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Comparative Study of Proximate, Mineral and Anti-nutrient Composition of African Yam Bean (*Sphenostylis stenocarpa* Hochst Ex. A. Rich. (Harms.) Accessions

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ABSTRACT

Background: This study compared the proximate, mineral and anti-nutritional composition of selected accessions of African yam bean. The objective was to assess the potential of these accessions to contribute to food and nutrition security critical to the survival of many rural communities currently ravaged by hunger and malnutrition in Africa.

Methods: Eight (8) accessions of African yam bean were used for this study. Seeds of each accession were processed and chemically analyzed using AOAC standard methods. The samples were replicated three times and F-LSD were used to separate significant means.

Result: Results obtained showed that there were significant variations in the proximate, mineral and anti-nutritional composition of the accessions. Accession TSs 519 had the highest crude protein composition (22.53%), dry matter (91.14%), carbohydrate content (22.53%), sodium (80.46 mg/100 g) and the lowest moisture content 8.86%. The ash content was highest in accession TSs 568 (5.26%). Accession TSs 535 had the highest content of phytate (3.74%), oxalate (1.73%), HCN (1.72%) and tannins (1.44%). Magnesium and potassium were highest in accessions TSs 595 (90.26 mg/100 g) and TSs 568 (280.51 mg/100 g) respectively. The high protein and carbohydrate contents of African yam bean could supplement traditional dishes consumed by both children and adults in order to alleviate protein-energy malnutrition in the developing countries especially in Africa, where this legume is indigenous.

Key words: Accessions, African yam bean, Anti-nutrients, Nutrition, Proximate.

INTRODUCTION

African yam bean (AYB) is a neglected indigenous legume with high nutritional potential. It produces both seeds and tubers (Ndidi *et al*., 2014). It had its origin in Ethiopia but it is now widely cultivated in tropical Africa, especially in Cameroon, Ghana and Nigeria (Porter, 1992). The nutritional potential of AYB is derived from both seeds and underground tubers with amino acid (lysine and methionine) content higher than those of pigeon pea, cowpea and bambara groundnut (Uguru and Madukaife, 2001). The crop has the potential to meet the ever increasing protein demands of the people in the sub-Sahara Africa if grown on a large scale (Popoola *et al*., 2011). It is cultivated mainly for subsistence as only about 30% of the dry grain produced is sold while the rest are consumed by the farming household (Enujiugha *et al*., 2012; Osuagwu and Nwofia, 2014). It has low commercial value, but its nutritious seeds and tubers are sought after by farmers for household consumption in many communities around Nkwanta and Ho West Districts of upper volta in Ghana (Klu *et al*., 2001). In many communities in south east of Nigeria AYB is prepared and consumed in multiple ways and has been given multiplicity of local names depending on the position of the crop in the trado-cultural settings (Nnamani *et al*., 2017). AYB are cultivated mainly for their tubers in East and Central Africa especially among the Bandudus, the Shabas and the tribe at Kinshasha in Democratic Republic of Congo (Potter, 1992; Nwokolo, 1996).

Aside from the high nutrient content, AYB has been reported to be a source of phytochemicals and bioactive compounds that offer health benefits such as the mitigation of lifestyle diseases to consumers (Duodu and Apea-Bah 2017; Soetan *et al.,* 2018). A high phytochemical content is a good indicator of high antioxidant activities such as free radical scavenging potential, reducing power and metal chelating effects (Oboh *et al.,* 2009; Enujiugha *et al.,* 2012; Soetan *et al.,* 2018). The presence of these phytochemicals makes this food crop one that should be exploited and used in the production of functional foods.

However, constraints to AYB cultivation and utilization include presence of high concentrations of anti-nutritional factors such as trypsin inhibitor, phytate, tannin, oxalate and

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alkaloids and long cooking time (Nwokolo, 1987; Ajibade *et al*., 2005; Azeke *et al*., 2005). Anti-nutritional compounds cause bloating and flatulence to humans, especially when they are not well cooked. These compounds may interrupt the bioavailability of mineral compounds such as calcium and iron if appropriate processing techniques are not followed (Ghavidel *et al*., 2007).

This work is aimed at evaluating the nutritional, mineral and anti-nutritional composition of selected accessions of African yam bean in order to contribute to the body of knowledge on the potential of this important but underutilized and less researched legume to food and nutrient security of African countries that consume it.

MATERIALS AND METHODS

Sample collection and processing

The seeds of AYB used in this study were collected from the Genetic Resource Centre (GRC) of International Institute of Tropical Agriculture, (IITA) Ibadan, Nigeria. A total of eight (8) accessions were assessed. The seeds were cleaned and broken seeds were removed. Seeds of each accession were grinded to paste and stored in labeled air-tight containers, kept in refrigerator for analysis on dry weight basis. Samples were analyzed at the Biochemistry Laboratory, National Root Crops Research Institute (NRCRI), Umudike, Nigeria.

Determination of proximate, mineral and anti-nutrient composition

Moisture, total ash and protein contents were determined by the gravimetric, incineration gravimetric and Kjeldahl digestion methods respectively as described in AOAC, (2005). Fat content of the sample was determined by the continuous solvent extraction method following a procedure by Pearson, (1999). Crude Fibre was determined by the Wende method (James, 1995). The carbohydrate content was calculated as the nitrogen free extractive (NFE), a method described by James, (1995).

The anti-nutritional factors such as the oxalate, saponin, phytate and tannins were determined. The soluble and total oxalate concentrations were determined using the method described by Savage and Deo (2000) with a slight change of 0.5 g in sample size. Saponin content was determined using the method described by AOAC (1990). Phytate of the samples were determined using the Biphyrimidine colorimeter following a procedure as described by Onwuka (2005) and tannin content of the samples were determined as tannic acid, as described by Ajayi, (2011).

The content of key minerals like potassium, sodium, calcium, phosphorus, magnesium, iron, zinc and manganese in the samples were also investigated. Calcium and Magnesium content of the digested sample were determined by EDTA complexiometric titration method as described by James (1995). The phosphorus in the sample was determined by the vanado-molybdate (yellow) spectrometry described by James (1995). Sodium and Potassium was determined by flame photometry method also described by James (1995). Iron, magnesium and zinc were determined using AOAC, (2005).

Statistical analysis

The samples were analysed in triplicates and treated as completely randomized design as outlined by Anya and Ozung, (2019). The F-LSD test was used to separate significant means. All the data analysis was carried out in R environment (R Core Team, 2021).

RESULTS AND DISCUSSION

Proximate composition of african yam bean accessions

The variabilities in proximate composition of AYB accessions sampled are presented in Table 1. Accession TSs 519 had the highest crude protein value (22.53%), while TSs 535 had the least value (19.57%). The range of protein values (19.57-22.53%) obtained in this study are within the range reported by various authors (Ajibola and Olapade, 2016; Adegboyega *et al*., 2020), but was higher than 10.6-11.7% previously reported by Nyananyo and Nyingifa (2011). Since plant food that provides about 12% of its calorific value from protein is considered a good source of protein (Effiong *et al*., 2009), AYB can be regarded

Table 1: Proximate composition of different accessions of African yam bean seeds.

Accessions	MC (%)	DM (%)	ASH (%)	CP (%)	CF (%)	FAT (%)	CHO (%)
TSs 568	11. 22^{a}	88.75^{f}	5.26^{a}	20.77^{c}	5.18^{c}	4.84^{de}	54.76^{a}
TSs 535	10 .79^{b}	89.21^{e}	4.79^{d}	19.57^{d}	4.88^{d}	5.28^{b}	54.70^{a}
TSs 564	10.34^{c}	89.66^{d}	5.21^{ab}	20.69^{c}	4.64^{f}	5.17^{c}	53.74^{ab}
TSs 577	10.18^{d}	89.82^{c}	5.23^{ab}	21.84^{b}	5.44^{a}	5.28^{b}	52.05^{b}
TSs 544	9.78^{e}	90.22^{b}	5.17^{b}	21.86^{b}	4.87^{d}	4.88^{d}	53.49^{ab}
TSs 595	9.73^{e}	90.28^{b}	4.76^{d}	21.58^{b}	5.17^{c}	4.79^{c}	53.76^{ab}
TSs 519	8.86^{h}	91.14^{a}	4.78^{d}	22.53^{a}	4.79^{e}	4.27^{f}	54.74^{a}
TSs 548	9.81^{e}	90.20^{b}	4.88^{c}	21.78^{b}	5.27^{b}	6.25^{a}	52.02^{b}
CV (%)	0.59	0.07	0.71	0.64	0.57	0.43	1.98
$LSD_{0.05}$	0.14	0.15	0.08	0.31	0.06	0.05	2.46
Mean	10.09	89.90	5.01	21.33	5.03	53.0	6.00

Mean values with different superscripts along a column are significantly different from each other at P<0.05. Values are means of three determinations.
TSs- Tropical *Sphenostylis stenocarpa*, MC- Moisture content, DM- Dry matter, CP- Crude protein, CF-Crude fat, CHO-Carbohydrate.

as food source with a high potential of combating protein deficiency.

There were significant differences in fat content of the accessions ranging from 4.27% in TSs 519 to 6.25% in TSs 548. The range of values of crude fat recorded in the current accessions (4.64-6.25%) were higher than that (1.31-2.62%) previously reported for AYB by Adegboyega *et al.* (2020) and lower than the average of 46.1% reported in groundnut by Ayoola *et al*. (2012). The low fat content of AYB seeds makes it good food crop for weight management (Adegboyega *et al*., 2020) but a poor source for commercial oil production compared to groundnut. The carbohydrate values (52.02-54.76%) obtained in this study were lower compared to the results (55.15-67.36%) reported for AYB by Adegboyega *et al*. (2020). Carbohydrates found in AYB as in most other legumes are likely high in resistant starch difficult to digest in small intestine (Baiyeri *et al*., 2018); resulting in low glycemic index (GI) that makes them good for diabetics.

Highest crude fibre and dry matter contents of 5.44% and 91.14% were recorded in TSs 577 and TSs 519 respectively and differed significantly from the rest of the accessions, while the lowest were TSs 564 and TSs 568, respectively. The level of crude fibre in AYB accessions studied (4.64 -5.44%) was lower than that found in cowpea by Mamiro *et al*. (2012). Crude fibre enhances food movement in the bowl thus helping to prevent constipation and diseases of the colon such as piles, appendicitis and cancer (Okon, 1983). The highest ash content of 5.26% was observed in TSs 568 while TSs 535, TSs 519 and TSs 595 had the lowest values. The level of ash content recorded in the studied accessions suggests that they might be good sources of dietary minerals since ash content of a seed is a measure of its mineral content. The highest (11.22%) and the lowest (8.86%) moisture content were recorded in TSs 568 and TSs 519 respectively. This moisture range is less than 12%, the maximum value required for safe storage of pulses to avoid the production of mycotoxins (Adegboyega *et al*., 2020) suggesting that seeds of AYB can be safely stored without the likelihood of mycotoxin contamination.

Mineral composition of African yam bean seeds

The mineral composition of the AYB accessions sampled is presented in Table 2. TSs 564 recorded the highest calcium value of 183.99 mg/100 g and differed significantly from the other accessions, while the lowest value of 169.30 mg/100 g was found in TSs 595. The potassium content (280.51 mg/100 g) of accession TSs 568 was significantly the highest while TSs 564 the accession with the highest Ca content had the least value potassium (195.77 mg/100 g). Despite having the least amount of Ca, the highest magnesium content of 90.26 mg/100 g was found in TSs 595 while the least value of 74.77 mg/100 g was recorded for TSs 519. TSs 564 had the highest composition of iron and zinc at 7.44 mg/100 g and 4.33 mg/100 g, respectively. However, the zinc content of TSs 564 did not differ significantly from that of TSs 544 (4.29 mg/100 g). Sodium content of the AYB accessions varied significantly from 59.74 mg/100 g in TSs 595 to 80.46 mg/100 g in TSs 519.

The results from this study showed that sodium, potassium, iron, magnesium and calcium were higher compared to those reported for soybean (Temple *et al*., 1991) and Bambara groundnut Nwokolo, (1987) and other legumes such as winged bean, peanut and cowpea (Claydon, 1975) and suggests that AYB could be a better source and/or alternative for these minerals. These minerals are reported to play important roles in many critical body metabolism (Lee *et al*., 2005, Baiyeri *et al*., 2018).

Anti-nutrient composition of African yam bean

There were significant differences (P<0.05) among the accessions for all the anti-nutrients (Table 3). Phytate content was highest in TSs 535 (3.47%) and TSs 548 (3.44%) but lowest in TSs 577 (2.17%), TSs 595 (2.18%) and TSs 564 (2.19%). Tannins content was highest in TSs 519 (1.47%) and TSs 535 (1.44%) but lowest in TSs 564 (0.91%). TSs 535 had the highest HCN content (1.72%) while TSs 564 had the least (0.98%) content. Three accessions, TSs 568, TSs 548 and TSs 535, had the highest oxalate content while TSs 577 had the lowest concentration of oxalate.

Table 2: Mineral composition of different accessions of African yam bean seeds.

Accessions	Ca (mg/100 g)	Mg (mg/100 g)	Fe (mg/100 g)	Zn (mg/100 g)	K (mg/100 g)	Na (mg/100 g)
TSs 568	173.30^{f}	80.53^{cd}	6.22^{cd}	3.91^{c}	280.51^{a}	62.75^{f}
TSs 535	176.37^{d}	76.02^{ef}	5.55^{f}	3.90^{c}	274.76^{c}	68.57^{c}
TSs 564	183.99^{a}	84.43^{bc}	7.44^{a}	4.33^{a}	195.77^{h}	65.38^{d}
TSs 577	182.78^{b}	82.56^{cd}	7.19^{b}	4.19^{b}	248.77^{d}	73.54^{b}
TSs 544	175.29^{e}	86.78^{ab}	6.19^{d}	4.29^{ab}	228.50^{f}	64.73^{de}
TSs 595	169.30^{g}	90.26^{a}	6.22^{cd}	3.84^{c}	216.27^{g}	59.74^{g}
TSs 519	173.72^{f}	74.77^{f}	6.33^{c}	3.94^{c}	276.78^{b}	80.46^{a}
TSs 548	178.34^{c}	79.37^{de}	5.77^{e}	3.46^{d}	236.56^{e}	62.75^{e}
CV (%)	0.21	2.22	0.89	1.39	0.16	0.42
$LSD_{0.05}$	0.85	4.189	0.13	0.13	0.88	0.68
Mean	176.63	81.84	6.37	3.98	244.74	67.44

Mean values with different superscripts along a column are significantly different from each other at P<0.05. Values are means of three determinations. TSs- Tropical *Sphenostylis stenocarpa*, CA- Calcium, Mg- Magnesium, Fe- Iron, ZN- Zinc, K- Potassium, Na- Sodium.

Table 3: Anti-nutrient content of different accessions of African yam bean seeds.

Accession	Tannins (%)	Saponin (%)	Flavonoid (%)	Alkaloid (%)	Phytate (%)	Oxalate (%)	HCN (%)
TSs 519	1.47^{a}	0.96^{d}	1.83^{a}	2.27^{d}	2.27^{d}	1.65^{b}	1.08^{e}
TSs 535	1.44^{a}	0.84^{e}	1.21^{c}	2.47^{c}	3.47^{a}	1.73^{a}	1.72^{a}
TSs 568	1.39^{b}	0.78^{f}	1.33^{b}	3.17^{a}	2.91^{c}	1.74^{a}	1.55^{b}
TSs 577	1.33^{c}	1.03^{c}	0.75^{h}	1.67^{g}	2.17^{e}	1.08^{f}	1.38^{c}
TSs 548	1.25^{d}	0.94^{d}	1.13^{d}	2.46^{c}	3.44^{a}	1.74^{a}	1.40^{c}
TSs 544	1.20^{e}	1.18^{b}	0.93^{f}	2.57^{b}	3.18^{b}	1.49^{d}	1.25^{d}
TSs 595	1.07^{f}	1.03^{c}	0.87^{g}	1.77^{f}	2.18^{e}	1.14^{e}	1.38^{c}
TSs 564	0.91^{g}	1.25^{a}	1.08^{e}	1.91^{e}	2.19^{e}	1.59^{c}	0.98^{f}
Mean	1.26	1.00	1.14	2.28	2.72	1.34	10.09
CV (%)	1.26	1.03	1.61	1.18	0.86	3.17	0.59
$LSD_{0.05}$	0.04	0.02	0.04	0.06	0.05	0.98	0.14

Mean values with different superscripts along a column are significantly different from each other at P<0.05. Values are means of three determinations. HCN- Hydrogen cyanide, TSs- Tropical *Sphenostylis stenocarpa*.

Flavonoids varied significantly from 0.93% in TSs 544 to 1.83% in TSs 519. Anti-nutritional factors are believed to be toxic and may negatively affect the nutrient value of seeds by impairing protein digestibility, changing of taste and bioavailability of nutrients (Jain *et al*., 2009; Ndidi *et al.,* 2014). The values of phytate and tannin obtained from this study are comparable to the values obtained by Adegboyega *et al*. (2020). The phytate content in all the accessions were higher than tannins, oxalate and HCN. Phytate binds minerals like calcium, iron, magnesium and zinc making them unavailable in the body. Tannins negatively affects feed intake, feed digestibility, production efficiency and cause reduced growth in animals (Aletor and Adeogun, 1995). The HCN values obtained in the current study corroborate the reports of Adegboyega *et al*. (2020). It has been reported by WHO (2014) that high concentration of HCN provokes a brief breakdown in the central nervous system leading to depression, convulsions, coma and death in humans and animals. However, some of these compounds like phytic acid and tannin are currently considered potential antioxidants containing health promoting effects and elimination of these compounds depends on the consumer's preference (Adegboyega *et al*., 2020).

CONCLUSION

There were significant variations in the proximate, mineral and anti-nutrient composition of AYB seeds from eight accessions assessed in this study. The protein contents of the accessions were quite high and compared well with other legumes, thus making it a good substitute that can help relieve the heavy demand on major legumes. The high protein and carbohydrate contents of AYB seeds could be of great value while considering their incorporation into various traditional dishes for both children and adults in order to alleviate protein-energy malnutrition in the developing countries.

Conflict of interest

All authors declare that they have no conflict of interest.

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