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PROXIMATE AND MINERAL COMPOSITION OF SEED AND TUBER OF AFRICAN YAM BEAN, *SPHENOSTYLIS STENOCARPA* (HOECHST. EX. A. RICH.) HARMS

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ABSTRACT

The compositional analyses of the seed and tuber of African yam bean were carried out and their constituents compared. There were highly significant differences (P< 0.001) between the crude protein, ash, nitrogen-free extract, and crude fibre and carbohydrate fractions of the seed in the five accessions of African yam bean. Fat (ether extract) and moisture content fractions of the seed did not differ significantly (P>0.05) between the five accessions. The yam bean tuber was composed mainly of carbohydrate (79.24%). The other constituents of the tuber showed low percentages except nitrogen-free extract (71.18%) that was more than those found in the seed. Both the seed and tuber of African yam bean had higher levels of carbohydrate than crude protein. The use of paired T-test showed that both the seed and tuber of African yam bean did not differ significantly (P>0.05) in the composition of their mineral contents.

Key words: Accession, African yam bean, Proximate analysis, *Sphenostylis stenocarpa.*

INTRODUCTION

African yam bean (*Sphenostylis stenocarpa*) is a grain legume, and legumes are good sources of protein and energy. The yam bean is cultivated in Central African Republic, Zaire, East Africa and Ethiopia for its tubers and in South Eastern Nigeria for its edible seeds (Okigbo, 1973). In areas where it is grown for its seeds, yam bean has become an important substitute for the more widely eaten cowpea. There are reports of the tubers being used as food and this contains more than twice the protein in sweet potatoes or Irish potatoes and more than ten times the amount in cassava roots (NAS, 1979).

Several authors (Okigbo, 1973; Edem *et al.*, 1990; Kine *et al., 1991*) have evaluated the chemical composition of the African yam bean. Yam bean contains high lysine levels while both methionine and tryptophan contents are low (Evans and Boulter, 1974). However, Duke *et al.* (1977) showed that both the lysine and methionine contents of the protein are equal to or better than those of soybean. African yam bean has high metabolic energy, low true protein digestibility, moderate mineral content and amino acid content that compares to most pulses (Nwokolo, 1987).

NAS (1979) showed that the crude protein content of yam bean seed varies from 19 to

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29 per cent. The seed contains 50 to 60 per cent carbohydrate and 5 to 6 per cent fibre (Watson, 1979). Oshodi *et al.* (1995) reported the amino acid and fatty acid composition of six varieties of African yam bean. The fatty acid composition of yam bean is similar to most of the common edible pulses (Nwokolo, 1987). It has been reported that the chemical composition of yam bean tuber compares favourably in starch and crude protein with some indigenous root crops (Okigbo, 1973).

Inspite of the fact that the chemical composition of African yam bean has been investigated, information seems to be lacking on compositional differences in different seed types, and between the seed and the tuber. This paper therefore, compares the proximate composition in five accessions of yam bean seed, and mineral composition of the seed and tuber.

MATERIALS AND METHODS

The seeds and tubers of African yam bean used for this study were harvested from an experimental farm in the Botanical Garden of the University of Nigeria, Nsukka, during the 2004 harvest season. Compositional analyses of the seed and tuber of *S. stenocarpa* was carried out using the official methods of analysis of the Association of Official Analytical Chemists (1984) and the FAO (1986).

Determination of percentage moisture content of seed and tuber

The seed or tuber sample was ground to fine form and mixed well. Two grammes of seed or tuber sample was accurately weighed into moisture dishes (in duplicate). The sample was dried for 24 hrs at 100 ^{0}C. After drying, the samples were removed from the oven (Memmert U. 27) and placed in a desiccator to cool for about 30 minutes and then reweighed. The percentage moisture content was calculated as follows:

$$\% \text{ Moisture } = \frac{(B-C)\ x\ 100}{A}$$

where, A and B are the sample weight and the weight of dish + sample, respectively prior to drying, and C the weight of dish + sample after drying. B – C is the loss in weight of sample after drying.

Determination of percentage ash content of seed and tuber

Five grammes of seed or tuber sample (fine form) was weighed into a porcelain dish that had previously been weighed. This was dried at 100 ^{0}C for three hours in an oven. The dish with content was transferred to a muffle furnace (Heraeus M 110) and ignited at 500 ^{0}C until free from carbon (residue appears greyish-white). This was removed from the oven and the ash moistened with a few drops of water (to expose bits of unashed carbon).

The ash was re-dried in the oven at 100^{o}C for 3 hours and re-ashed in the furnace at 500^{o}C for another one hour. This was removed from the muffle furnace, allowed to cool for a moment, placed in a desiccator until it cooled, and was then weighed. The percentage ash was calculated as follows:

$$\% \quad \text{Ash} \ = \frac{(\text{B} - \text{C}) \times 100}{\text{A}}$$

where,
A = sample weight prior to drying
B = weight of dish and contents after ashing
C = weight of empty dish.

All weights were expressed in grammes (g).

Determination of percentage crude protein of seed and tuber

Two grammes of oven dried ground seed or tuber sample was placed into 30 ml Kjeldahl digestion flask (Gerhardt). Fifteen millilitres (15 ml) of concentrated sulphuric acid and 1g of catalyst mixture were added into the flask. The flask was cautiously heated on a digestion rack in a fumehood until a greenish clear solution appeared. After about 30 minutes when the digest had cleared, the flask was heated for another 30 minutes and allowed to cool. Ten millilitres (10 ml) of distilled water was added to avoid caking.

The sample was transferred to the Kjeldahl apparatus (Gerhardt). A 50 ml receiver flask containing 5 ml boric acid–indicator solution was placed under the condenser of the distillation apparatus so that the tip was about 2 cm inside the solution. To the digested sample in the apparatus was added 10 ml of 40 per cent NaOH solution through funnel stopcock. Distillation commenced immediately by closing the steam by-pass and opening the inlet stopcock on the steam jet arm of the distillation apparatus. When the distillate reached the 35 ml mark on the receiver flask, distillation was stopped by closing inlet stopcock first, then opening the steam by-pass. The condenser tip was rinsed with distilled water. The excess acid was titrated to first pink colour with O.1N NaOH. The percentage crude protein was calculated as follows:

$$\%\,\text{Crude protein} = \frac{\text{Titre} \times 14.01 \times \text{Normality of the acid} \times 100 \times 6.25}{1000 \times \text{Weight of sample}}$$

Where, 6.25 is a general factor suitable for products in which the portion of specific protein is not well defined, $\frac{14.01}{1000}$ is a constant and titre is the volume after titration.

Determination of percentage crude fat (ether extract) content of seed and tuber

Five grammes (5g) of ground seed or tuber sample was placed in a thimble lined with a circle of filter paper. The thimble with its contents was placed in a 50 ml beaker and dried in an oven for 6 hours at 100 ^{0}C.

The thimble with its contents was transferred to a Soxhlet extractor (Gerhardt). The beaker was rinsed several times with ethyl ether and emptied into the Soxhlet extraction flask. The sample contained in the thimble was extracted with ethyl ether for 6 to 8 hours at a condensation rate of at least 3 to 6 drops per second. At the completion of the extraction, the fat extract was transferred from the extraction flask into a pre-weighed evaporating dish with several rinsing of ethyl ether. The evaporating dish was placed in a fumehood with the fan on, to evaporate the ethyl ether until no odour was detectable.

The dish with its contents was dried in an oven for 30 minutes at 100 ^{0}C, removed from the oven, cooled in a desiccator and

weighed. The percentage crude fat was calculated as follows:

$$\% \text{ Crude fat (ether extract)} = \frac{W_2 - W_1 \times 100}{S}$$

where:
W_1 = weight of empty evaporating dish
W_2 = weight of evaporating dish + content after drying.
S = sample weight before drying.

Determination of percentage crude fibre content of seed and tuber

Five grammes (5g) of ground seed or tuber sample was weighed and placed in a one litre conical flask. A 150 ml preheated 0.128 M H_2SO_4 was added and the content boiled for 30 minutes. The content was filtered through fluted funnel and the residue washed three times with hot water. To the digest was added 150 ml preheated 0.15 M KOH and heated to boiling. Some drops of antifoaming agent (n-octanol) was added and the content boiled slowly for 30 minutes, filtered and the residue washed three times with hot water, followed by washing three times with acetone in Cold Extraction Unit (Tecator 1615).

The resulting residue was dried in the oven at 130 ^{0}C for 1 hr, cooled in a desiccator and weighed, and then ashed at 500 ^{0}C for 30 minutes, cooled in a desiccator and later weighed. The percentage crude fibre was calculated as follows:

$$\% \text{ crude fibre} = \frac{W_2 - W_3}{W_1} \times \frac{100}{1}$$

where:
W_1 = Sample weight before drying
W_2 = Weight of residue after drying
W_3 = Weight of residue after ashing

Determination of nitrogen-free extract content of seed and tuber

The nitrogen-free extract of seed or tuber was determined by summing up the percentages of moisture, ash, crude protein, fat(ether extract) and crude fibre, and subtracting from 100 (Mcdonald *et al.*, 1973). The difference in value was designated the nitrogen-free extract.

Determination of carbohydrate content of seed and tuber

The percentage carbohydrate content of seed or tuber of African yam bean was determined by summing up the percentages of moisture, ash, crude protein, fat (ether extract) and subtracting from 100 (Mcdonald *et al*., 1973). The difference in value was taken as the percentage total carbohydrate content of seed or tuber. The total carbohydrate of either the seed or tuber is contained in two fractions, the crude fibre and the nitrogen – free extractives.

Determination of mineral content of yam bean seed and tuber

The mineral content of the seed or tuber of African yam bean was estimated by dry ashing as described previously (Pearson, 1976).

Two grammes (2g) of dried samples of plant material, ground to pass through a 1 mm mesh sieve were transferred into a crucible and ashed in a muffle furnace at 500 ^{0}C for 3 hours. The crucibles were removed after the ashing was completed. After cooling, 10 ml of 2M hydrochloric acid was added and heated directly until boiling. The contents in each crucible were thereafter transferred into 50 ml volumetric flask and then diluted to 50 ml.

The optical density of elements except phosphorus was determined using the Atomic Absorption Spectrophotometer (Model 200 – A). For phosphorus determination, 2 ml of Ammonium Molybdate vanadate and 5 ml of 5 M hydrochloric acid were added to 2 ml of the stock solution. The concentration of phosphorus was determined through the measurement of the yellow phospho-vanado-molybdate complex using Cecil Carating Digital Spectrophotometer Series 2.

The concentration of each element contained in the sample was calculated thus:

$$\text{conc. of each element} = \frac{\text{Microgram/ml of sample} \times \text{Dilution} \times \text{Original Volume}}{\text{Weight of sample} \times 10^6}$$

(conc. × 10000 = concentration in part per million (ppm); ppm ×100 = mg/100g; mg/100g × 1000 = microgram/100g.

RESULTS

Proximate analysis of the seed and tuber of S. stenocarpa

The compositional analysis of the seed of five accessions of *S. stenocarpa* is shown in Table 1.

The crude protein fraction of the seed was highest in accession 3 (23.7%), closely followed by accession 5 (23.0%) while the lowest crude protein component of the seed was recorded in accession 4 (9.9%). There were highly significant differences (P< 0.001) between the crude protein fractions in the five accessions of African yam bean seed. The ash fraction of the seed was more in accession 1 (2.8%), followed by accession 2 (2.5%) while accession 4 showed the lowest ash fraction (1.3%). The percentage ash fractions showed highly significant differences (P< 0.001) between the five accessions of *S. stenocarpa* seed. Accession 4 showed the highest nitrogen-free extract fraction (65.9%), followed by accession 2 (65.7%), while the least nitrogen-free extract percentage was shown in accession 3 (53.6%). There were highly significant differences (P<0.001) between the nitrogen-free extract fractions in the five accessions of African yam bean seed. The ether extract component of the seed was highest in accession 1 (1.2%), followed by accession 3 (1.1%) while accession 5 recorded the lowest ether extract fraction (0.8%). The various fractions of ether extract did not differ significantly (P> 0.05) between the five accessions.

The moisture content of the seed was highest in accession 4 (9.6%), followed by accession 1(9.1%), while the lowest percentage moisture content was shown in accession 2 (8.0%). There were however no significant differences (P>0.05) between the percentage moisture content in the five accessions of African yam bean seed. The crude fibre fraction of the seed in the five accessions of *S. stenocarpa* was highest in accession 4 (12.4%), followed by accession 2 (12.2%) while accession 5 showed the least (7.4%) crude fibre

fraction. There were highly significant differences (P< 0.001) between the crude fibre components in the five accessions of African yam bean seed. The results in Table 1 indicate that the seed of accession 4 had the highest carbohydrate content (78.3%), followed by accession 2 (77.9%) while accession 3 showed the lowest (65.0%) carbohydrate content. There were highly significant differences (P< 0.001) between the carbohydrate contents in the five accessions of *S. stenocarpa.* It could be seen from the results above that the seed of the five accessions of African yam bean have high percentage carbohydrate content than crude protein.

The proximate composition of African yam bean tuber is shown in Table 2. The results showed a crude protein and carbohydrate composition of 8.32% and 79.24%, respectively. The results equally presented the tuber of *S. stenocarpa* as being composed mainly of carbohydrate. The other constituents showed low percentages except nitrogen-free extract (71.18%) that was more than those found in the seed of all the accessions. However, the crude protein level in the tuber was found to be smaller than those recorded in the five accessions of African yam bean seeds. Both the seed and tuber of *S. stenocarpa* therefore possess higher levels of carbohydrate than crude protein or other constituents.

Mineral content of African yam bean seed and tuber

The mineral composition of African yam bean seed and tuber is shown in Table 3. Comparison of the minerals found in both seed and tuber indicate that magnesium; phosphorus, potassium, iron and manganese were more in the tuber than seed. However the quantity of sodium, calcium, zinc and copper in the tuber were less than those found in the seed. The use of paired t-test showed that both the seed and tuber did not differ significantly (P>0.05) in the composition of their mineral contents (Table 3).

Table 1: Proximate analysis of the seeds of five accessions of *S. stenocarpa*

Accessions	Crude protein (%)	Ash (%)	Nitrogen-free extract (%)	Ether extract (%)	Moisture (%)	Crude fibre (%)	Carbohydrate (%)
1	21.0	2.8	56.8	1.2	9.1	9.1	65.9
2	10.7	2.5	65.7	1.0	8.0	12.2	77.9
3	23.7	1.6	53.6	1.1	8.7	11.4	65.0
4	9.9	1.3	65.9	1.0	9.6	12.4	78.3
5	23.0	2.4	57.7	0.8	8.6	7.4	65.2
F-LSD$_{(0.05)}$	1.84	0.44	2.10	NS	NS	1.45	1.76

NS = Not significant

Table 2: Proximate composition of African yam bean tuber

Crude Protein %	Crude Fibre %	Ash %	Nitrogen-free Extract %	Ether Extract %	Moisture %	Carbohydrate %
8.32	8.06	2.44	71.18	0.60	9.40	79.24

Table 3: Mineral composition of African yam bean seed and tuber

Minerals	Seed	Tuber
Mg (mg/100g)	43.2	46.7
P (mg/100g)	27.4	660.1
K (mg/100g)	116.4	487.9
Na (mg/100g)	421.3	214.4
Ca (mg/100g)	43.6	26.8
Zn (µg/100g)	50.0	37.5
Cu (µg/100g)	23.0	16.0
Fe (mg/100g)	12.6	31.6
Mn (µg/100g)	14.0	18.0
Mean	83.5	171
CV (%)	156.3	140.6

$t_{(0.05)}$ for comparing the two means = 0.96

DISCUSSION

The proximate composition of African yam bean seed and tuber is comparable to those of other legumes. The highest percentage crude protein of 23.7 % was obtained in the seed of three accessions of African yam bean. These were however lower than those reported for soybean, winged bean and jack bean (Ekpenyong and Borchers, 1978; Apata and Ologhobo, 1994) but were higher than those of peanut, cowpea, chickpea, lima bean and pigeon pea. Although African yam beans showed lower crude protein values than soybeans, the high biological value of the proteins require that greater attention should be given to this crop in the humid tropics where the crop is generally accepted. The percentage ash and ether extract contents of African yam bean seed were lower than those reported for these other legumes. The percentage moisture content of African yam bean seed was higher than that of peanut but lower than those of soybean, cowpea and chickpea (Ekpenyong and Borchers, 1978). On the other hand, the crude fibre content of the seed in the five accessions of *S. stenocarpa* was more than those of winged bean, soybean, peanut, cowpea, lima bean and jack bean (Apata and Ologhobo, 1994). The nitrogen-free extract reported for bambara groundnut (Nwokolo, 1987), soybean (Temple *et al.,* 1991) were less than those obtained for each of the five accessions of African yam bean seed. The percentage carbohydrate content of African yam bean

seed was very high compared to those reported for winged bean, soybean, peanut, cowpea and chickpea (Ekpenyong and Borchers, 1978). It is, therefore, clear from this study that the seed of *S. stenocarpa* is composed mainly of carbohydrates rather than proteins.

The percentage carbohydrate content of African yam bean tuber was slightly above that of the seed. The carbohydrate content of yam bean tuber was far more than those reported for winged bean, cassava and sweet potatoes (Cerny, 1978). The crude protein found in the tuber was lower than those of the seed. The crude protein obtained in the African yam bean tuber was lower than that of winged bean but was higher than those of cassava and sweet potatoes (Cerny, 1978). Similarly, the crude fibre content of African yam bean tuber was also higher than those reported for winged bean (Claydon, 1978), cassava and sweet potatoes (FAO, 1972). The percentage ash and ether extract contents of African yam bean tuber were also higher than those of winged bean, cassava and sweet potatoes. The nitrogen-free extract obtained in African yam bean tuber was higher than what was recorded for the seed. The percentage moisture content of the tuber was however lower than that of winged bean (Claydon, 1975) cassava and sweet potatoes (FAO, 1972).

The mineral composition of African yam bean seed revealed an appreciable amount of magnesium, potassium, phosphorus, sodium, calcium, zinc, copper and manganese when compared with those obtained for bambara groundnut (Nwokolo, 1987). However, bambara groundnut contained more iron than African yam bean seed. The results obtained in this study indicate that sodium, potassium, iron, manganese and copper were more in African yam bean seed than soybean (Temple *et al.*,1991). However, potassium, phosphorus, magnesium and calcium were higher in soybean, winged bean, peanut and cowpea (Claydon, 1975) than for African yam bean seed. It was only the iron content of yam bean seed that was more than those of the above-mentioned legumes.

Magnesium, phosphorus, potassium, iron and manganese contents of African yam bean tuber were higher than those of the seed. The phosphorus and iron content of African yam bean tuber were more than those reported for winged bean (Claydon, 1978), cassava, sweet potatoes and yam (FAO, 1972). The calcium content of *S. stenocarpa* tuber was also more than those of winged bean, cassava and yam but lower than that of sweet potatoes. The amount of manganese obtained in yam bean tuber was higher than that of winged bean (Claydon, 1978) but lower than what was reported for sweet potatoes (FAO, 1972). Also, the zinc content of African yam bean tuber was higher than those of winged bean, sweet potatoes and yam.

CONCLUSION

It has been shown that the seed and tuber of African yam bean contain the different food fractions and minerals that are comparable to other food legumes. African yam bean should therefore be accorded its rightful position as a source of food in future. As a result, there is the need to improve its production. It is also necessary to genetically improve the crop against disease and pest attacks. Varieties with

good characteristics should be developed to promote their usage. Most of the available varieties are hard to cook and also contain anti-nutritional factors. For these varieties to be fully accepted as food, such traits should be eliminated.

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