

## EVALUATION OF THE NUTRITIONAL COMPOSITION OF THE SEEDS OF SOME SELECTED AFRICAN YAM BEAN (*SPHENOSTYLIS STENOCARPA* HOCHST EX. A. RICH (HARMS)) ACCESSIONS

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### ABSTRACT

*African yam bean (AYB) is an important but neglected and underutilized crop producing edible seeds and tubers. The poor awareness of the nutritional values of AYB constitutes one of the major problems limiting its utilization. This study was, therefore, carried out to determine the nutritional potentials of five accessions of African yam bean (TSs 125, TSs 116, TSs 86, TSs 69 and TSs 60) by analyzing their proximate composition and micronutrients (Iron (Fe), Zinc (Zn) and Selenium (Se)). The experiment was laid out in completely randomized design (CRD) with three replications. The results obtained showed significant ( $p < 0.05$ ) variations in the proximate composition of the AYB accession. The crude protein was in the range of 21.84-23.41 %, crude fat 3.40-3.86 %, fibre 6.17-6.76 %, carbohydrate 52.8-54.48 %, dry matter 90.42 - 90.6 %, ash 4.22 - 4.35 %, and moisture 9.4 - 9.58 %. The Se concentration varied from 312 mg/100 g in TSs 116 to 58 mg/100 g in TSs 60 while Fe ranged between 10.40 mg/100g in TSs 60 and 6.07mg/100g in TSs 86. Zinc varied between 8.83 mg/100g in TSs 116 and 6.37 mg/100 g in TSs 69. TSs 116 was best accession in terms of crude protein, dry matter, ash, selenium and zinc, while TSs 60 was best in terms of iron. The study revealed AYB seeds as a food crop rich in protein, carbohydrate, fibre, selenium, iron and zinc. The genotypic variability can be exploited in developing African yam bean varieties with better qualities in terms of nutrient density.*

**Keywords:** Neglected, underutilized, nutrient-dense, micronutrient and protein

### INTRODUCTION

Protein - energy malnutrition and micronutrient deficiencies ("hidden hunger") are serious health issues globally, especially in the developing countries, including Nigeria. About 14 million people – 8.5% of the total Nigerian population - are undernourished (FAO, 2012). In Nigeria, in addition to lack of protein and energy, a major cause of under-nutrition is inadequate micronutrients such as vitamin A, iodine, iron, and zinc. Almost 63% of the Nigerian women are anaemic and 31% are iodine deficient, while close to 30% of under-fives are vitamin A deficient and 20% are zinc deficient (Micronutrient Initiative, 2013; FMH, 2014). High under-five mortality rate; 158 per 1,000 live births has been recorded for Nigeria, with malnutrition

accounting for 53% of these deaths (UNICEF, 2011). These nutritionally-related problems are more prevalent among the resource-poor living in the rural areas and poor city dwellers, because they cannot afford balanced diets. Zinc plays an important role in insulin action, carbohydrate and protein metabolism (Lee *et al.*, 2005). The administration of zinc, magnesium, selenium, vitamin A and vitamin E improves tissue response to insulin and increases the efficacy of drugs which act through this pathway (Gunasekera *et al.*, 2011). Studies showed higher Zn deficiency in diabetic adults compared to normal adult subjects (Lee *et al.*, 2005 and Yoon and Lee 2007). Lower plasma selenium concentration was also reported in diabetic patients, women

with gestational diabetes, and those with pancreatitis (Kornhauser *et al.*, 2008, Quilliot *et al.*, 2011 and Al-saleh *et al.*, 2004). Zinc, together with these other minerals and vitamins are, therefore, crucial in reducing the incidence of type II diabetes or in its management. Iron facilitates the oxidation of carbohydrates, proteins and fats (Aremu *et al.*, 2005) and aids haemoglobin in the transport of oxygen. It is also an important component of the cytochromes that function in cellular respiration (Soetan *et al.*, 2010). Iron is involved in the synthesis and packaging of important neurotransmitters for brain function (Beard, 2001). Iron deficiency has been reported for varying degrees of impairment in cognitive performance, lowered work capacity, lowered immunity to infections, pregnancy complications e.g. babies with low birth weight, poor learning capacity and reduced psychomotor skills (Batra and Seth, 2002). The consumption of foods rich in iron, zinc, selenium and other vital micronutrients is, therefore, important to the human wellbeing.

Legumes have been noted as a major source of protein, complex carbohydrates and minerals in developing countries. Legumes are also low in fat, do not have cholesterol and are rich in other dietary components such as dietary fibre, which is important in weight management and in regulating blood cholesterol and sugar. Coupled with their nutritional superiority, legumes have also been ascribed economic, cultural, physiological and medicinal roles owing to their possession of beneficial bioactive compounds (Philips, 1993). These useful bioactive compounds in legumes have hypocholesterolemic, antiatherogenic, anticarcinogenic and hypoglycemic properties (Ndidi *et al.*, 2014). Neglected and underexploited indigenous legumes such as African yam bean (AYB) have especially been receiving increasing attention and currently being explored due to their huge nutritional and health potentials. African yam bean produces both edible seeds and tubers. It originated in Ethiopia, but both wild and cultivated types now occur in tropical Africa as far as Egypt and also throughout West Africa from Guinea to southern Africa (Busson, 2001). The seeds are highly proteinous and capable of growth in marginal areas where other pulses fail to thrive (Okpara and Omaliko, 1995). Uguru and Madukaife (2001) reported higher values of lysine and methionine in AYB seeds than in pigeon pea, cowpea and Bambara ground nut. African yam bean is also valued for its satiety over several hours after consumption, especially among farmers and the resource-poor. African yam

bean, thus, has high potential to contribute to curbing hunger, and alleviating protein and micronutrient malnutrition in sub-Saharan Africa, if grown on a large scale. In ethno-medicine, AYB is indicated for managing diabetes and high blood pressure. It is used for curing mumps in Benue State, Nigeria, and suggests that African yam bean has some phytochemicals, minerals and antioxidants that have some positive physiological actions and/or pharmacological effects. Five elite African yam bean accessions were therefore analyzed for their proximate composition, iron, zinc and selenium concentrations, with the view of creating more awareness of the nutritional and health benefits of this crop.

## MATERIALS AND METHODS

Thirty six African yam bean accessions were evaluated in a potted experiment at the University of Ghana Department of Crop Science teaching and research farm. The experiment was laid out in completely randomized design (CRD) with three replications. The seeds were planted in May, 2015 and harvested in December, 2015. Thirty two out of these 36 accessions were collected from the Genetic Resources Center of the International Institute of Tropical Agriculture, (IITA), Ibadan Nigeria (Table 1). Five elite African yam bean accessions (TSs 125, TSs 116, TSs 86, TSs 69 and TSs 60) among the IITA accessions were selected for this study based on their yield (unpublished data). The seeds of these five high yielding African yam bean accessions in three replicates were analyzed for micronutrients: Fe, Zn, Se and proximate composition.

### Methods

#### Sample Preparation

Extraneous materials and bad seeds were handpicked out of the seeds of the selected five African yam bean accessions. The clean seeds were ground into fine flour using electric mill.

#### Proximate Analysis

The seeds of the Africa yam bean accessions were analyzed for proximate composition using AOAC (2005) methods.

#### Crude Protein (CP) Determination

Crude protein in the samples was determined by the semi-micro Kjeldahl technique which consisted of digestion and nitrogen determination using adapted auto-analyzer method. **Digestion:** African yam bean flour sample (0.5 g) was weighed into the Kjeldahl digestion tubes; 1 Kjeldahl catalyst tablet and 10 ml of concentrated H<sub>2</sub>SO<sub>4</sub> was added to the

tubes and the contents digested in a fume cupboard for 4 hours until a colourless solution was left in the tube. The digest was cooled and carefully transferred into a 100 ml volumetric flask; the flask was made up to 100 ml with distilled water. One millilitre (1 ml) of the standard solution (digest) was dispensed from the 100 ml into a test tube. Four milliliters (4 ml) of the diluent was added and thoroughly mixed. After mixing, 1.5 ml of potassium phosphate tartrate and mixed, then 2.5 ml of alkaline phenate was added and also thoroughly mixed. Lastly, 1.5 ml of commercial bleach (JIK) was added and mixed thoroughly. The solution was left for 30 minutes and read on Atomic Absorption Spectrophotometer (AAS), Buck Scientific Model: Buck 210VG at a wavelength of 630 nm. Calibration curve was used to determine the nitrogen content. A value of 6.25 was multiplied with the value of nitrogen to convert it to protein.

#### Crude fibre determination

Two grams (2.0 g) of the flour sample was weighed into a flask and 100 ml of 0.255 N H<sub>2</sub>SO<sub>4</sub> added. The mixture was heated under reflux for 1 hour on a heating mantle and filtered through a sieve cloth. The residue was returned to the fibre flask to which 100 ml of 0.313 N NaOH was added and heated under reflux for another 1 hour. The mixture was filtered through a fibre sieve cloth and 10 ml of acetone added to dissolve any organic constituent. The residue was washed with 50 ml hot water on the sieve cloth before it was finally transferred into a crucible. The residue was oven-dried in a crucible at 105 °C, cooled in a desiccator, weighed and a shed in a muffle furnace at 550 °C for 4 hours followed by cooling in a desiccators and weighing.

The percentage crude fibre was calculated as:

$$\% \text{ Crude Fibre} = \frac{W_1 - W_2}{\text{Weight of sample}} \times 100$$

(where W<sub>1</sub> is weight of sample residue after oven drying and W<sub>2</sub> is weight of residue after ashing)

#### Moisture content determination

The weight of an empty moisture can (W<sub>0</sub>) was taken: two grams (2 g) of the AYB flour sample was added to the moisture can and weighed (W<sub>1</sub>). The sample was dried using hot air drying oven at 105-1100 C to constant weight, cooled in a desiccators and weighed (W<sub>2</sub>). Percentage moisture content was calculated as:

$$\% \text{ Moisture} = \frac{W_1 - W_2}{W_1 - W_0} \times 100$$

(where W<sub>0</sub> is weight of empty moisture can, W<sub>1</sub> is the weight of moisture can with sample, W<sub>2</sub> is weight of moisture can + oven-dried sample to constant weight).

#### Ash content determination:

African yam bean flour (0.5 g) was weighed into a crucible and heated in the muffle furnace at 500-6000C. The sample was cooled in a dessicat or and weighed. The Percentage ash was calculated as:

$$\% \text{ Ash} = \frac{W_2 - W_0}{W_1 - W_0} \times 100$$

(where W<sub>0</sub> is the weight of the empty crucible, W<sub>1</sub> is the weight of the crucible with sample while W<sub>2</sub> is the final weight of the crucible with sample turned ash)

#### Crude fat determination

One gram (1 g) of AYB flour sample was weighed into extraction thimble and plugged lightly with cotton wool. The thimble was placed in the extractor fitted with reflux condenser and a 250 ml soxlet flask which had been previously dried in an oven, cooled in a dessicator and weighed. The soxhlet flask was filled to ¾ of its volume with petroleum ether (bpt 40 – 60 °C) and the sample refluxed until extraction was completed after which the flask which contained the fat extracted was removed and dried to a constant weight in an oven at 105 °C. The amount of fat extracted was calculated as:

$$\% \text{ Fat} = \frac{W_2 - W_0}{\text{Weight of sample}} \times 100$$

(w<sub>0</sub> - initial weight of dry soxhlet flask, W<sub>1</sub> - final weight of oven-dried flask + the extracted fat)

#### Nitrogen free extract (NFE)

Nitrogen free extract was determined by subtracting the values % moisture (M), % crude protein (CP), % fat, % crude fibre (CF) and % ash from 100:

$$\% \text{ NFE} = [100 - (\% \text{ M} + \% \text{ CP} + \% \text{ fat} + \% \text{ CF} + \% \text{ ash})]$$

#### Determination of minerals

The minerals were analyzed using AOAC (2005) method. African yam bean sample flour (0.1 g) was weighed into a clean 125 ml

conical flask. Four milliliters (4 ml) of concentrated  $H_2SO_4$  was added to the sample and the flask swirled carefully to ensure that the entire sample was wet. The contents of the flask were heated in a fume hood, on a hot plate set at 'medium heating'. The flask was removed and cooled. Ten drops of  $H_2O_2$  was added slowly to the flask, to avoid vigorous reaction of the contents. The content of the flask was swirled and reheated, followed by cooling, careful addition of another 6 drops of  $H_2O_2$  and reheating. Six drops of  $H_2O_2$  was added while cooling until there was a colour change from black to dark brown. The flask with its content was kept on the hot plate and heated for the last time, and six drops of  $H_2O_2$  was added while heating. It was cooled for 10-15 minutes, the solution became colourless. The content of the flask was finally transferred into a 100 ml volumetric flask and made up to 100 ml with distilled water. The 100 ml extract was used to determine Fe, Zn and Se using PinAAcle 900T (AAS).

#### Statistical analysis

Data obtained was subjected to analysis of variance (ANOVA) in CRD. Significance of treatment means was determined by least significance difference at 5% probability level using GENSTAT 5.0 Release 4.23 Discovery Edition.

## RESULTS

### Proximate composition

Result of the proximate composition for the African yam bean samples revealed a considerable genotypic variation (Table 2). Crude protein varied significantly ( $p < 0.05$ ) in the samples. TSs 116 was significantly ( $p < 0.05$ ) higher (23.41 %) in crude protein than the other accessions while TSs 69 was lowest in crude protein content; however this was not statistically ( $p > 0.05$ ) different from TSs 86 and TSs 60. The crude fat contents of TSs 116 (3.86 %) and TSs 125 (3.79 %) were significantly ( $p < 0.05$ ) higher than the rest of the AYB accessions while TSs 69 was significantly ( $p < 0.05$ ) lowest in fat content (3.4%). The fiber content of the accessions did not vary statistically ( $p > 0.05$ ) however the crude fibre content of TSs 86 (6.76 %) was numerically higher than those of the other AYB accessions in fibre content. The fibre content of the AYB accessions ranged from 6.17 % to 6.76 %. The carbohydrate content of the African yam bean samples also varied significantly ( $p < 0.05$ ). The carbohydrate content of TSs 69 (54.48%) was significantly ( $p < 0.05$ ) higher than that of the other accessions, while that of TSs 116 (52.80 %)

was the least. The AYB samples did not significantly vary in dry matter content, TSs 116 (90.60%) was however numerically higher in dry matter content than the other accessions. The ash content of the seeds did not vary significantly; however the ash content of TSs 116 (4.35%) was numerically higher than that of the other samples. The moisture content of the samples ranged between 9.40% in TSs 116 and 9.56 % in TSs 60 and were not statistically significant ( $p > 0.05$ ).

### Mineral content

Table 3 shows the iron, zinc, selenium contents of the African yam bean accessions. The selenium concentration varied from 312 mg/100 g in TSs 116 to 58 mg/100 g in TSs 60. The zinc concentration in TSs 116 (8.83 mg/100 g) was the highest while that of TSs 125 (6.57 mg/100 g) was the least. TSs 60 (10.40 mg/100 g) had numerically highest iron content followed by TSs 69 (10.17 mg/100 g) and TSs 116 (9.03 mg/100 g) while TSs 86 was least in iron content (6.07 mg/100 g).

## DISCUSSION

### African yam bean

The protein content of the samples of the African yam bean accessions in this study was higher than the 10.6 -11.7 % reported by Nyananyo and Nyingifa (2011) for African yam bean and agreed with the findings of Eromosele *et al.* (2008) who reported values of 21-29 % for the protein content of AYB and within the range of 9.9-23.7% of protein values reported for AYB by Ameh (2007). It has been shown that any plant food that provides about 12 % of its calorific value from protein is considered a good source of protein (Effiong *et al.*, 2009; Ali 2010). African yam bean with its good balance of high protein and carbohydrate is therefore a promising food crop that can be useful in combating protein-energy malnutrition. Abete *et al.* (2009) reported a diet with majority of its protein being derived from legumes when compared with other protein-rich diets fed to obese men in eight weeks induced the greatest amount of weight loss.

**Table 1: Collection center of the African yam bean seeds**

Accession	Collection Center
TSs 116	GRC IITA
TSs 125	GRC IITA
TSs 69	GRC IITA
TSs 60	GRC IITA
TSs 86	GRC IITA

GRC IITA: Genetic Resources Center International Institute of Tropical Agriculture

The obese men that ate legumes at least four times a week experienced significant reduction in waist circumference, body mass fat, blood pressure and total cholesterol. According to earlier reports, clinical studies consistently showed that when replacing carbohydrate-rich foods with legumes, legumes reduced postprandial glucose elevations in both diabetic and non-diabetic participants while legumes also in other eleven trials lowered fasting blood glucose (Thompson *et al.*, 2012). This study has revealed that African yam bean is a protein-rich legume. The crude fat (3.4-3.9 %) obtained for the African yam bean accessions was lower than the crude fat obtained for the other legumes; such as soya bean (28.2 %) by Ogbemudia *et al.* (2017) and groundnut (46.1%) by Ayoola *et al.* (2012). Fat and oil in legumes are usually healthy for human consumption because of their unsaturated nature. The low fat content of African yam bean seed makes it a promising food crop for weight management. The low fat content in African yam bean seed enhances the processing of the seeds to flour without going through the defatting stage in flour production. The level of fibre for African yam bean in this study was higher than that in groundnut (2.83 %) by Ayoola *et al.* (2012) but lower than that (10.37- 17.21 %) in cowpea by Mamiro *et al.* (2011). Consumption of fibre has been associated with decreasing low-density lipoprotein (LDL) cholesterol, which is a risk factor in atherosclerosis, coronary heart disease, and ischemic stroke, which can also increase the risk of diabetes, cardiovascular diseases, and some other disease conditions. Inclusion of African yam bean and other legumes in meals and their flour in pastries is, therefore, recommended to reduce the incidence of these health problems. The carbohydrate content of the seeds (52.80 - 54.48 %) falls within the range (42.77 - 62.76 %) reported for Bambara groundnut by Atoyebi *et al.* (2017), 54.31-59.64 % for lima beans by Yellavila *et al.* (2015) and 38.18-56.96 % for cowpea by Mamiro *et al.* (2011). Legumes are especially high in resistant starch (RS), generally defined as starch and starch products not digested in the small intestine (Murphy *et al.*, 2008). Legumes also have a low glycemic index (GI) compared with other carbohydrate-rich foods, likely as a result of both their RS and fibre. The low GI of legumes can potentially produce clinically relevant benefits (Messina, 2014). The ash content (4.22 - 4.35%) of the AYB accessions studied agreed with that (4.30 %) reported for African yam bean by Adamu *et al.* (2015). The ash content of the AYB accessions studied was

lower than that (5.35 %) obtained for AYB by Chinedu and Nwinyi (2012) but higher than the ash content of common beans (3.26%), mung bean (3.82%), pigeon pea (3.55%), black eyed beans (3.41%), and soybean (4.01%) by Adamu *et al.* (2015). Since ash content of a seed is the measure of its mineral content of a material (Anhwange *et al.*, 2004), the level of ash recorded in African yam bean suggests it is a good source of dietary minerals. The optimum moisture content for pulses is in the range of 9 – 12% to avoid production of mycotoxins and for safe storage. At a moisture level below 10%, respiration in most food grain almost stops, increasing the grain storage life (Sujeetha, 2014). The moisture content of the AYB accessions analyzed was less than 10% and falls within the optimum moisture content range for safe storage of pulses. The low moisture and high dry matter content of the AYB seeds analyzed explains why dry African yam bean seeds obtained from pods harvested during the dry season (without any additional drying after harvest) can be stored in polythene bags for several months, at room temperature, without microbial growth and deterioration.

#### Mineral content

The result of this study has shown that the accessions analyzed were statistically similar with respect to iron, zinc and selenium. This could have been as a result of high intra-genotypic variation which could have been responsible for low inter-genotypic variation, showing that within each genotype, there is high degree of variability which seems to obscure variation among genotypes for the traits of interest. Furthermore, the high coefficient of variation (CV) of the micronutrients (Se and Fe) and the high out crossing ratio of about 10% in African yam bean reported by Adewale (2011) may also be indicted for the non-uniformity in the seed samples for each genotype (accession). The higher the CV, the greater level of dispersion around the mean. The lower the value of the CV, the more precise the estimate (In see, 2016) Considering the results, it is however worth noting that the accessions numerically varied with respect to micronutrients analyzed and that the African yam bean seeds were relatively higher in micronutrients than some of the edible legumes.

The iron contents of the AYB accessions in this study (6.07-10.40 mg/100 g) and zinc contents (6.57-8.83 mg/100g) were higher than that (3.10 mg/100g) reported for Fe and that (5.0 mg/100g) reported for Zn in groundnut by Badau *et al.* (2013).

## Nutritional Composition of Seeds of Some African Yam Bean Accessions

**Table 2:** Proximate composition of the African yam bean accessions (%)

Accession	Crude protein	Fat	Fibre	Carbohydrate	Dry matter	Ash	Moisture
TSs 116	23.41a	3.86a	6.17	52.80a	90.60	4.35	9.40
TSs 125	23.12a	3.79a	6.32	52.99a	90.51	4.29	9.49
TSs 69	21.84b	3.40b	6.52	54.48b	90.45	4.22	9.55
TSs 86	21.96b	3.44b	6.76	54.04b	90.43	4.23	9.57
TSs 60	21.95b	3.47b	6.57	54.11b	90.42	4.31	9.58
Grand mean	22.46	3.59	6.47	53.68	90.48	4.28	9.52
LSD (0.05)	0.813	0.255	NS	0.993	NS	NS	NS

NS: Non significant at 5% probability level. %: percentage

**Table 3:** Mineral composition of the African yam bean accessions (mg /100 g)

Accession	Selenium	Selenium CV (%)	Zinc	Zinc CV (%)	Iron	Iron CV
TSs 116	312	69.07	8.83	14.78	9.03	82.13
TSs 125	103	32.14	6.57	13.31	8.67	65.28
TSs 69	144	99.09	6.37	17.37	10.17	26.69
TSs 86	133	7.69	8.42	46.54	6.07	5.80
TSs 60	58	90.32	7.90	26.52	10.40	89.40
Grand mean	150		7.62		8.87	
LSD(0.05)	NS		NS		NS	

NS: Non significant at 5% probability level

They were also higher than that (1.11 mg/100g) reported for Fe and (4.07 mg/100g) reported for Zn in soya bean by Oluyemi *et al.* (2005).

The iron and zinc contents of the seeds also indicate that African yam bean is a good dietary source of iron and zinc. The selenium level in the AYB seeds in this study (58-312 mg/100 g) indicates that African yam bean seed is a rich source of selenium compared to the selenium levels (5.06-5.08 mg/100 g) reported for Bambara groundnut and (1.31-3.68 mg/100 g) reported for breadfruit (Ujowundu, 2013). Selenium is an essential trace element for humans and animals and has been reported too low in food produced in most of Europe, parts of Africa, Asia and New Zealand (Haug *et al.*, 2007). Selenium deficiency diseases are not commonly reported but the daily Se intake is lower than the recommended Rayman (2004). Increasing the Se consumption in human diet can therefore be achieved by the consumption of plants that naturally contain more Se than others (Haug *et al.* 2007). This study has identified promising AYB genotypes superior for nutrient quality traits analyzed. TSs 116 was best accession in terms of crude protein, dry matter, ash, selenium and zinc while TSs 60 was best in terms of iron. African yam bean seed is recommended for inclusion in human food preparation and consumption. It is also recommended for inclusion in fish and livestock feed meals and as meat alternative for vegetarians. The genotypic variability with respect to these traits could be explored by breeding programs in developing improved

African yam bean varieties with better qualities in terms of nutrient density.

## CONCLUSION

The results of this study showed that African yam bean accessions were rich in protein, carbohydrate, fibre, iron, zinc, selenium, had high dry matter content and low in fat. African yam bean has great potentials for combating protein-energy malnutrition and mitigating the effects of iron, zinc and selenium deficiencies and maintain healthy metabolic processes. Efforts should therefore be made towards increased production and consumption of African yam bean. The result of this study has revealed there is an evident genotypic variability in the AYB accessions analyzed for proximate quality and micronutrients and should be explored in developing improved varieties with enhanced nutritional qualities.

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## REFERENCES

- Abete I, Parra D, and Martinez J.A. (2009). Legume-, fish-, or high-protein - based hypocaloric diets: effects on weight loss and mitochondrial oxidation in obese men. *J. Med Food.*, **12** (1), 100-108
- Adamu G.O.L, Ezeokoli O.T, Dawodu A.O, Adebayo-Oyetoro A.O. and Ofodile L. N. (2015). Macronutrients and micronutrients profile of some underutilized beans in Southwestern Nigeria. *International Journal of Biochemistry Research and Review.*, **7** (2), 80-89

- Adewale B.D. (2011). Genetic diversity, stability and reproductive biology of African yam bean. PhD thesis, University of Agriculture, Abeokuta, Nigeria
- Ali A. (2010). A comparative study of nutrients and mineral molar ratios of foods with recommended dietary allowances. *Journal of Food Science and Technology*, **2**, 104-108
- Al-Saleh E. Nandakumaran, M. Al-Shammari M. and Al-Harouny A. (2004). Maternal-fetal status of copper, iron, molybdenum, selenium and zinc in patients with gestational diabetes. *J. Matern. Fetal Neonatal Med.*, **16**, 15-21
- Ameh G.I. (2007). Proximate and mineral composition of seed and tuber of African yam bean *Sphenostylisstenocarpa* (Hoechst. Ex. A. Rich) Harms)). *Asset*. **6** (1), 1-10
- Anhwange B.A. Ajibola V.O. and Oniye S.J. (2004). Amino acid composition of the seeds of *Moringaoleifera* (Lam), *Detariummicrocarpum* (Guill & Sperr) and *Bauhinia monandra* (Linn.). *ChemClass Journal*, **1**, 9-13.
- AOAC (2005). *Official Methods of Analysis* (18th ed.) Association of Official Analytical Chemists, Washington D.C., USA
- Aremu, M.O. Olonisakin A. Otene I.W. and Atolaiye B.O. (2005). Mineral content of some Agricultural products grown in the middle belt of Nigeria. *Oriental Journal of Chemistry*, **21** (3), 419 – 425
- Atoyebi J.O. Osilesi. O. Adebawo O. and Abberton M. (2017). Evaluation of nutrient parameters of selected African Accessions of Bambara Groundnut *Vignasubterranea* (L.) Verdc.) *American Journal of Food and Nutrition*, (5) **3**, 83-89
- Ayoola P.B. Adeyeye A. and Onawumi O.O. (2012). Chemical evaluation of food value of groundnut (*Arachihypogaea*) seeds. *American Journal of Food and Nutrition*, **2** (3), 55- 57
- Badau M.H. Abba H.Z. Agbara G.I. and Yusuf A.A. (2013). Proximate composition, mineral content and acceptability of granulated maize dumpling (*Dambumasara*) with varying proportions of ingredients. *Global Advanced Research Journal of Agricultural Science*, **2** (1), 07-016
- Batra J. and Seth P.K. (2002). Effect of iron deficiency on developing rat brain. *Indian Journal of Clinical Biochemistry*, **17**(2), 108-114
- Beard J. L. (2001). Iron biology in immune function, muscle metabolism and neuronal functioning. *Journal of Nutrition*, **131**, 5685-5695
- Chinedu S.N. and Nwinyi C.O. (2012). Proximate analysis of *Sphenostylisstenocarpa* and *Voadzeia subterranean* consumed in South – Eastern Nigeria. *Journal of Agricultural Extension and Rural Development*, **4** (3), 57-62
- Effiong G.S. Ibia T.O. and Udofia U.S. (2009). Nutritive and energy values of some wild fruit spices in south eastern Nigeria. *Electronic Journal of Environment Agriculture and Food Chemistry*, **8**, 917-923
- Eromosele C.O. Arogundade L.A. Eromosele, I.C. and Ademuyiwa, O. (2008). Extractability of African yam bean (*Sphenostylisstenocarpa*) protein in acid, salt and alkaline aqueous media. *Food Hydrocolloids*, **22**, 1622-1628
- FMH (2014). <http://www.health.gov.ng/doc/NSPAN.pdf>
- Food and Agriculture Organization (2012). The State of food insecurity in the world 2012. economic growth is necessary but not sufficient to accelerate reduction of hunger and malnutrition. FAO, Rome: <http://www.fao.org/docrep/016/i3027e/i3027e.pdf>
- GENSTAT (2003). GENSTAT 5.0 Release 4.23DE, Discovery Edition 1, Lawes Agricultural Trust, Rothamsted Experimental Station
- Gunasekara P. Hettiarachchi M. Liyanage C. and Lekamwasam S. (2011). Blood sugar lowering effect of zinc and multivitamin/mineral supplementation is dependent on initial fasting glucose. *Journal of Diabetology*, **1** (2), 1-13
- Haug A. Graham R.D. Christophersen O.A. and Lyons G.H. (2007). How to use the world's scarce selenium resources efficiently to increase the selenium concentration in food. *Microbial Ecology in Health and Disease*, **19**, 209-228
- Insee (2016) <https://www.insee.fr/en/metadonnees/definition/c1366>
- Kornhauser C. Garcia-Ramirez J.R. Wrobel K. Perez-Luque E.L. Garay-Sevilla, M.E. and Wrobel K. (2008). Serum selenium and glutathione peroxidase concentrations in type 2 diabetes mellitus patients. *Prim. Care Diabetes*, **2**, 81-85
- Lee J.H. Lee H.J. Lee I.K. Yoon J.S. (2005). Zinc and copper status of middle- and old-aged woman in type 2 diabetes. *The Korean Journal of Nutrition*, **38**, 56-66
- Mamiro P.S. Mbwaga A.M. Mamiro D. Mwanri A.W. and Kinabo J.L. (2011). Nutritional quality and utilization of local and improved cowpea varieties in some regions in Tanzania *Journal of Agriculture, Food, Nutrition and Development*, **11** (1), 4490-4502
- Messina V. (2014). Nutritional and health benefits of dried beans. *American Journal of Clinical Nutrition*, **100**, 437-442
- Micronutrient Initiative (2013). Nigeria country profile. Retrieved from: <http://www.micronutrient.org/english/view.asp?x=596>
- Ndidi U.S. Ndidi C.U. Aimola I.A. Bassa O.Y. Mankilik M. Adamu Z. (2014) Effects of processing (Boiling and roasting) on the nutritional and anti-nutritional properties of Bambara groundnuts (*Vigna subterranean* [L.] erdc.) from Southern Kaduna, Nigeria. *Journal of Food Processing*, 1-9. DOI: 10.1155/20172129

- Nyananyo B.L. and Nyingifa A.L. (2011). Phytochemical investigation on the seed of *Sphenostylisstenocarpa* (Hochst ex A. Rich.) Harms (Family Fabaceae) *J. Appl. Sci. Environ. Manage.*, **15** (3), 419-423
- Ogbemudia R.E. Nnadozie Blessing C. and Anuge B. (2017). Mineral and Proximate Composition of Soya Bean. *Asian Journal of Physical and Chemical Science.*, **4** (3), 1-6
- Oluyemi E.A. Akinlua A.A. Adenuga A.A. and Odebajo M.B. (2005). Mineral contents of some commonly consumed Nigerian foods. *European Journal of Scientific Research.*, **6** (2), 11-15
- Okpara D.A. and Omaliko C.P.E. (1995). Effects of staking, nitrogen and phosphorus fertilizer rates on yield and yield components of African yam bean (*Sphenostylis stenocarpa*). *Ghana Journal of Agricultural Science.*, **28**, 23-28 <http://dx.doi.org/10.4314/gjas.v28i1.2004>
- Philips R.D. (1993). Starchy legumes in human nutrition and culture. *Plant Foods and Human Nutrition.*, **44** (3), 195-211.
- Quilliot, D., Dousset, B.; Guerci, B., Dubois, F., Drouin, P. and Ziegler, O. (2001). Evidence that diabetes mellitus favors impaired metabolism of zinc, copper, and selenium in chronic pancreatitis. *Pancreas.*, **22**, 299-306
- Rayman M.P. (2004). The use of high-Se yeast to raise Se status: how does it measure up? *British Journal of Nutrition.*, **92**, 557-573
- Soetan, K.O., Olaiya, C.O. and Oyewole, O.E. (2010). The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science.*, **4** (5), 200-222
- Sujeetha, J.A.R.P, Abirami, C.V.K. and Alagusundaram, K. (2014). Bio-intensive safe storage methods for pulses: Review. *Jioplast.*, **7** (1), 98-103
- Thompson S.V. Winham D.M. and Hutchins A.M. (2012). Bean and rice meals reduce postprandial glycemic response in adults with type 2 diabetes: a cross-over study. *Nutrition Journal.*, 11:23
- Ujowundu C.O. Nwaogu L.A. Ujowundu F.N. and Belonwu D.C. (2013). Effect of gas flaring on the phytochemical and nutritional composition of *Treculia Africana* and *Vigna subterranean*. *British Biotechnology Journal.*, **3** (3), 293-304
- Uguru M.I. and Madukaife S.O. (2001). Studies on the variability in agronomic and nutritive characteristics of African yam bean (*Sphenostylisstenocarpa* Hochst ex. A. Rich Harms). *Plant Product Resource Journal.*, **6**, 10-19
- United Nations Children's Fund (UNICEF). (2011). At a glance: Nigeria. Retrieved from: [http://www.unicef.org/infobycountry/nigeria\\_statistics.html](http://www.unicef.org/infobycountry/nigeria_statistics.html)
- Yellavila, S.B., Agbenorhevi, J.K., Asibuo, J.Y. and Sampson, G.O. (2015). Proximate composition, minerals content and functional properties of five Lima Bean accessions. *Journal of Food Security.*, **3** (3), 69-74
- Yoon J.S. and Lee J.H. (2007). A suggestion to improve zinc status of type 2 diabetic women: relation among zinc, protein and phytate intake. *Journal of Korean Dietetic Association.*, **13**, 301-310