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Physical, Proximate and Anti-nutritional Composition of African yam bean (*Sphenostylis stenocarpa*) Seeds Varieties

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Abstract

The physical, proximate and anti-nutritional properties of five accessions of African yam bean (AYB) seeds (TSs 57, TSs 61, TSs 93, TSs 94 and TSs 116) obtained from Genetic Resource Centre (GRC) of International Institute of Tropical Agriculture (IITA) were studied and compared. This was aimed at unraveling the nutritional importance of this crop to enhance its production and utilisation. The physical properties investigated include seed size, length to diameter ratio, seed weight, percentage of seed coat, bulk density and loose density. Proximate composition and anti-nutritional factors such as saponin, oxalate, phytate, alkaloids, tannin, trypsin inhibitor and hydrogen cyanide of these accessions processed flours were also examined. The results of physical properties indicated significant differences ($P<0.05$) among the accessions except accessions TSs 93 and TSs 94 that did not differ in their lengths and diameters and also accessions TSs 61 and TSs 116 did not differ in their thicknesses. Results of proximate analysis revealed that crude fibre, fat and carbohydrate contents of the accessions were not significantly different from one another at ($P<0.05$) except TSs 94 that differed in its carbohydrate and TSs 116 also differed in its crude fibre from others. Meanwhile, in terms of anti-nutritional factors, there existed no significant difference in saponin contents but there were significant differences in oxalate, phytate, alkaloids, tannin, trypsin inhibitor and hydrogen cyanide among the accessions tested.

Keywords: accessions, african yam bean, anti-nutritional factors, physical and proximate

1. Introduction

Protein-energy malnutrition is one of the most serious health problems common in the developing countries (Food and Agriculture Organisation of the United Nations (FAO), 2000). Meanwhile, legumes are recognised as an economical source of calories and proteins, particularly for developing countries since their seeds contain high concentration of carbohydrates (50-67%) and protein (23-25%) (Olapade, Oluwole, & Aworh, 2012). Studies have shown that the lesser known legumes together with other conventional legumes can be used for combating protein malnutrition prevalent in the third world (Arisa & Aworh, 2007). Food-security and sustainability are serious global concerns in recent times. Moreover, many indigenous food crops of Africa which promise to reduce nutritional food insecurities are presently neglected and underutilised (Ajayi, 2011). African yam bean (AYB) is one of such underutilised crop with great genetic and economic potentials (Ajibade et al., 2005; Betsche, Azeke, Buening-Pfaue, & Fretzdorff, 2005). It is a crop with tremendous nutritional potentials (Adewale and Odoh, 2013) and its economic potential has been recognised, especially in reducing malnutrition among Africans (Adewale, 2010).

AYB is an herbaceous leguminous and annual crop that contains bean seeds that are usually enclosed in a pod like cowpea. Each pod contains between ten and thirty seeds that may be of more than one colour. These pods are usually borne on a climbing stem with wide heart-shaped leaves; one at each node spaced apart along the stem (Asoiro & Ani, 2011). Apart from the seeds, the plant also produces spindle shaped starchy tubers smaller in size than those of sweet potato. It takes between 5 to 8 months to mature (Nwodo & Nwinyi, 2012) and these small underground tubers are of various sizes and shapes (Adewale & Dumet, 2011). AYB is usually grown in West Africa particularly in Cameroon, Cote d'lvoire, Ghana, Nigeria and Togo. It is used extensively in various dietary preparations because of its potential for supplementing the protein requirement of many families throughout the year (Ajayi, 2011), though its seeds harbour vast genetic diversities for nutritive and anti-nutritive factors (Ajibade et al., 2005; Betsche, Azeke, Buening-Pfaue, & Fretzdorff, 2005). AYB is a good source of protein, carbohydrate, vitamins and minerals. However, constraints to its cultivation and utilisation include presence of high concentrations of anti-nutritional factors such as trypsin inhibitor, phytate, tannin, oxalate and alkaloids and long cooking time (Nwokolo, 1987; Ajibade, Balogun, Afolabi, Ajomale, & Fasoyiro, 2005; Fasoyiro, Ajibade, Omole, Adeniyan, & Farinde, 2006). Ndidi et al. (2014) opined that processing reduced the level of anti-nutrients to their tolerable levels. Moreover, processing such as heating, soaking or fermenting has been used to lower anti-nutritional factors and improve their nutritional value (Onyeike, Ayalogu, & Uzogara, 1995). According to Okonkwo, Njoku and Mbah (2013), AYB extract was found not to be toxic up to 5000 mg/kg, indicating the safety of the plant for both human and animal consumption. Furthermore, Onyeike (2012) opined that autoclaving AYB decreased the levels of cyanogenic glycosides, oxalates, tannins, saponins and trypsin inhibitors, which were further reduced by cooking to physiologically tolerable levels.

Despite these constraints, the demand of its seed grains for human consumption is linked to size and shape (Shahin, Symons, & Poysa, 2006). This is due to the fact that various metric measurements of the seeds are very essential quantitative variables for determining size and shape of the seeds (S. Wyllie-echeverria, Coxfls, Chuchill, Brotherson, & T. Wyllie-echeverria, 2003). Also, the knowledge of physical properties of seeds are essential parameters require in the designing of equipment necessary for harvesting and post-harvest handling, transportation and processing of agricultural produce into different consumable and marketable food items. Various types of unit operations such as cleaning, grinding and sorting are designed on the basis of these properties (Ojo & Ade-Omowaye, 2015). The physical properties of legumes are, therefore important pre-requisites for the designing of equipment and facilities for harvesting, handling, conveying, separating, drying, aerating, storing and mechanical extraction of oil and other food processes (Oyebode, Ojo, & Oshodi 2007).

For instance, in Nigeria, there is rarely any large-scale producer of AYB. As a result; most small-scale producers carry out these operations manually which are quite cumbersome and time consuming. Hence, this necessitates the assessment of physical properties, nutritive and anti-nutritive factors of the five accessions of AYB to reveal the importance of the crop, thereby improving the productivity and promoting the utilisation.

2. Materials

Five accessions of AYB were obtained from Genetic Resource Centre of IITA Ibadan, Oyo State, Nigeria. The seeds were cleaned to remove dirt and damaged seeds and were divided into two portions. The first portion was used to determine physical properties of the seeds while the other portion was processed into flours and used to determine proximate composition and anti-nutritional factors.

3. Methods

The physical properties of the five African yam bean accessions were determined as follows:

The seed size was determined as described by Kaushik, K. Kumar, S. Kumar and Roy, (2007) with slight modification. The seed length, seed diameter and seed thickness of 100 seeds were measured in millimeters using digital Vernier caliper. The average seed size was then calculated. The ratio between the seed length and diameter was estimated from the individual values of the length and diameter of the seeds as described by Omokhafe and Alika (2004). The 100 seed weights of the accessions were determined by randomly selecting, counting and weighing of seeds that have been previously cleaned using Soehnle professional weighing balance model 9230. The percentage of seed coat was also determined by dividing its weight of each accession with its corresponding seed weight. The bulk densities and loose densities of the five accessions of AYB seeds were determined using a 100 ml measuring cylinder as described by Onwuka (2005a) with slight modification.

AYB flours were processed according to the method described by Okoye, Ezigbo and Animalu (2010). Proximate compositions of the samples were determined as described by AOAC (2005). The anti-nutritional factors such as saponin, oxalate, phytate, alkaloids, tannin, trypsin inhibitor, and hydrogen cyanide were determined. Phytate of the samples were determined using the Biphyrimidine colorimeter method as described by Onwuka (2005b) and tannin content of the samples were determined as tannic acid, following a procedure of Ajayi, (2011). Trypsin inhibitor was determined by spectrophotometric method as described by (Nwosu, 2011) while oxalate and saponin were determined using the methods of AOAC (1990). All the tests were done in triplicate and statistical analysis of the data was performed using analysis of variance and Duncan's Multiple Range Test procedures fixed at P = 0.05 was used to separate mean values. This was done using Statistical Package for Social Sciences, SPSS (windows version 20).

4. Results and Discussion

The physical properties of AYB seed accessions are depicted in Table 1. It was observed that the seeds sizes ranged from 7.95 mm x 5.46 mm x 5.82 mm to 8.21 mm x 6.03 mm x 6.30 mm, TSs 61 was the least while TSs 93 was the highest in size. It was observed from the accessions tested that the seed length was longer than the width and thickness but the difference between seed width and thickness was not consistent. This result was comparable to that of Adewale, Kehinde, Aremu, Popoola and Dumet (2010). The results of length to diameter showed that sample TSs 61 was the highest while TSs 116 was the least. It was revealed that 100 seeds weight was highest in TSs 94 (24.02 g) followed by TSs 57 (23.40 g), TSs 61 (20.83 g), TSs 93 (20.80 g) and TSs 116 (20.74 g) was the least. These results fall within the range obtained by Adewale and Udoh, (2013) of values (11.46-36.0 g). Also, the results of the bulk density and loose density were in the range 0.7428 gcm^{-3} - 0.8357 gcm^{-3} and 0.6709 gcm^{-3} - 0.7681 gcm^{-3} respectively. The bulk density values were lower than those obtained by Asoiro and Ani (2011) of values (1.0179 gcm^{-3}). The accession TSs 57 was the highest in bulk density, while TSs 116 was the highest in loose density while TSs 93 had the least value for both bulk density and loose density. The percentage seed coats obtained were in the range of 7.631% and 13.674%. Accession TSs 93 (13.674%) had the highest percentage seed coat while accession TSs 116 (7.631%) had the least.

Table 1. Physical properties of five accessions of *Sphenostylis stenocarpa* seeds

AYB Accessions	Length (mm)	Diameter (mm)	Thickness (mm)	Length to diameter	Hundred seed weight (g)	Seed coat (%)	Bulk density (gcm^{-3})	Loose density (gcm^{-3})
TSs 57	8.15_{ab}	5.75_{b}	6.18_{ab}	1.42_{ab}	20.74_{c}	7.63_{d}	0.8356_{a}	0.7552_{a}
TSs 61	7.95_{b}	5.46_{c}	5.82_{c}	1.47_{a}	20.81_{c}	7.85_{cd}	0.8011_{a}	0.7441_{b}
TSs 93	8.21_{a}	6.03_{a}	6.30_{a}	1.38_{b}	20.83_{c}	8.19_{c}	0.6933_{c}	0.6710_{c}
TSs 94	8.20_{a}	5.96_{a}	6.07_{b}	1.39_{b}	23.40_{b}	10.84_{b}	0.8010_{a}	0.7507_{a}
TSs 116	7.95_{b}	5.60_{c}	5.85_{c}	1.43_{ab}	24.02_{a}	13.67_{a}	0.7076_{b}	0.7679_{a}

Values are means of three determinations. Means with the same subscript along the column are not significantly different (P<0.05).

Table 2 showed the result of proximate composition of processed African yam bean flours of the five accessions. The highest moisture content was observed in TSs 57 (14.95%), followed by TSs 61 (13.87%), while the lowest percentage moisture content was obtained in TSs 93 (12.19%). The highest percentage crude protein of 26.68% was obtained from TSs 94 while the lowest crude protein was recorded in accession TSs 57 (22.72%). These values fall within the range reported by Obiakor (2008) and Aburime (2012) of values 21-29% and 19.96-31.87% respectively. There were no significant differences (P<0.05) exist between the percentage crude protein, fibre, and carbohydrate of the five accessions except accession TSs 116 that was significantly different in terms of crude fibre and also accession TSs 94 was significantly different from others in terms of its crude protein and carbohydrate. Meanwhile, there existed no significant difference in fat content among all the accessions tested. The range of carbohydrate content obtained in this study compared with the value recorded by Ojukwu, Olawuni, Ibeabuchi and Amandikwa (2012) of value (58.47%).

Table 2. Proximate composition of five accessions of processed African yam bean flours

Accession Number	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Ash (%)	Crude Fibre (%)	Carbohydrate (%)
TSs 57	14.95_{a}	22.72_{b}	2.03_{a}	1.01_{c}	2.94_{a}	59.29_{a}
TSs 61	13.87_{a}	23.94_{b}	1.67_{a}	1.90_{b}	2.52_{a}	58.62_{a}
TSs 93	12.19_{b}	24.27_{b}	1.91_{a}	2.40_{a}	2.37_{a}	59.22_{a}
TSs 94	13.19_{b}	26.68_{a}	1.93_{a}	1.92_{ab}	2.51_{a}	56.28_{b}
TSs 116	12.30_{b}	23.95_{b}	1.86_{a}	2.09_{ab}	2.03_{ab}	59.79_{a}

Values are means of three determinations. Means with the same subscript along the column are not significantly different (P<0.05).

The results of anti-nutritional factors of the five accessions were shown in Table 3. It was observed that TSs 93 had the least anti-nutritional factors in all the parameters tested except in alkaloids and hydrogen cyanide where TSs 57 was least while TSs 61 had highest anti-nutritional factors in all the parameters tested except in saponin and hydrogen cyanide where TSs 94 had highest values. The values of anti-nutritional factors obtained in this work were lower than those obtained from Nwosu, (2013) and these values fall within the permissible limit based on Ndidi, C. U. Ndidi, O., Abbas, Aliyu, Francis, and Oche (2014).

Table 3. Anti-nutritional factors of processed African yam bean flours

Accession Number	Saponin (%)	Oxalate (%)	Phytate (%)	Alkaloids (%)	Tannin (%)	Trypsin (TIU/mg)	HCN (mg/kg)
TSs 57	0.101_a	0.0056_a	0.0136_a	0.189_b	0.0026_b	3.05_b	6.86_c
TSs 61	0.123_a	0.0070_a	0.0145_a	0.252_a	0.0059_a	3.32_a	7.43_b
TSs 93	0.090_a	0.0029_b	0.0126_b	0.204_b	0.0015_b	2.22_c	7.39_b
TSs 94	0.129_a	0.0034_b	0.0127_b	0.274_a	0.0016_b	2.40_c	7.76_a
TSs 116	0.112_a	0.0044_b	0.0127_b	0.216_b	0.0023_b	2.92_b	6.48_d

Values are means of three determinations. Means with the same subscript along the column are not significantly different (P<0.05).

5. Conclusion

The assessment of physical properties, proximate composition and anti-nutritional factors of AYB accessions will play a major role in designing, constructing and developing equipment that will enhance good handling, harvesting, processing, transportation practices and desirable marketing strategies that will promote the utilisation of crop. This research has established that there existed significant differences in the nutritional and anti-nutritional values of AYB seeds except fat and saponin content that were not significantly different from one accession to another. The protein contents of the accessions were quite high, therefore, it compared well with other legumes and made it a good substitute and it will help relieve the heavy demand on major legumes. The high protein and carbohydrate contents of AYB could be of great value for incorporating into various starchy and traditional dishes for both children and adults to alleviate protein energy malnutrition in the developing countries. The tested accessions contain a low anti-nutritional factor which means that these accessions could solve the anti-nutritional factor constraints in the utilisation of AYB seeds. The result of this research revealed the importance of the crops and could encourage farmers to engage in the cultivation of the crop. Hence, enhancing the optimum utilisation and maximisation of the potentials of the seeds will contribute to the efforts of preventing the seeds from extinction.

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