii* (24.50%), *Berlinia auriculata* (22.48%), *D. microcarpum* (22.78%), and *P. osun* (25.29%).

The mean ether extract values in the subdivisions Mimosoideae and Caesalpinoideae were 14.45% and 15.80%, respectively. Crude fiber levels in the subdivision Mimosoideae varied between 10.66% in *T. tetrapleura* and 20.56% in *A. senegal*. Values of 7.22% in *B. auriculata* and 20.00% in *Cassia siebberiana* were the lowest and highest fiber levels, respectively, in the subdivision Caesalpinoideae. However, a grand mean of 14.51 ± 3.83% was obtained for the family.

The average nitrogen-free extract (NFE) content for the Leguminoseae was 43.28 ± 9.53%. Members of the subdivision Caesalpinoideae contained the highest NFE levels. Total ash ranged between 2.33% in *D. oliverii* and 6.38% in *Cassia nodosa* in the 16 species in the Leguminoseae relatively high value of 5.88% was obtained in *A. pavonina* while a low value was obtained in *P. africana* (2.94%).

The mineral composition of species of the Leguminosea investigated are present in Table III.

Table III presents the macrominerals (%) of the seeds. Average values for calcium, magnesium, sodium, potassium, and phosphorus were 0.210 ± 0.05%, 0.142 ± 0.02%, 0.041 ± 0.01%, 0.797 ± 0.11%, and 0.402, respectively. Potassium was the most abundant mineral, followed by phosphorus. The levels of these minerals were however higher in the subdivision Mimosoideae than in the Caesalpinoideae. *P. osun* (Papillionateae) contained 0.387%, 0.088%, 0.019%, 0.950%, and 0.458% of calcium, magnesium, sodium, potassium, and phosphorus, respectively.

In the subdivision Mimosoideae, highest calcium level was obtained in *T. tetrapleura*. *P. Clappertoniana* contained the highest levels of magnesium and potassium. Phosphorus content ranged between 0.21% in *T. tetrapleura* and 0.48% in *A. pavonina*.

Sodium levels were generally low in all the species of Leguminoseae investigated. Composition of the microminerals of species presented in Table III (in ppm) showed that average zinc, copper, iron, and manganese contents were 270.25 ± 83.50, 20.64 ± 1.65, 390, 80 ± 41.56, and 101.18 ± 24.81, respectively. In the subdivision Mimosoideae, zinc content varied between 42.50 ppm in *A. senegal* and 1452.00 ppm in *P. chilensis*. *P. chilensis* contained the highest level of zinc and iron but the lowest level of manganese. High zinc concentration (680.00 ppm) was also obtained in *A. pavonina*.

In the subdivision Caesalpinoideae, zinc content varied between 85.00 ppm in *C. siebberiana* and 580.00 ppm in *T. indica*. Highest level of iron was obtained in *D. microcarpum* (810.00 ppm). Relatively high iron contents were also obtained in *D. oliveri* and *B. monandra*. *P. osun* contained 350.00 and 100.00 ppm, respectively, of iron and manganese.

DISCUSSION

There appeared to be scanty literature on the composition of these underexploited leguminous wild species. However, Earle and Jones (1962) reported crude protein values of 40.00%, 43.00%, and 33.90% for the seeds of *A. pavonina*, *Enterolobium cycloparcum*, and *Prosopis juliflora*, respectively. Mba et al. (1974) reported a crude protein content of 42.63% for the African oil bean seed (*Parkia fillicoidea*), while Okigbo (1975) reported a crude protein value of 32.10% for the seed of *Pterocarpus soyauxii*. Mardal et al. (1985) also reported a crude protein content of 40.80% for the seed of *Acacia auriculaeformis*.

The results presented revealed that some of the leguminous members investigated contained fairly high protein levels when compared with the values reported by the above workers and also with the values of 21.66% and 27.20%, respectively, reported for the undercorticated and decorticated peanut seeds by Oyenuga (1968). Those that fall into this category in the present study are the seeds of *A. pavonina*, *A. senegal*, *P. africana*, *P. clappertoniana*,

Table III. Mineral Composition[a] of Some Members of the Family Leguminoseae

		macrominerals, %					microminerals, ppm			
species	subdivision	calcium	magnesium	sodium	potassium	phosphorus	zinc	copper	iron	manganese
A. pavonina	Mimosoideae	0.260	0.271	0.046	0.763	0.487	685.00	25.00	247.50	30.00
A. senegal	Mimosoideae	0.320	0.170	0.018	1.253	0.484	42.50	30.00	475.00	75.00
P. africana	Mimosoideae	0.174	0.081	0.048	0.557	0.473	90.00	30.00	316.50	360.00
P. Clappertniana	Mimosoideae	0.240	0.300	0.077	1.304	0.428	180.00	20.00	200.00	90.00
P. chilensis	Mimosoideae	0.138	0.081	0.031	0.608	0.480	1452.00	30.00	630.00	15.00
T. tetrapleura	Mimosoideae	0.475	0.270	0.028	0.768	0.210	92.00	12.50	302.00	85.00
A. nilotica	Mimosoideae	0.268	0.198	0.026	0.700	0.450	100.00	22.50	325.00	885.00
mean		0.268	0.207	0.078	0.851	0.430	377.36	24.29	356.57	105.71
D. oliverii	Caesalpinoideae	0.079	0.076	0.024	0.528	0.187	211.25	15.00	697.50	15.00
B. monandra	Caesalpinoideae	0.112	0.079	0.031	0.790	0.413	404.00	15.00	487.50	22.50
A. africana	Caesalpinoideae	0.140	0.074	0.091	0.720	0.390	88.50	10.00	270.00	30.00
T. indica	Caesalpinoideae	0.100	0.118	0.083	1.094	0.458	580.00	25.00	285.00	22.50
B. auticulata	Caesalpinoideae	0.215	0.082	0.032	0.648	0.117	108.75	15.00	395.00	30.00
C. nodosa	Caesalpinoideae	0.165	0.051	0.035	0.550	0.385	105.00	25.00	250.00	200.00
D. microcarpum	Caesalpinoideae	0.068	0.074	0.045	0.626	0.555	135.50	15.00	810.00	195.00
C. siebberiana	Caesalpinoideae	0.221	0.260	0.016	0.886	0.454	85.00	15.00	395.00	315.00
mean		0.137	0.102	0.036	0.730	0.377	214.75	16.88	448.75	103.75
P. osun	Papilionoideae	0.387	0.088	0.019	0.950	0.458	100.00	25.00	350.00	100.00
mean for leguminoseae		0.210 (0.05)[b]	0.142 (0.02)	0.041 (0.01)	0.797 (0.11)	0.402 (0.25)	270.23 (83.50)	20.63 (1.65)	402.19 (41.56)	104.38 (24.81)

[a] Average of duplicate analysis. [b] Mean and standard deviation in brackets.

P. chilensis, *A. nilotica*, and *P. osun*. The high protein content among these wild leguminous species butressed the reports of Pant and Bishnoi (1967) and Pant et al. (1968) who indicated that some wild leguminous seeds were fairly good sources of protein. On the basis of this finding, it would appear that these species could be used as alternative sources of protein in livestock feeding, especially in Nigeria where the scarcity and the high cost of the conventionally used plant protein sources have nearly paralyzed the livestock industry. However, before they can be used in this way, the levels of toxic and antinutritional factors and of essential amino acids should be investigated.

Five species (*P. osun*, *A. pavonina*, *D. oliveri*, *B. auriculata*, *D. microcarpum*) showed very high ether extract values among the members. These values were higher than the value reported for wild *Balanites orbicularis* by Radunz et al. (1985). Thus, barring other factors and taking cognizance of their protein content, these species may be useful in the formulation of high protein caloric diets especially for fish. They may also serve as new sources of oil for other nutritional and industrial uses.

Relative to the levels reported for conventional edible legumes by Bressani and Elias (1974), fairly high levels of fiber were obtained in the wild leguminous seeds. High crude fiber could effectively trap and protect a greater proportion of their nutrients (proteins and carbohydrates) from hydrolytic breakdown, resulting in lowered digestibility, and therefore reduce the extent to which their end products of digestion could be utilized as explained by Fetuga et al. (1973), McNab (1975), and Southgate and Durning (1970).

The ash values were indicative of these species as fair sources of minerals. The relative proportions of these minerals may however be of more important consideration since some minerals may be highly concentrated, leading to the detrimental deficiencies of others that may be essential.

Bressani and Elias (1974) reported values of 0.10% and 0.30%, respectively, for calcium and phosphorus in edible leguminous seeds, and they were classified as poor sources of these two esential minerals. The values reported for calcium in the present work showed that about 10% of the species had their calcium content at 0.10% or below, while about 20% had their phosphorus content at 0.30% or below. It means that more than 80% of these species were better sources of calcium and phosphorus than the conventionally used legumes. The wide variability (as indicated by the standard deviation) obtained in the phosphorus content of the species may be ascribed to the differences in the species investigated. It may also be a reflection of the difference in the phosphorus status of the soils of the different locations where these seeds were collected in accordance with the views of Underwood (1966).

The high calcium content with correspondingly low phosphorus content in the seed of *T. tetraplaura* reflects a disproportionate distribution of calcium and phosphorus that may affect their utilization for ideal growth and bone formation. Magnesium levels are generally low when compared with values reported for other plant protein sources by Underwood (1966). Zinc and manganese have been reported to be highly concentrated in the outer layer of seeds and mill byproducts like wheat bran or rice bran and could be relied upon to supply 2–3 times more zinc than encountered in edible legumes (Underwood, 1966). Although wide variability was obtained in the zinc and manganese content, the generally high levels in these wild species may not be unrelated to their higher fiber content relative to that of the conventionally edible legumes. Potassium levels are generally high with corresponding low sodium content. The results with sodium were in accord with the contentions of Chamberlain (1955) that tropical crops carry subnormal concentrations of sodium, which is a reflection of the low sodium content of the soils. The species also appeared to be good sources of iron.

The results presented are mostly for raw seeds. As legumes, it should be expected that cooking or other forms of heat processing could affect their elemental composition if they contain unstable, highly soluble, or volatile compounds of the different elements. It should also be borne in mind that the potential of any feedstuff as a source of the major elements depends on the availability (as mentioned earlier) rather than the total content. There is evidence that certain plant constituents particularly decrease the availability of certain elements: zinc (O'Dell, 1969); iron (Sharpe et al., 1950), magnesium (Roberts and Yudkin, 1960), and calcium (Harrison and Mellanby, 1939). Legumes are particularly rich sources of phytates, which could reduce significantly the overall availability of the minerals found in them.

Futher investigations are needed in this direction to establish their real potentials as sources of divalent minerals.

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A Desert Plant from Egypt, *Anabasis setifera*: An Efficient Natural Factory of Carvacrol and Thymol

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The volatile oil from *Anabasis setifera* was found to consist of a highly pure mixture of two isomeric compounds, carvacrol (85%) and thymol (15%). No other compounds were detected in the oil by high-resolution gas chromatography–mass spectrometry. The selectivity and efficiency of the plant (volatile oil 2.5% of the fresh weight) in producing such isomers are remarkable.

In the course of our investigation of the chemistry of desert plants from Egypt, we encountered a fragrant undershrub growing widely in large colonies in the plains of the littoral zones of the western deserts, the Red Sea coastal region, and the Sinai. The plant is not attacked by insects or fungi and is not eaten by grazing animals. It was identified to be *Anabasis setifera* of the family Chenopodiaceae.

The volatile oil was obtained by steam distillation of the fresh aerial parts of the plant in 2.5% yield as described in the Experimental Section. The steam distillate had insecticidal activities toward cotton leaf worm (*Spodoptera littoralis*), housefly (*Musca domestica*), and rice weevil (*Stiophilus oryzae*). Analysis of the steam distillate by

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