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The proximate composition of some tropical legume seeds grown in two states in Nigeria

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Investigations into the variations in food values and energy potentials of four staple foods collected from two states in Nigeria, using whole grains, decorticated seeds and defatted seeds, were carried out. They were found to contain high levels of crude protein ranging from 23·2% to 26·7%, 23·0% to 28·0% and 39·0% to 48·4% for *Afzelia africana*, *Canavalia ensiformis* and *Pentaclethra macrophylla*, respectively; high energy values of 5·18 kcal g^{-1} to 5·66 kcal g^{-1}, 4·26 kcal g^{-1} to 4·30 kcal g^{-1}, 3·90 kcal g^{-1} to 4·15 kcal g^{-1}, 5·60 kcal g^{-1} to 6·15 kcal g^{-1} for *Afzelia*, *Brachystegia*, *Canavalia* and *Pentaclethra*, respectively; and oil levels of 37·15% to 39·50% and 39·0% to 51·5% for *Afzelia* and *Pentaclethra*, respectively. The highest levels of calcium (0·752%) and phosphorus (0·542%) were obtained with *Brachystegia* and *Canavalia*, respectively.

An ANOVA test of the nutrient contents, when subjected to arcsin transformation, indicated a highly significant difference ($P \leq 0.001$) with location. Likewise, the coefficient of determination showed positive significant differences ($P \leq 0.05$ to $P \leq 0.001$) between locations. © 1997 Elsevier Science Ltd. All rights reserved

INTRODUCTION

The search for alternative feed ingredients for man and livestock, especially for non-ruminants, continues to attract the attention of researchers all over the world. The observed increase in the search for alternative feed ingredients, especially for the developing countries of the world, is of paramount importance for two main reasons: (1) the low production of oil seed cakes and cereal grains; (2) the stiff competition existing between man and the livestock industry for these existing feed materials.

Four local staple seeds in Nigeria—*Afzelia africana*, *Brachystegia eurycoma*, *Canavalia ensiformis* and *Pentaclethra macrophylla*—are examined in this study. All four belong to the family Leguminosae, and *B. eurycoma* and *A. africana* to the subfamily Caesalpinodae. When matured and dried, their pods dehisce by an explosive mechanism with the valves curling outwards to expose the seeds. The seed of *P. macrophylla* is flattish in shape varying from oblanceolate to subrhomboid and measuring 3–5 cm wide and 6–7 cm long. The seed coat is leathery.

B. eurycoma grows along stream banks in high forest zones of tropical Africa. It grows to a large height, to 36 m, and to 7·5 m in girth. Flowering occurs in the months of March and April with fruiting taking place from September to January. The fruit is a pod ranging from 13·5 cm to 20 cm in length, shiny in texture and flat, as for *P. macrophylla*.

A. africana grows to a height of 34 m, 13 m in dry situations, with a girth of up to 3 m. It flowers around February to June and fruits in April to June, or extending to August. Fruits are at right-angles to the stout stalk and measure up to 17·5 cm long by 9 cm broad and 4 cm thick. There are about eight seeds in the ellipsoidal pod, each measuring 1·4–3·2 cm long, glossy black with waxy orange aril/cap, forming a cup at the base and arranged transversely side by side in grooves in the middle of the pod.

Because of the importance of these four seeds for medicinal purposes (*A. africana* and *B. eurycoma*), industrial usage as in soap, margarine and candle-making (*A. africana* and *P. macrophylla*), as staple diets such as condiments and thickeners in soup (*A. africana* and *B. eurycoma*), 'African salad' (*P. macrophylla*) and as snap beans in French Asia, Japan and in the tropics (*C. ensiformis*), some research has already begun (Keay *et al.*, 1964; Mbadiwe, 1975; Kar & Okechukwu, 1978; Vickery & Vickery, 1979; FAO, 1981; Nwokolo, 1987). The prohibitive prices of oil seed cakes, such as groundnut cake and soybean meal, and the high cost of importing protein sources used in livestock feed in Nigeria, make it necessary to find suitable and cheap

substitutes; hence evaluation of the nutrient contents and energy values of these selected locally consumed seeds is required.

This paper reports on the nutrient composition and energy values of these four seeds, as well as their calcium and phosphorus contents. The effects of location, decortication and defatting on their chemical composition are also investigated.

MATERIALS AND METHODS

The seeds, collected from Ishiagu in Abia State and Abakiliki in Enugu State in Nigeria, were each ground separately in a Wiley mill to pass through a 1·0 mm sieve and stored in air-tight containers for analysis until required.

Decortication of seeds

Most seeds of the test materials have an outer cortex which is hard, except for *C. ensiformis* seeds which are whitish and fragile. The seeds were cracked in a mortar using a pestle, care being taken to ensure that they were not crushed. Then the outer seed cover was removed to give the decorticated seed.

Defatted seeds

The ground sample was first subjected to ether extraction (to extract the oil content) before subjecting it to nitrogen determination and subsequent crude protein determination.

The nitrogen-free extract (NFE) was obtained as 100% − (% moisture content + % crude protein + % ether extract + % crude fibre + % ash).

Proximate chemical compositions

The ash content was determined by heating 2–4 g of the dried sample in a silica dish at 600°C for 6 h (AOAC, 1975; 14.006). The macro-Kjeldahl method was used for the determination of nitrogen (AOAC, 1975; 2.049) and the crude protein was calculated by multiplying by a factor of 6·25; moisture content (AOAC, 1975; 14.004), ether extract using Soxhlet apparatus (AOAC, 1975; 14.018) and crude fibre (AOAC, 1975; 7.054) were also determined. Calcium was determined by atomic absorption spectrophotometry using HCl (AOAC, 1975); the concentration of phosphorus in the solution was determined as the yellow phosphovanadomolybdate complex using HCl and ammonium molybdate reagent (AOAC, 1975).

The energy potential in a food, placed in a platinum crucible and lowered into a bomb calorimeter, and the heat of combustion were determined and calculated according to Hugh and Hollingsworth (1969).

Nested ANOVA (analysis of variance) was adopted after transforming the percentage composition to arcsin and analysis excluded dry matter content (Sokal & Rohlf, 1981, pp. 271–292); the coefficient of determination was done by correlating each nutrient from the two States (Sokal & Rohlf, 1981, p. 570).

RESULTS AND DISCUSSION

The means (± standard error) of three determinations of the proximate chemical composition of decorticated seeds of four tropical seeds drawn from two locations are shown in Table 1. Pooled results indicated that the moisture content, crude protein and ash content of the seeds from Abia State were, respectively, 13·6%, 11·0% and 3·1% less than the values for seeds from Enugu State, while crude fibre and ether extract of the seeds from Abia State were, respectively, 4·54% and 11·9% more than seeds from Enugu State.

For *B. eurycoma* and *P. macrophylla*, the crude protein contents of Enugu seeds were, respectively, 12·5% and 27·6% greater than seeds from Abia State; for the ether extract, seeds from Abia State were, respectively, 11·5% less and 28·2% more for *B. eurycoma* and *P. macrophylla* than seeds from Enugu State. Crude fibre content of *A. africana* from Abia seeds was 38·1%

Table 1. Percentage proximate chemical composition of four tropical seeds from two locations using decorticated seeds

	Dry Matter	Moisture Content	Crude Protein	Crude Fibre	Ether Extract	Ash	NFE
Abia State:							
A. africana	94.20 ± 0.25	5.80 ± 0.03	16.6 ± 0.00	5.65 ± 0.02	37.15 ± 0.06	2.5 ± 0.01	32.3 ± 0.02
B. eurycoma	92.50 ± 0.20	7.50 ± 0.09	8.75 ± 0.04	2.90 ± 0.08	11.50 ± 0.03	2.20 ± 0.00	67.2 ± 0.03
C. ensiformis	92.60 ± 0.31	7.40 ± 0.07	26.5 ± 0.05	7.60 ± 0.02	9.60 ± 0.03	2.00 ± 0.00	46.9 ± 0.05
P. macrophylla	95.20 ± 0.16	4.80 ± 0.01	33.7 ± 0.05	3.65 ± 0.07	51.50 ± 0.04	2.7 ± 0.01	3.66 ± 0.03
Enugu State:							
A. africana	93.00 ± 0.18	7.00 ± 0.00	15.0 ± 0.03	3.50 ± 0.00	39.50 ± 0.01	2.60 ± 0.00	32.4 ± 0.05
B. eurycoma	92.40 ± 0.31	7.60 ± 0.01	10.0 ± 0.00	2.70 ± 0.00	13.00 ± 0.02	2.30 ± 0.00	64.4 ± 0.06
C. ensiformis	90.60 ± 0.20	9.60 ± 0.06	24.6 ± 0.07	9.60 ± 0.01	7.20 ± 0.05	2.00 ± 0.01	46.2 ± 0.03
P. macrophylla	94.68 ± 0.12	5.32 ± 0.08	46.5 ± 0.12	3.10 ± 0.07	37.00 ± 0.03	2.80 ± 0.01	5.90 ± 0.02

Means of three determinations ± standard error.
NFE (Nitrogen Free Extract) determined by difference.

above that for seeds from Enugu State. Amubode & Fetuga (1983) provided further evidence of the environmental differences in *A. africana* from Oyo State with 19·8% crude protein, 2·5% ether extract, 3·9% ash and 8·8% crude fibre, although their ether extract value was extremely low (6% of the value reported here).

It was observed that, with the more oily seeds (*A. africana* and *P. macrophylla*), an increase in crude protein led to a decrease in ether extract in that location and vice versa, a trend that was not noticed amongst the less oily (*B. eurycoma* and *C. ensiformis*) seeds. The ash content maintained a uniform variation of ±0·1% both within and between locations.

The effects of defatting seeds and using whole grains to determine the chemical composition of seeds are illustrated in Table 2. Defatting increased the crude protein level over decortication by a pooled average of 23·3%, while whole seeds decreased by 28·3% over decorticated seeds. Crude fibre decreased by 6·07% with defatted seeds and increased by 7·47% over decorticated seeds with whole grain when compared to decorticated seeds. Similar trends in variations were noticed between States when defatted and whole grains were considered.

A nested ANOVA test using the arcsin transformation is shown in Table 3. A highly positive significant difference ($P \leq 0{\cdot}001$) was found between the two locations. When the prediction equation (see Table 4) was used for crude protein, the seeds from Enugu State were significantly better ($P \leq 0{\cdot}001$) than those from Abia State, whereas, correlating the ether extract and crude fibre contents, those of Abia State were significantly different ($P \leq 0{\cdot}05$, $P \leq 0{\cdot}01$, respectively) from those of Enugu State. Ash and moisture contents were not significantly different ($P \geq 0{\cdot}05$).

The crude proteins of decorticated seeds were generally higher than whole grain but less than that of defatted seeds. Decortication reduced the crude fibre content which was partly contributed by the cortex covering the seed, a process that may have some effect on improving the digestibility of the other constituents. It was observed that decortication improved the crude protein, decreased the crude fibre and had the advantage of enhancing digestibility. Defatting further gave higher crude protein values over decorticated and whole grains. Defatting may have the advantage of reducing digestive difficulties in animals (Kar & Okechukwu, 1978; Nwokolo, 1987).

Table 2. Percentage proximate chemical composition of four tropical seeds from two locations using defatted and whole grains

	Defatted Seeds		Whole Grains	
	Crude Protein	Crude Fibre	Crude Protein	Crude Fibre
Abia State:				
A. africana	23.2 ± 0.01	5.42 ± 0.00	10.0 ± 0.03	6.21 ± 0.01
B. eurycoma	13.3 ± 0.04	2.54 ± 0.04	5.75 ± 0.01	3.20 ± 0.05
C. ensiformis	26.6 ± 0.00	7.20 ± 0.01	23.5 ± 0.02	8.00 ± 0.06
P. macrophylla	39.0 ± 0.11	3.41 ± 0.08	26.7 ± 0.03	3.99 ± 0.00
Enugu State:				
A. africana	26.7 ± 0.04	3.25 ± 0.03	9.40 ± 0.01	3.80 ± 0.05
B. eurycoma	16.8 ± 0.01	2.40 ± 0.02	6.00 ± 0.00	3.10 ± 0.04
C. ensiformis	28.0 ± 0.00	9.33 ± 0.06	20.8 ± 0.02	10.02 ± 0.01
P. macrophylla	48.4 ± 0.01	2.80 ± 0.00	28.1 ± 0.07	3.30 ± 0.06

Mean of three determinations ± standard error.

Table 3. Nested analysis of variance of all parameters excluding dry matter based on the two locations

Source of Variation	df.	Sum of Squares	Mean of Squares	F. ratio	Fexpected ∞ = 0.01
Among groups (Treatments)	9	2,760.126	306.681	5.726	3.30
Subgroups (Seeds)	7	359.954	51.420	0.960	
Within groups	23	1,231.926	53.562		
Totals	39	4,352.006			

Table 4. Interrelationship between the seeds from the two locations—Abia and Enugu States of Nigeria—using regression analysis

Dependent Variable (Y)	Independent Variable (X)	Prediction Equation	Regression Coefficient (R)	Coefficient of Determination (R^2)	Significant of R^2 in Equation
Abia Crude Protein	Enugu Crude Protein	Y = −3.750 + 3.101X	0.950	0.902	$P \leq 0.001$
Abia Ether Extract	Enugu Ether Extract	Y = 3.571 − 4.381X	0.946	0.894	$P \leq 0.05$
Abia Crude Fibre	Enugu Crude Fibre	Y = −3.499 + 2.836X	0.867	0.751	$P \leq 0.001$
Abia Moisture Content	Enugu Moisture Content	Y = −0.016 + 0.015X	0.892	0.796	$P \geq 0.05$
Abia Ash	Enugu Ash	Y = 48.978 + 7.717X	0.812	0.659	$P \geq 0.05$

Table 5. The gross energy values (kcal/g) of four tropical seeds and environmental effect on non-defatted seeds

Location	*A. africana*	*B. eurycoma*	*C. ensiformis*	*P. macrophylla*
Abia	5.66	4.26	4.15	6.15
Enugu	5.80	4.30	3.90	5.60

Ikediobi (1981) considered the quantity of protein in *P. macrophylla* (48·0%) to be as good if not superior to the Food and Agricultural Organization (FAO) reference protein (soybean). Protein values of 44·0%, 46·8%, 34·1%, 53·6% have been recorded for defatted *P. macrophylla* (Mba *et al.*, 1974; Kar & Okechukwu, 1978; Achinewhu, 1983; Nwokolo, 1987), which compare favourably with soybean 44·1% (Oyenuga, 1968) and 46·0% (Akinola, 1980), and agree with the 39·0% and 48·4% obtained in this report for *P. macrophylla* using defatted seeds.

The crude protein mean values of 23·2–26·7% for *A. africana* and 28·0% for *C. ensiformis* using defatted seeds are similar to the 24·3–34·5% in water melon, 24·7% in cowpea, 27·2% in lima bean (shelled), 23·8% in pigeon pea (Oyenuga, 1968) and 22–29% in jackbean (Udedibie *et al.*, 1986). Also, the crude protein level in *B. eurycoma* (13·3–16·8%) could be considered adequate when compared to 10·7% for maize, 9·02% for millet and 11·7% for rice (Oyenuga, 1968).

The seeds of *A. africana* and *P. macrophylla*, although rich in protein, have high energy values of 5·66 kcal g^{-1} and 6·15 kcal g^{-1}, respectively, for non-defatted seeds (see Table 5). These values are close to the values found for 5·52 kcal g^{-1} for soybean and 5·12 kcal g^{-1} for linseed (Maynard & Loosli, 1979), while the energy potentials of non-defatted *B. eurycoma* (4·30 kcal g^{-1}) and *C. ensiformis* (4·15 kcal g^{-1}) compare very well with those for groundnut (4·55 kcal g^{-1}) (Maynard & Loosli, 1979), unshelled bean (4·097 kcal g^{-1}) (Oyenuga, 1968), cowpea (4·31 kcal g^{-1}) and soybean (3·35 kcal g^{-1}) (Caribbean Food and Nutrition Institute, 1974). These findings place these tropical seeds not only as protein-rich foods but also as high energy-yielding foods.

High oil values of 37·2–39·5% (*A. africana*) and 37–51·5% (*P. macrophylla*) agree favourably with those of most oil seeds such as castor oil, 35–55% (Langenheim & Thimann, 1982) and 51·9% (Nwokolo, 1987), and water melon, 35·36% (unshelled) and 46·74% (shelled) (Oyenuga, 1968). On the basis of these results, the seeds could be regarded as potential sources of oil for industrial purposes and other usage.

Considering the most important major mineral elements (calcium and phosphorus), ratios of 1:0·42, 1:0·25, 1:1·81, 1:1·14 were recorded for *A. africana*, *B. eurycoma*, *C. ensiformis* and *P. macrophylla*, respectively (see Table 6). The very high values of calcium (0·752%, 0·501%) and low phosphorus (0·185%, 0·212%) for *B. eurycoma* and *A. africana*, respectively, are comparable to those of groundnut (0·75% calcium, 0·38% phosphorus) (Oyenuga, 1968), whereas the low calcium (0·379%) and high phosphorus (0·432%) of *P. macrophylla* agree with results of 0·15% calcium and 0·99% phosphorus for unfermented climbing melon seed (Achinewhu, 1983) and 0·28% calcium and 0·66% phosphorus for soybean (NRC, 1978). A combination of the seeds with high calcium and those with high phosphorus would make a good diet for livestock.

Table 6. Percentage mineral composition (calcium and phosphorus) in four tropical seeds

Seeds	Calcium (%)	Phosphorus (%)	Ca:P Ratio
A. africana	0.501	0.212	1:0.42
B. eurycoma	0.752	0.185	1:0.25
C. ensiformis	0.300	0.542	1:1.81
P. macrophylla	0.379	0.432	1:1.14

The importance of these seeds as feed substitutes for farm animals and human diet from the results of this study cannot be overemphasized. Further work is geared towards ascertaining their amino acid composition and the presence of any toxicants.

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