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Dehulling the African Yam Bean (*Sphenostylis stenocarpa* Hochst. ex A. Rich) Seeds : Any Nutritional Importance? Note I

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Abstract

The flour from three colour varieties of dehulled seeds and hull of the African Yam bean (AYB) (*Sphenostylis stenocarpa*) were analysed for proximate composition, ash solubility and alkalinity and the mineral composition, The dehulled seeds were labelled A_2, B_2 and C_2 while the corresponding hulls were labelled A_3, B_3 and C_3 respectively. Both protein and carbohydrate were highly concentrated in the dehulled samples while crude fat and crude fibre were more concentrated in the hulls. The ash was more than 90 % soluble in dilute mineral acid and significant correlation existed (0.99) in the ash solubility characteristics. With the exception of phosphorus and potassium, other minerals determined (Cu, Zn, Co, Na, Ca, Mg, Mn, Fe) were found to be more concentrated in the hulls than in dehulled samples and correlation coefficients were significantly high among the samples with values ranging between 0.94 ($^{r}{}_{A2\,A3}$, $^{r}{}_{B2\,B3}$) and 0.95 ($^{r}{}_{C2\,C3}$) at $\alpha = 0.05$. Error of prediction of relationship between dehulled and hull samples was low in the seed fractions, ash analysis and mineral composition. These results showed that dehulling of AYB can cause a reduction in its nutritional qualities.

Introduction

The African yam bean (AYB)

Sphenostylis stenocarpa grows wild in many of the tropical areas. It is one of the underutilised legumes in Nigeria (Aletor, *et al.* 1989). Areas of cultivation include West African and parts of equatorial Africa (Tindall, 1986), AYB seeds can be brown, white, speckled or marble with a hilum having a dark brown border. The AYB has tubers and seeds which form a valuable and prominent source of plant protein in the diet of Nigerians.

There have been various studies on different aspects of the AYB. The chemical composition of the hulled seeds of the AYB was evaluated by Aletor *and* Aladetimi (1989), Edem *et al.* (1990) and Kine *et al.* (1991a). Studies were carried out on the comparative food qualities of AYB (Kine *et al.* 1991b). Oshodi *et al.* (1995a) reported results on the amino and fatty acids composition of the hulled seeds of AYB flour. Adeyeye (1996a) reported on the relative merits of the presence of hull on the nutritional qualities of the AYB flour.

Kine *et al.*, (1991a) carried out the chemical evaluation of the nutritional value of one variety of both hulled and dehulled AYB and they also reported the comparative studies on the food qualities of AYB and cowpea (Kine, 1991b). Oshodi *et al.* (1995b) and Adeyeye (1995) reported on the vitro multienzyme digestibility of protein of six varieties (hulled and dehulled) of AYB flours while Adeyeye *et al.* (1994) and Oshodi *et al.* (1997) reported on the functional properties of some varieties (hulled and dehulled) of AYB flour. Adeyeye (1997) reported on the amino acid composition of six varities of dehulled AYB.

The dehulled seeds of the AYB are normally used in the preparation of *ekuru* or *kuduru* (meal make of dehulled bean ground and steamed), *moin-moin* or *ole* (prepared like ekuru but in addition contains edible oil and pepper), *akara* (cake) and *alapa* (a combination of half melon and half beans), it is called fricassee (Dictionary, 1980). The dehulled beans can also be cooked directly for children consumption to avoid flatulence (Murphy, 1964). Other food sources from dehulled AYB include *abari* and *gbegiri* (Which is a form of sauce). However, there have been no report on the likelyhood of nutritional loss due to dehulling of the AYB. This paper therefore reports on the seeds fractions, proximate composition of the dehulled and hull samples, analysis and solubility/ alkalinity of both samples as well as the analysis of the samples for mineral composition of the AYB.

Materials and Methods

Collection and treatment of samples

African yam bean seeds were collected from the farm located at Ayedun-Ekiti, Ekiti State, Nigeria. Firstly, the bad beans, stones and other non-AYB substances were eliminated and from the different colours, three varieties of white (A_1), light-brown with black strips (B_1) and reddish-brown (C_1) were identified.

Each colour variety was then dehulled. To make the dehulling process easier, boiled deionised water was poured into a 2 dm^3 beaker containing the seeds and left at room temperature (25^O C) until cool. The hull was removed according to the method of Oshodi and Ekperigin (1989) The dehulled seeds (now labelled A_2, B_2 and C_2) (Table I) were oven-dried at 45^O C, cooled, weighed and then dry-milled into flour and sieved through a screen mesh of aperture 425 microns. The hulls (now labelled A_3, B_3 and C_3) were also sundried, weighed, milled and sieved. Sieved samples were put in labelled McCartney bottles and kept in the deep freezer pending analysis.

Table I. Sample Identification by colour

Colour variety	Alphabet numbers
White (dehulled seeds)	A_2
White (hull)	A_3
Light brown with black strips Dehulled seeds	B_2
Light brown with black Strips (hull)	B_3
Reddish brown (dehulled seeds)	C_2
Reddish brown (hull)	C_3

Analysis of the samples

Proximate analysis

Moisture, total ash, ether extract and crude fibre were determined by the AOAC methods (1990), While nitrogen was determined by the micro-Kjeldahl method described by Pearson (1976) and the percentage of nitrogen was converted to crude protein by multiplying with 6.25 Carbohydrate was determined by difference.

The minerals were analysed from solutions obtained by first dry-ashing the seed flours/hulls at 550^{O} C and dissolving the ash in beakers with 25 cm^3 of 10 % hydrochloric acid and 5 % $LaCl_3$ solution, heated to boiling, filtered into standard flasks and made up to mark with distilled de-ionised water. Mg, Mn, Ca, Co, Fe, Zn and Cu in the samples were determined with an atomic absorption spectrophotometer (Pye Unicam, Model Sp 9, Cambridge, UK). Those of Na and K were determined with a flame photometer (Corning, Model 405, Gallenkamp, London, UK) (AOAC, 1990) Earlier, the detection limits of the metals had been determined using the methods of Varian Techtron (1975) with the following values in ppm : Cu (0.002), Mn (0.002), K (0.005), Na (0.012), Zn (0.002), Co (0.01), Fe (0.03), Ca (0.01) and Mg (0.001). All detection limits reported were for aqueous solution. The optimum analytical range was 0.1 to 0.5 absorbance units with a coefficient of variation of 0.87 % to 2.20 %. The phosphorus was determined colorimetrically by Spectronic 20 (Gallenkamp, UK) using the phosphovanado molybdate method of AOAC (1990). All chemicals used were of analytical grade and obtained from the British Drug Houses (BDH, London).

Ash analysis

(a) Water- soluble

The procedure for the determination of total ash was followed (AOAC, 1990). The ash obtained was boiled with 25 cm^3 distilled water and the liquid filtered through an ashless filter paper and thoroughly washed with hot distilled water. The filter paper was then ignited in the original dish, cooled and water insoluble ash weighed (Abbey and Ayuh, 1991).

$$\text{Water-soluble ash (\%)} = \text{Total ash (\%)} - \text{Water - insoluble ash (\%)}.$$

(b) Soluble ash alkalinity

The filterate obtained from (a) above was cooled and titrated with 0.1M hydrochloric acid using methyl orange indicator, the alkalinity of the soluble ash was determined. The alkalinity was expressed as cm^3 Molar acid/100g sample (Pearson *et al.,* 1981).

(i) K_2CO_3 alkalinity

The alkalinity, cm^3 M acid/100 g sample value as obtained in (b) was multiplied by 0.0691 to get the K_2CO_3 alkalinity.

(ii) Na_2CO_3 alkalinity

The alkalinity, cm^3 M acid/100g sample value as obtained in (b) was multiplied by 0.053 to get the Na_2CO_3 alkalinity.

(c) Acid-insoluble ash

The procedure for the determination of total ash was followed (AOAC, 1990). The ash was boiled with 25 cm^3 dilute hydrochloric acid (10 % v/v HCL) for 5 minutes, the liquid was filtered through an ashless filter paper and thoroughly washed with hot water. The filter paper was then ignited in the original crucible, cooled and weight (Pearson, *et al.* 1981).

Acid-insoluble ash (%) =

$$\frac{\text{Acid - insoluble ash}}{\text{Weight of sample}} \times 100$$

(d) Sulphated ash

The procedure for the determination of total ash was followed (AOAC, 1990). This was followed by the moistening of the ash with conc. H_2SO_4 and igniting gently to constant weight.

Sulphated ash (%) =

$$\frac{\text{Weight of sulphated ash}}{\text{Weight of sample}} \times 100$$

Data analysis

All the data generated were analysed statistically (Chase, 1976). The statistical calculations reported included correlation coefficient (C.C.), coefficient of alienation (C.A.), index of forecasting efficiency (I.F.E.) and regression coefficient (R.C.) as related to seed anatomical fractions, proximate composition, mineral composition and ash solubility/ alkalinity. The level of significance $\alpha = 0.05$. All determinations were in triplicate.

Results and Discussion

Anatomical composition

The hull content of the African yam bean seeds analysed is shown in Table II. The value ranged between 7.53 % – 8.15 %. The intervarietal differences in the hull content might be due to genotypical differences since the samples came from the same source and the dehulling method was similar for all samples. The correlation coefficient showed that as the hull dimnished, the corresponding dehulled sample increased resulting in a

Table II. Seed fractions of African yam bean flour (% dry weight)

Sample[a]	Hull[b]	Dehulled[b]	C.C.	C.A.	I.F.E.	R.C.
A_1 (Whole seed)	7.53	92.47				
B_1 (whole seerd)	8.15	91.85	-1.00*	0.00	100.00	-1.03
C_1 (whole seed)	8.08	91.92				

$\alpha = 0.05$; C.C. = correlation coefficient; C.A. = coefficient of alienation;
I.F.E. = Index of forecasting efficiency (%); R.C. = regression coefficient
* = significant; [a]A_1 = white; B_1 = light brown with black strips; C_1 = reddish brown.
[b]Determinations were in triplicate

perfect significant negative correlation ($\alpha = 0.05$). The coefficient of alienation which produces an index of lack of relationship was 0.0 % which means a good relationship existed between the hull and dehulled samples. Also the index of forecasting efficiency which gives the reduction in errors of prediction over relationship was high (100.00 %) meaning the relationship is easily predictable.

The regression coefficient was - 1.03 meaning that for every unit increase in the hull content, there was a corresponding decrease of 1.03 in the dehulled sample. Kine *et al.* (1991) reported a value of 8.6 % hull in one variety of AYB while Abbey and Ayuh (1991) reported 17.5 %. The variability in the current report and the results in literature could be attributed to differences in the origin of samples. Variations in sample origin included differences in sampling time after harvest, the cultivar used and the environment where the crop was grown (Neme, *et al.*, 1990).

Proximate composition

The proximate compositions for the samples are shown in Table III. All the dehulled samples showed high values for protein and carbohydrate but far lower values of the two parameters were recorded for the hull samples showing that the dehulled samples were better concentrated sources of proteins and carbohydrates. On the other hand, the hull samples were better concentrated in crude fibre and ether extract. With the exception of B_3, the total ash was more concentrated in the hull than the dehulled samples.

The higher content of ash in the hull samples might be due to higher mineral concentration while the higher crude fibre was definitely due to the hull. The proximate values reported for the dehulled AYB flour followed the trend reported by Abbey and Ayuh (1991) and Kine *et al.* (1991a). Adeyeye (1996a) reported the fatty acid analysis of the hulled and dehulled samples of the AYB seeds and found out that the hulled samples were better

Table III. Intercorrelations in the proximate values between samples A_2 and A_3 B_2 and B_3 C_2 and C_3 of African yam bean flour (g/100g) on dry extract basis[a]

Parameter	A_2	A_3	B_2	B_3	C_2	C_3
Protein	24.24	10.65	24.56	14.99	21.39	17.18
Total ash	2.49	2.54	2.23	1.53	2.33	2.99
Crude fibre	1.73	31.86	2.54	34.49	1.99	33.05
Crude fat	8.61	8.53	8.15	17.04	10.79	16.48
Carbohydrate	621.93	46.42	62.52	31.95	63.50	30.30
C. C.	0.69		0.43		0.44	
C.A.	0.72		0.90		0.90	
I.F.E.	27.61		9.72		10.20	
R.C.	0.50		0.23		0.21	

[a]Determinations were in triplicate.

concentrated in most of the fatty acids deter mined, this could have been due to the presence of the hull. The hull is important in the production of the crude fibre which may have hypocholesterolemic properties (Adeyeye and Ayejuyo, 1994).

The correlation coefficient in the proximate results was high in $^{r}{}_{A2\ A3}$ (0.69) but low in $^{r}{}_{B2\ B3}$ (0.43 and $^{r}{}_{C2C3}$ (0.44) but none was significant at $\alpha = 0.05$. The reduction in the errors of forecasting relationship in all the samples were low. A_2A_3 (27.61 %), B_2B_3 (9.72 %) and C_2C_3 (10.20 %). All the samples have positive regression coefficients with values of 0.50 (A_2A_3), 0.23 (B_2B_3) and 0.21 (C_2C_3) showing that the hull still contribute positively to the proximate composition of AYB. However, it also showed that the dehulled part contributed more (but not significantly) to the proximate composition.

Ash solubility/alkalinity

The ash solubility/alkalinity results are shown in Table IV. With the exception of A_3, water-soluble ash values were higher in hull samples although the values were generally low across the board with values ranging between 0.54 % in A_2 to 1.74 % in C_3. The low values for the water-soluble ash resulted into high values for the water-insoluble ash in both categories of samples. Water-soluble ash is a useful criterion on the examination of preserves and jams for fruif content.

The values of the ash-soluble in hydrochloric acid solution in the dehulled and hull samples are shown in Table IV. The ashes of both the dehulled and the hull samples were highly acid soluble with values ranging from 99.30 % – 99.90 % for dehulled samples with an average of 99.69% while the values ranged from 97.03% – 99.18% with an aver age of 98.34 % for the hull samples. These

Table IV. Intercorrelations in the ash analysis (%) between samples A_2 and A_3 B_2 and B_3 C_2 and C_3 of African yam bean flour[a]

Parameter	A_2	A_3	B_2	B_3	C_2	C_3
Water soluble ash	0.54	0.50	0.43	1.26	0.69	1.74
Acid soluble ash	99.90	98.81	99.88	99.18	99.30	97.03
K_2CO_3 alkalinity	8.50	2.40	11.10	1.18	10.20	2.01
Na_2CO_3 alkalinity	6.50	1.84	8.50	0.91	7.80	1.54
Sulphated ash	3.43	3.38	2.67	2.68	1.44	4.05
C. C.	0.99*		0.99*		0.99*	
C.A.	0.14		0.14		0.14	
I.F.E.	85.89		85.89		85.89	
R.C.	1.01		1.03		0.99	

*Result significant at $\alpha = 0.05$

[a]Determinations were in triplicate.

results showed that the hulls contained more stony insoluble materials than the dehulled samples. The maxima are prescribed for herb and spices in some countries (Pearson, *et al.,* 1981).

The values of K_2CO_3 alkalinity and the Na_2CO_3 alkalinity are shown in Table IV. A cursory look at the Table would show that the dehulled samples contained higher percentages of both K_2CO_3 and Na_2CO_3 when compared to the hull sample values. This meant that the dehulled samples might likely be more concentrated in potassium and sodium than the corresponding hull samples. This procedure of K_2CO_3 and Na_2CO_3 determination might be used to test for the relative aboundance of potassium and sodium in a sample to serve as a guide before the mineral analysis.

The alkalinity values are often useful when considered in conjunction with ash figure for confirming other results in relation to the original composition. In some foods, such as tea, a low water soluble ash and low alkalinity of the ash indicate previous abstraction of important constituents with consequent lowering of quality (Pearson, *et al.,* 1981).

The sulphated ash values in the samples are shown in Table IV. The sulphated ash values were slightly higher than the total ash in both dehulled and hull samples except in C_2. The sulphated ash gives a more reliable ash content for a sample containing varying amounts of volatile substances which may be lost at the ignition temperature used (Pearson, *et al.*, 1981). When the results for the total ash and the sulphated ash were compared, it was observed that the majority of the samples might likely contain volatile substances which might have been lost at the ignition temperature (550^{O} C) used.

The correlation coefficients in the ash solubility/alkalinity were high with values of 0.99 for $^{r}{}_{A2\ A3}$, $^{r}{}_{B2\ B3}$ and $^{r}{}_{C2\ C3}$ and all were significant at $\alpha = 0.05$. The reduction in the errors of forecasting relationship in all samples were high. A_2A_3 (85.89 %), B_2B_3 (85.89 %) and C_2C_3 (85.89 %). All the regression coefficients were high with values ranging between 0.99 and 1.03.

Mineral composition

The results of the mineral composition are shown in Table V. The samples would be good sources of the nutritionally valuable minerals reported. Generally, the dehulled samples were better concentrated in K and P while hull samples were better concentrated in Cu, Zn, Na, Ca, Mg, Mn and Fe. The correlation coefficients were also high with the following values : $^{r}{}_{A2\ A3}$ (0.94), $^{r}{}_{B2\ B3}$ (0.94) and $^{r}{}_{C2\ C3}$ (0.95) and they were all significant at $\alpha = 0.05$. The regression coefficients showed that for every unit increase in the mineral composition of A_2, B_2 and C_2 there was a corresponding increase of 0.73 in A_3, 1.02 in B_3 and 0.56 in C_3 respectively.

Table V. Intercorrelations in the mineral element composition between samples A_2 and A_3, B_2 and B_3, C_2 and C_3 of African yam bean flour (mg/100g) on dry extract basis

Mineral	A_2	A_3	B_2	B_3	C_2	C_3
Cu	10.01	28.80	1.28	3.51	1.80	1.38
Zn	8.58	20.10	3.81	9.16	56.07	25.42
Co	3.72	3.17	0.52	1.75	3.36	2.63
P	282.62	59.16	2.12.17	63.78	291.55	51.52
Na	5.81	8.32	1.81	9.75	6.89	14.87
K	676.00	562.19	497.04	552.39	714.36	441.95
Ca	10.44	73.60	7.57	55.90	9.43	6.48
Mg	11.84	14.93	8.96	13.15	12.72	20.18
Mn	1.72	21.33	16.00	14.25	14.84	37.17
Fe	6.24	9.49	3.73	19.73	6.78	12.74
C. C.	0.94*		0.94		0.95	
C.A.	0.34		0.34		0.31	
I.F.E.	65.88		65.88		68.78	
R.C.	0.73		1.02		0.56	

*Result significant at $\alpha = 0.05$ [a]Determinations were in triplicate.

This meant that the hull contribution to the mineral composition of the AYB under study was $B_3 > A_3 > C_3$. The reduction in errors of prediction of relationship were high in all the samples, the values were A_2A_3 (65.88 %), B_2B_3 (65.88%) and C_2C_3 (68.78 %). These results made the prediction of relationship very easy. The observation for the mineral composition of B_2B_3 correlated with the report of Oshodi and Ipinmoroti (1990) who determined some nutritionally valuable minerals in Irvingia gabonensis.

It is well known (Mertz, 1981; Adeyeye, 1996b and Adeyeye and Arogunjo, 1997) that mineral elements are necessary for life. Cobalt (II) is a component of vitamin B_{12} (cyanocobalamin) which is essential for the prevention of anaemia. Iron was high in all the samples but higher in the hull samples. About 1-10 % of iron from plant sources are normally absorbed by the body (Bender, 1992) although this value can be improved upon when plants are consumed with meat. For example, the addition of meat to legume or cereal diet can double the amount of iron absorbed and so contribute significantly to the prevention of anaemia, which is so widespread in developing countries like Nigeria (Bender, 1992)

Zinc is present in all tissues of the body and it is a component of more than 50 enzymes (Bender, 1992). The minimum Zinc allowance (about 15-20 mg) per day (Adeyeye and Arogunjo, 1997) would be met by A_3, C_2 and C_3 (Table V). Copper was highly concentrated particularly in A_2, A_3 and B_3. Copper and iron are present in the enzyme cytochrome oxidase involved in energy metabolism. Copper deficiency is of little concern since it is widely distributed in other types of food (Adeyeye, 1996b).

The concentration of manganese was very high in the hull samples. This observation is in sharp contrast to what obtains in meat (Adeyeye, 1996b and Fleck, 1976). Manganese functions as an essential constituent for bone structure, for reproduction and for normal functioning of the nervous system, it is also a part of the enzyme system (Fleck, 1976)

Calcium concentration was high in A_3 and B_3 than in any other samples. Calcium is an important constituent of body fluids. It is a co-ordinator among inorganic elements particularly K, Mg or Na where calcium is capable of assuming a corrective role when such metals are in excessive amount in the body (Fleck, 1976). Ca, P and vitamin D combine together to avoid rickets in children and osteomalacia (the adult rickets) as well as osteoporosis (bone thinning) among older people (Moldawer, *et al.*, 1965). A dietary regime of adequate dietary Ca over the years should be a deterrent to this condition.

High values of phosphorus were recorded particularly in the dehulled samples. No good value ratio existed between Ca and P in any of the samples. Phosphorus is always found with Ca in the body, both contributing to the supportive structures of the body. It is present in cells and in the blood as soluble phosphate ion, as well as in lipids, proteins, carbohydrates and energy transfer enzymes (Food, 1974). Phosphorus is an essential component in nucleic acids and the nucleoproteins responsible for cell division, reproduction and the transmission of hereditary trairts (Hegsted, 1967).

The samples are good sources of potassium and magnesium but low in sodium. Magnesium is an activator of many enzyme systems and maintains the electrical potential in nerves (Shils, 1973). Potassium is primarily an intercellular cation, in large part this cation is bound to protein and with sodium influences osmotic pressure and contributes to normal pH equilibrum (Fleck, 1976). Plants and animal tissues are rich sources of potassium, thus a dietary lack is seldom found. For sodium, the mineral is widely distributed in foods, with plants containing less than animal sources (Fleck, 1976). The results in Table V corroborate this earlier observation.

Conclusion

The results of this study showed that the hull of the AYB is important not only in the production of crude fibre (which may have hypocholesterolemic properties) but also in contributing to the quality of the minerals. This means that dehulling will reduce the contribution of the hulls to the nutritional qualities of the African yam bean seeds. This nutritional quality reduction may be reduced by grinding and adding the removed hulls to the dehulled AYB when used for the preparation of ekuru, moin-moin, akara, alapa and ole in which their smoothness can still be retained. It is an intention to retain the nutritional qualities of both hull and dehulled portions of legumes that make countries of the Latin America normally whole-fry their legumes (Brenes, *et al.*, 1973). Nigeria consumers may wish to adopt this system of whole-grain use of African yam bean seeds for the preparation of the earlier mentioned delicacies.

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