EVALUATION OF NUTRIENTS AND ANTI-NUTRITIONAL FACTORS OF DIFFERENT SPECIES OF AFRICAN YAM BEAN (SPHENOSTYLIS STENOCARPA)

1.Onuoha, Chikaodiri H, 1. Harry, Bassey J. & 2. Eze, Sunday O.

1. Institute of Agricultural Research & Training, Obafemi Awolowo University
P.M.B 5029, Apata Ibadan, **NIGERIA**
2.Department of pure and Industrial Chemistry, Abia State University
PMB 2000, Uturu, Abia State, **NIGERIA**

ABSTRACT

Six species of African Yam Bean (AYB) collected from three agro-ecological zones of Nigeria- the gene bank of the Institute of Agricultural Research & Training (I.A.R &T) Ibadan, in South West Zone, local market in Obanliku L.G.A, Cross River State, in South South Zone, and a local market in Ohuhu, Umuahia North L.G.A, Abia State, of South East Zone all in Nigeria were analyzed for their nutrients and anti-nutritional factors using standard methods. The study was aimed at recommending the use of the best of these species in livestock feed production. The analysis was carried out in replicates for all determinations and the results of the replicate were expressed as mean ± SEM. Data obtained were subjected to analysis of variance (ANOVA) using SAS (2004), version 9.0 software. Differences between the means were separated by Duncan Multiple Range Test (DRMT) at 5% (0.05) level of significance. The results of the nutrient evaluation obtained from the proximate analysis and anti-nutritional composition of the seeds as carried out showed that there were significant differences ($p< 0.05$) among the nutrients and the anti-nutritional factors and the oligosaccharide levels of the different species used. The results also indicated that those species with white or closely white colour have nutrient values that are considered good for incorporation in animal feed.

Keywords: Species, African Yam Bean, Anti-nutritional factor, oligosaccharides, proximate analysis.

INTRODUCTION

African Yam Bean (*Sphenostylis stenocarpa* Ex. A. Rich, Harms) is an under-utilized food legume usually cultivated for its edible seeds and tubers in most Sub-Saharan African Countries but not popular in the tropics as other legumes ***(***Azeke *et al* 2005; Moyib *et al*, 2008). It is a good source of protein, carbohydrate, minerals and vitamins with its protein content, twice that of sweet or Irish potatoes and very much higher than those in yam and cassava *(*Liday (2013, Amoatey *et al*; 2006*)*.

The demand for animal protein for human nutrition in the developing world is high due to the increase in population and the widespread malnutrition ***(***OECD-FAO,2010). However, the productivity of animals in the developing regions is low. Hence, there is poor animal protein intake *(Alli*-Balogun *et al. 2003).* The seed of African Yam Bean is a highly priced food legume in South Eastern Nigeria owing to high crude protein content that falls between the ranges of 21 to 29% in tubers which is about 2 to 3 times the amount of protein in potatoes (Emiola, 2011; and Uguru *et al*, 2001). Oke *et al, (2013),* equally reported protein content of AYB and Lima bean flours to be about 24.72% and 23.53%, respectively. AYB ranks well among neglected crops and can contribute to food security if its genetic resources are saved for utilization in breeding and improvement **(**Adewale *et al.*, 2012). AYB seeds have good nutritional profile with high level protein, carbohydrate, lipid, minerals, and other nutrients comparable with that of other common legume grains **(**Uche *et al*, 2014. The seed can be cooked or fried when made into flour or paste and can also be used as an extender. This explains the report of (Elsie *et al*; 2016) that making AYB paste can be used as meat extender in the production of comminuted meat balls type product. Processing drastically reduced the level of anti-nutrients in the AYB with minimal effect on the nutritional quality, **(***Uche et al, 2014).*Because of its nutritional content, AYB has become an important substitute for the more widely eaten cowpea in areas where it has been grown for its seeds. It can also be used as a substitute of soya bean in animal feed as in the case of processed kidney bean. The research studies of Hussein, *et al*; 2016. and Emiola, 2011 showed that processed kidney bean can replace soya bean meal up to 75% (195g/kg) without adverse effects on egg quality. Likewise a low quantity of AYB in the meal of weaner rabbits could substantially substitute for soya bean. *(*Akinmutimi *et al*, (2006), specifically remarked that AYB would be good alternative protein source for livestock and poultry.

Some researchers Okeola and Machuka, 2001; Ajibade *et al*, 2005, Fasoyiro *et al*, 2006***)*** identified the presence of some anti-nutritional factors in the seed of African Yam Bean. These are alkaloids, flavonoids, saponins, trypsin inhibitor, phytate, tannin and oxalate. In addition to the afore mentioned factors are the α-galactose (stachyose) and lecitin**.** ***(****Oboh et al,* 1998***)*** while *Nwinuka et al. (*1997) identified some gassy factors like sucrose, raffinose and stachyose. Betche *et al****.*** ***(*****2005),** identified α-amylase as the notable anti-nutrients in AYB. These anti-nutritional factors can be reduced by using efficient processing techniques and proper cooking **(**Adewale *et al*., 2013**).** Good processing ensures safe consumption of African yam bean meals by human and livestock according to the result of study by **(**Hussein *et al*; 2016**)** which showed an increase in weight for animals in both the control and the test groups of white Leghorn layers**.** ***(***Kine *et al;* 1991*) and* Edem *et al* 1990*)* evaluated the chemical composition and nutritional content of 44 genotypes of AYB, they reported that the crop is well balanced in essential amino acids and has higher amino acid content than pigeon pea, cowpea and bambara groundnut.

Asare, *et al* (1994), observed that African Yam Bean is a good source of fodder for ruminant animals and perform better in seed yield when intercropped with maize, yam and okra. However, only a very small sector of the farmers appreciates its cultivation hence they are the holder of the crop's genetic resources *(*Adewale *et al*, 2012*)* and explorations to collect more varieties from farmers are necessary to increase production, improvement and high yield of the crop so as to have enough for both human and animal consumption.

Incorporating African Yam Bean in the feeds of some livestock has been attempted. The experimentation of AYB hull on rat feeding **(**Agunbiade and Longe; 1999), showed increased weight and higher feed conversion efficiency compared with cellulose free and pure cellulose meal. This infers that AYB hull could be a good source of dietary fibre.

In spite of the fact that the chemical composition and nutritional content of AYB have been investigated by these researchers, there is still little information on the compositional differences and similarities of nutritional values among the species of African Yam Bean cultivated at different locations in different agro ecological zones of the country (Nigeria). This study work therefore sought to evaluate the differences in both the nutrients and anti-nutritional factors of six species of African Yam Bean from different Agro Ecological Zone of Nigeria with a view of using and recommending the best species for livestock feed formulation.

MATERIALS AND METHODS

The seeds of six African yam bean species used for this study were collected in April, 2015 from the gene bank of Institute of Agricultural Research & Training (I.A.R &T) Ibadan South West Nigeria, a local market in Obanliku L.G.A, Cross River State, South South Nigeria and local a local market in Ohuhu, Umuahia North L.G.A, Abia State,in South East Nigeria. The details are as shown in Table 1. Samples of the seeds used were first sundried for four (4) days after which it was ground and then taken to the Microbiology Laboratory of the Institute of Agricultural Research & Training (I.A.R&T), Ibadan for analysis. Samples were analyzed chemically by alkaline titration method according to the official methods of analysis described by the Association of Official Analytical Chemist **(**A.O.A.C, 2004).The method described in Reddy *et al*; (1982) was used for phytate determination.Trypsin inhibitor analysis was done using spectrophotometric method as described by Arntfield *et al*; (1985). The method of Doss *et al*; (2011**)** was used for tannin analysis while the optical density (absorbance) readings were taken at 500nm wavelength. Oxalate determination was carried out based on the method of Leyva *et al*; (1990**).** Solutions were prepared and read on the spectrophotometer at 440nm, while the oligosaccharides were analyzed using Calorimetric methods for determination of sugars and related substances with the solutions prepared and read on the spectrophotometer at 490nm wavelength (Analytical Chemistry 28, 350-356).

The analysis was carried out in replicates for all determinations and the results of the replicate were expressed as mean ± SEM. Data obtained were subjected to analysis of variance (ANOVA) using SAS (2004), version 9.0 software.

Differences between the means were separated by Duncan Multiple Range Test (DRMT) at 5% (0.05) level of significance.

Table I: Morphological Descriptions of six African Yam Bean species from different agro ecological zones in Nigeria based on their seed coat colour.

S/N	SAMPLE	SPECIES CODE	SEED COAT COLOUR	SOURCE
1	A	TSs_{12}	Brown	I.A.R.&T, Ibadan
2	B	TSs_{11}	White	Ohuhu in Umuahia North L.G.A, Abia State
3	C	TSs_{16}	Greyish white	Obanliku L.G.A in Cross River State
4	D	TSs_{8}	Reddish golden$^{(v)}$	Ohuhu in Umuahia North L.G.A, Abia State
5	E	TSs_{126}	Light blond	I.A.R.&T, Ibadan
6	F	TSs_{24}	Cognac brown$^{(v)}$	I.A.R.&T, Ibadan

- Specie code and Colour description by Kornerup and Wanscher (1978) NB: The prefix *v* denotes speckling on seeds with respective testa basal colours others without the prefix are monocoloured.

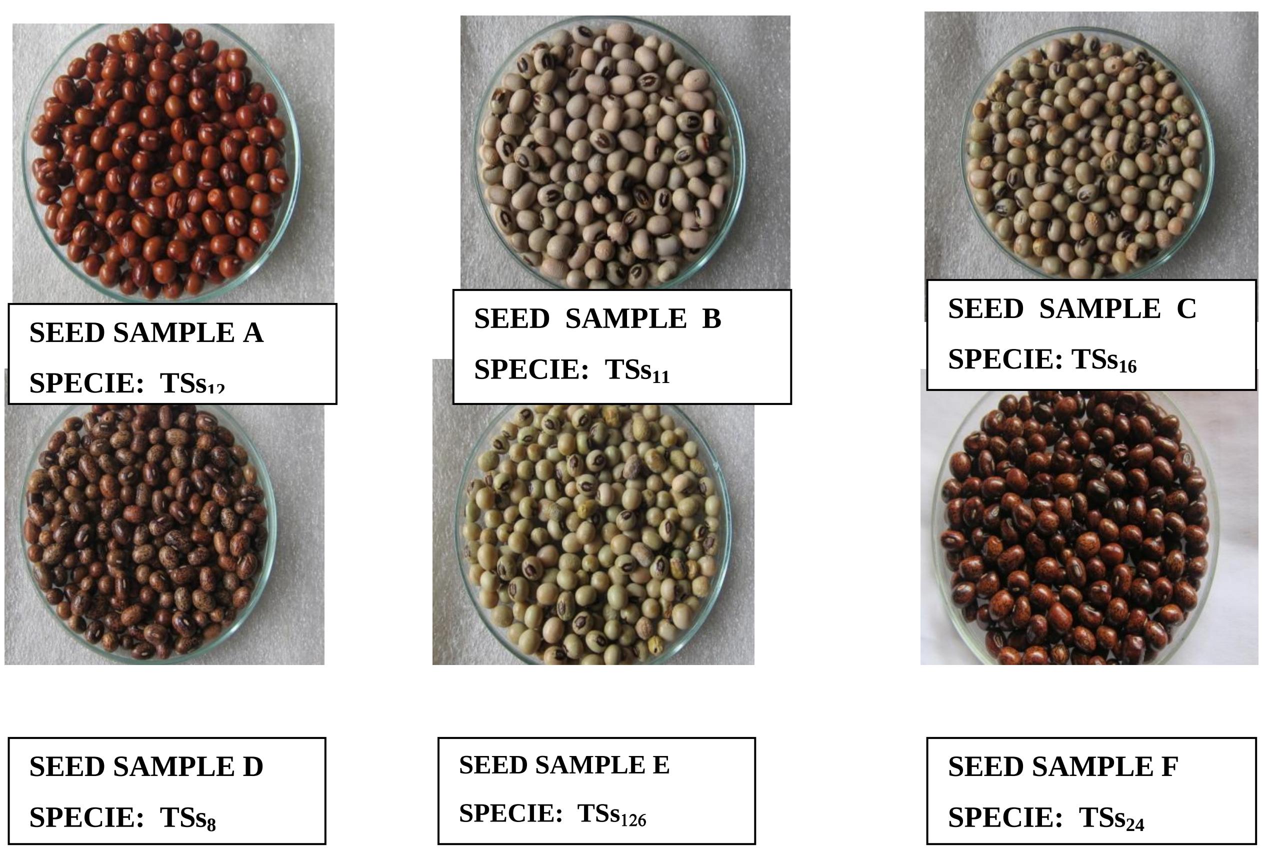

FIG I: SEED SAMPLES OF THE SIX SPECIES OF AFRICAN YAM BEAN USED

RESULTS

The proximate and compositional analysis carried out on the six species of African Yam Bean (AYB) are shown below in Tables 2 and 3 respectively.

The crude protein content of the seeds was highest in sample E (28.36%) followed by seed sample A (28.00%) while the lowest crude protein of the seed was recorded in sample C (26.88%). There were significant differences ($p<0.05$) among the crude protein content of the six species used. Crude protein contents of the six AYB samples obtained in this study was similar to that of processed kidney bean (28.00%) except in soya bean where it was higher (38.00%) as reported by Hussein *et al*; 2016 and were slightly higher than that reported by Audu and Aremu (2011), Emiola (2011), Sisay *et al*., (2015b) and Emiola and Ologhobo (2006**)** which were 23.6, 24.7, 25.8 and 26.8%, respectively..

There was no significant difference between the crude fibre content of sample A (the brown coloured sample from Ibadan) and C (the greyish-white sample from Cross River State) differing significantly with the other samples. The crude fibre content of the seeds was highest in sample A (5.30%) closely followed by seed sample C (5.26%) while the lowest was recorded in seed sample E (3.95%). The crude fibre in samples E, is generally lesser than that from most seeds as well as *Sphenostylis stenocarpa* obtained in Eastern Nigeria**, (**Ojiako *et al*; 2010**)** with Crude fibre representing the amount of indigestible sugar present in AYB. The crude fibre content of AYB is comparable to that of kidney bean reported by, Emiola (2011), Audu and Aremu, (2011) who reported 5.0, and 4.7%, respectively.

Seed sample A showed the highest Ether Extract (EE) content (2.48%) followed by seed sample C (2.17%) while the lowest ether extract was recorded in seed sample F (1.78%). There were significant differences ($p<0.05$) in ether extract content among the six species used. The EE content of AYB used in this study is lower than that in kidney bean as reported by Emiola (2011) and Hussein *et al;* (2016).

Dry matter content was highest in seed sample A (94.34%) followed by seed sample B (93.89%) while seed sample D (88.17%) recorded the lowest dry matter content. The various content of dry matter differs significantly ($p<0.05$) among the six species. The DM contents of AYB in this study was higher when compared with that of soya bean and processed kidney bean as reported by Hussein et al; (2016) and at close range or similar to that of processed kidney bean as reported by Audu and Aremu (2011) (96.8%), Sisay *et al.* (2015b) (88.00%).

The moisture content of the seeds was highest in seed sample F (59.87%) followed by seed sample D (11.85%) while the lowest was recorded in seed sample A. (5.66%). There were significant differences ($p<0.05$) in the percentage moisture content among the six species of African Yam Bean used. The moisture contents for all the samples fall within the recommended range of 0–13% as reported by James (1995**).**

The ash content of the seed in the six specie of AYB used was highest in sample A (5.61%) closely followed by seed sample F (5.52%) while the lowest was recorded in seed sample E (3.79%). There were significant differences ($p< 0.05$) in the percentage ash content among the species and is lower than that obtained in SYB and PKB which is 7.8 and 7.0 respectively as reported by Hussein *et al*; (2016).
The result in table 2 indicate that the seed sample B (61.95%) has the highest Nitrogen-free extract (NFE) closely followed by seed sample C (61.89%) while seed sample A had the lowest (58.62%) NFE content. There were significant differences in the nitrogen free extract

content ($p< 0.05$) among the six species of AYB. The nitrogen-free extract (NFE) for the AYB seeds was found to be lower when compared to previous reports on certain underutilized food legumes such as Cassia floribunda and *Tamarindus indica* [Vadivel *et al*; 2001 and Pugalenthi *et al*, 2004**]**. From the above results, it could be deduced that the seeds of the AYB species used in this study, have high percentage of crude protein, crude fibre, ether extract and moisture content than ash and nitrogen free extract.

Anti-Nutritional Factor of African Yam Bean Seeds.

Comparison of the anti-nutritional factors found in them indicate that tannin, oxalate and phytate were more in seed sample A (0.14mg/g, 0.25mg/g, 0.31 mg/g) than the remaining five samples of the seeds. Alkaloids were more in seed sample E (14.79mg/g) and seed sample A (14.61mg/g) than in the other seed samples. Saponin were more in seed sample D (0.16mg/g) and seed sample A (0.15mg/g) than in the other seed samples. Flavonoid and Lectin were more in seed sample F (0.24and 0.11mg/g) than the other seed samples. Trypsin inhibitor and sucrose were more in seed sample C (0.13 and 0.19mg/g) than the other seed samples. Raffinose and α-amylase have the highest content in seed sample A than the remaining five seed samples of African Yam Bean used. α-galactosides in seed sample B (Abia white) was (0.15mg/g), having highest value of α-galactosides than in the other five seed samples. Antinutritional factors are generally toxic and may negatively affect the nutrient value of seeds by impairing protein digestibility and mineral availability. However, they are heat labile and hence may be inactivated by processing methods involving heat generation Uche *et al*; (2014).

TABLE II.
Proximate analysis of six different sample seeds of African yam bean.

Sample	Crude protein %	Crude fibre %	Ether extract %	Dry matter %	Moisture content %	Ash Content %	Nitrogen free extract %
A	28.00^{b}	5.30^{a}	2.48^{a}	94.34^{a}	5.66^{e}	5.61^{a}	58.62^{d}
B	27.47^{d}	4.31^{d}	1.86^{cd}	93.89^{b}	6.12^{d}	3.92^{d}	61.95^{a}
C	26.88^{e}	5.26^{a}	2.17^{b}	92.97^{d}	7.04^{c}	3.79^{e}	61.89^{a}
D	26.92^{e}	4.52^{c}	1.90^{cd}	88.17^{f}	11.85^{b}	5.45^{b}	61.22^{ab}
E	28.36^{a}	3.95^{e}	1.84^{cd}	93.11^{c}	6.89^{c}	4.82^{c}	61.04^{b}
F	27.80^{c}	5.04^{b}	1.78^{d}	91.75^{e}	59.87^{a}	5.52^{ab}	59.87^{c}
SEM	0.16	0.15	0.07	0.62	5.91	0.23	0.36

***Mean (a-f) with different superscript in each column differ significantly @ 5% level i.e. ($p<0.05$) & vice versa**

TABLE III
Anti-nutritional factor (ANF) composition of six different sample seeds of African Yam Bean.

PARAMETER Mg/100g	**SAMPLE A**	**SAMPLE B**	**SAMPLE C**	**SAMPLE D**	**SAMPLE E**	**SAMPLE F**	**SEM**
Tannin	0.143 ^{a}	0.121 ^{c}	0.113 ^{d}	0.137 ^{b}	0.101 ^{e}	0.111 ^{d}	0.004
Alkaloids	14.61 ^{b}	14.33 ^{d}	14.02 ^{e}	14.04 ^{e}	14.79 ^{a}	14.50 ^{c}	0.086
Oxalate	0.247 ^{a}	0.231 ^{b}	0.188 ^{c}	0.118 ^{f}	0.134 ^{d}	0.123 ^{e}	0.016
Phytate	0.314 ^{a}	0.215 ^{c}	0.213 ^{c}	0.216 ^{c}	0.213 ^{c}	0.227 ^{b}	0.011
Saponin	0.146 ^{b}	0.128 ^{f}	0.141 ^{c}	0.158 ^{a}	0.136 ^{d}	0.132 ^{e}	0.003
Flavonoids	0.232 ^{b}	0.219 ^{c}	0.212 ^{d}	0.214 ^{d}	0.221 ^{c}	0.240 ^{a}	0.003
Trypsin inhibitor	0.114 ^{c}	0.109 ^{d}	0.126 ^{a}	0.122 ^{b}	0.117 ^{c}	0.116 ^{c}	0.002
Lectin	0.011 ^{c}	0.012 ^{c}	0.013 ^{c}	0.015 ^{c}	0.104 ^{b}	0.112 ^{a}	0.014
α-galactosides	0.141 ^{b}	0.148 ^{a}	0.116 ^{c}	0.110 ^{d}	0.012 ^{f}	0.017 ^{e}	0.017
Sucrose	0.134 ^{b}	0.134 ^{b}	0.187 ^{a}	0.125 ^{c}	0.016 ^{e}	0.111 ^{d}	0.015
Raffinose	0.118 ^{a}	0.116 ^{ab}	0.114 ^{b}	0.113 ^{b}	0.014 ^{d}	0.106 ^{c}	0.011
α-amylase inhibitor	0.087 ^{a}	0.071 ^{b}	0.014 ^{c}	0.080 ^{ab}	0.005 ^{c}	0.010 ^{c}	0.011

***Mean (a-f) with different superscript in each row differ significantly @ 5% level i.e. ($p<0.05$)**
& vice versa.

DISCUSSION

The fact that a plant or part of a plant is eaten by animals is only an indication of acceptability and some factors are used to determine the nutritive value of feedstuff fed to the animals as to know the feed value of that particular plant species. Plant phytochemicals as in anti-nutritional factors, exhibit diverse pharmacological and biochemical actions when ingested by animals (Amadi *et al*, 2006, Soetan 2008). Some of them have been shown to be deleterious to health or evidently advantageous to human and animal health if consumed at appropriate amounts, ***(***Sugano *et al*; 1993). For example, trypsin- inhibitor which are ANFs for monogastric animals do not exert adverse effect in ruminant because they are degraded in the rumen *(*Cheeke and Fenwick G.R., 1990). Increased protein intake (especially proteins with sulfur containing amino acids) leads to an increased glomerular filtration rate, reduced renal reabsorption of calcium, hypercalciuria and thus leaching of calcium out of the bone (Kumar *et al.*, 2013**).** It is suggested that evaluation and nutritional characterization of alternative protein ingredients that are locally available and relatively affordable to improve animal feed and commercial poultry production as to increase efficiency is an urgent requirement.(Nalle *et al;* 2010; Ani and Okeke, 2011).

Anti nutritional factors are generally toxic and may negatively affect the nutrient value of seeds by impairing protein digestibility and mineral availability (*Uche et al; 2014*), for example alkaloids is reported to cause gastrointestinal and neurological disorder ***(***Aletor, 1993***)*****.** Tannin cause decreased in feed consumption, palatability and reduced growth in animals ***(***Aletor 1993a*;)*. Trypsin (protease inhibitor) causes pancreatic enlargement and depress animal growth by interfering with the digestion and absorption of nutrients in the gastro-intestinal tract ***(***Aletor and Fatuga, 1987***)*****.** Phytate binds minerals like calcium, iron, magnesium and zinc making them unavailable to the animal.However, only oxalate has a significant effect on mineral level which is in agreement with the report of (Adegunwa *et al;* 2012**)** which suggest that oxalate forms complexes with minerals. *Kumar, (1992),* also reported that anti-nutritional factors diminish animal productivity and may cause toxicity during periods of scarcity or confinement when the feed rich in them is consumed by animals in large quantity. The proximate and anti-nutritional composition of African Yam Bean seed is comparable to other food legumes. From the result of this work, the highest percentage crude protein of 28.36% was obtained in specie E of the African Yam Bean, this however was lower than those reported for soya bean, winged bean and processed kidney bean **(**Sisay *et al*; 2015a Audu *et al;* 2011, and Emiola 2011) but were higher than those of cowpea, chickpea and pigeon pea. On the other hand, the crude fibre content of the seeds in the six species of AYB used for this study, was more than that of wing bean, soya bean, peanut, cowpea, lima bean and jack bean as reported by (Apata and Ologhobo, 1994). However, Several studies have indicated that heat processing (cooking and dry heating) increases the digestible nutrients available to young animals, especially chicken resulting in improved growth **(**Emiola and Ologhobo 2006**).** They can be detoxified by several processing method such as soaking, cooking, boiling, germination, autoclaving, fermentation, sprouting, genetic manipulation and other processing methods, which however may interfere with the level of protein and fibre contents used as indicator of high nutritive value as reported by Apata and Ologhobo 1994. However, ***(***Betch *et al*; 2005***)*** reported that fermentation can substantially improve the nutritional quality of AYB and reduces loses due to thermal influences of most food values. Roasting was found to have greater efficiency in the elimination or reduction of the levels of phytate available in AYB while boiling seemed to eliminate oxalate more efficiently when compared with roasting (Beckley *et al*, 2012).

CONCLUSION

From the study work of the results above, it can be deduced that the seed of specie A in most of the value, has the highest content of all the nutritive and anti-nutritional factors analyzed except in moisture content and nitrogen-free extract were it has the lowest value. Being the specie on the highest side of most values analyzed especially in anti-nutritional factors, it therefore shows that specie A will not be the best for animal feeding because of the high contents of the factors it contain rather it will be best used for human consumption when it has undergo certain processing method as outlined earlier on. Most of the contents and factors analyzed in Species B, C and E, fell between the range of values as analyzed by other researchers, hence can best be used in animal feeding, I therefore conclude that specie B, C, and E, will be good for use in livestock feed formulation, the three having moderate values in both the nutrients and anti-nutritional factor contents and also have likely white colour seed coat signifying more content of α-galactosides which has little or no much negative effect,

ISSN 2059-3058

this agreed with the work of *Betche et al; (2005)* that cyanogenic glycoside is higher in the white seeds of AYB compared to those with other seed coat colours. Species D and F can also be used in animal feeding provided if other food crop is added in the feedstuff as to supplement the contents so as to increase feed consumption in animals and make it palatable for them.

RECOMMENDATION

The anti-nutritional factor and proximate comparison of the six species of African Yam Bean used in this work can provide useful information regarding the selection of both desirable and potential variety for animal consumption; therefore I recommend that further research work be carried out on the three recommended species to determine the best of them for incorporation in livestock feed. However, it is important to note that before these seed can be used in animal feed, it has to be processed and detoxified by several processes Such as soaking, boiling, autoclaving, fermentation etc, to the level which is safe before it can be incorporated in their feed. This will help in reducing the negative effect of the anti-nutritional factors and as well improve the nutritional quality of the African Yam Bean.

ACKNOWLEDGEMENTS

The authors are grateful to the Head of the Microbiology Laboratory of the Institute of Agricultural Research & Training (I.A.R&T), Ibadan for assisting with the equipment for the analysis of the samples

REFERENCES

Adegunwa, M.O. Adebowale, A.A. and Solano, E.O. “Effect of thermal processing on the biochemical composition, anti-nutritional factors and functional properties of beniseed (*Sesamum indicum*) flour,” American Journal of Biochemistry and Molecular Biology, vol. 2, no. 3, pp. 175–182, 2012.

Adewale, B., Daniel, A., & Aremu, C. O. (2013). The Nutritional Potentials and Possibilities in African yam bean for Africans. International Journal of Agriculture, 3(1), 8-19.

Adewale BD, Dumet DJ, Vroh-BI 1, Kehinde OB, Ojo DK, Adegbite AE, Franco J, (2012). Morphological diversity analysis of African yam bean and prospect for utilization in germ plasm conservation and breeding. Gen.Res.crop Evo, 59(5):927-936

Agunbiade, S.O., O.G. Longe, (1999). African Yam Bean hull chemical composition and its effects on rat’s mineral retention, serum biochemical components and enzymatic activities. Nahrung 42:89-93.

Ajibade S.R, M.O Balogun, O.O Afolabi, K.O, Ajomole and S.B. Fasoyiro (2005). Genetic variation in nutritive and anti-nutritive contents of African yam bean (Sphenostylis.stenocarpa).Trop.Sc.45 (4):144-148.

Akinmutimi, A.H., Amaechi N., Unogo M., (2006). Evaluation of raw African yam bean meal as substitute for soya bean meal in the diet of weaner rabbit. J. Anim. Vet. Adv, 5(11):907-911

Aletor VA, (1993). Allelochemicals in plant food and feeding stuffs. Part I. Nutritiona biochemical and physiopathological aspects in Animal production. J. Vet. Hum. Toxicol. 34(1): 57-67.

Alli-Balogun JK, Lakpini CAM, Alawa JP, Mohammed A, Nwanta JA (2003). Evaluation of cassava foliage as a protein supplement for sheep. Niger. J. Anim. Prod. 30(1):37-46.

Amadi BA, Ibiegbulam CO, egbebu AC, (2006). Assessment of the effect of aqueous extract of pawpaw (Asimina triloba) root on organ weights and liver functions of albino rats. Int. J. Natural and Applied. Sci. 2:79-81.

Ani AO, Okeke GC (2011). The Performance of Broiler Birds Fed Varying Levels of Roasted Pigeon pea (Cajanus cajan) Seed Meal. Pak. J. Nutr. 10 (11):1036-1040.

AOAC(2004). Official methods of analysis of the association of official analytical chemists, 20th ed.

Apata D.F, Ologhobo A.D, 1994. Biochemical evaluation of some Nigerians legume seeds. Food Chem.. 49:333-338.

Arntfield, S.D. Ismond, M.A.H. and Murray, E.D. "The fate of anti-nutritional factors during the preparation of the faba bean protein isolate using micellization techniques," Canadian Institute of Food Science and Technology Journal, vol. 18, no. 2, pp. 137–143, 1985. View at Publisher · View at Google Scholar

Asare EO, Shehu Y, Agishi EA, (1984). Preliminary studies on indigenous species for dry season grazing in the northern guinea savanna zone of Nigeria. Trop Grassl, 18:148-152.

Audu SS, Aremu MO (2011). Effect of processing on chemical composition of red kidney bean (Phaseolus Vulgaris L.) Flour. Pak. J. Nutr. 10(11): 1069-1075.

Azeke MA, Barbara F, Ham BP, Whelm H and Thomas B (2005). Nutritional value of AYB(*Sphenostylis stenocarpa*). Improvement by lactic acid fermentation. J.Sci. Food Agric, 85(6):963-970.

Beckley Ikhajiagbe1, Joseph Kwesi Mensah, (2012). Genetic Assessment of Three Colour Variants of African Yam Bean [*Sphenostylis stenocarpa*] Commonly Grown in the Midwestern Region of Nigeria. Int. Journal of Modern Botany 2012, 2(2): 13-18 DOI:10.5923/j.ijmb.20120202.01

B**e**tche T, Azeke M, Buening-Pfaue H, Fretzdorff B, (2005). Food safety and security: Fermentation as a tool to improve the nutritional value of African yam bean, Conference proceedings of the International Agricultural Research for development, October 2015, Stuttgart-Hohenheim Pp1-5.

Calorimetric method for determination of sugars and related substances, Analytical chemistry 28,350-356.

Cheeke PR, Fenwick GR (1990). The chemistry and biological significance of saponins in feeding stuff. Int.Rev.Food.Sci.Nutr.157:62.

Doss, A. Pugalenthi, M. Vadivel, V. G. Subhashini, G. and Subash, R. A. "Effects of processing technique on the nutritional composition and antinutrients content of under-utilize food legume Canavalia ensiformis L.DC," Int. Food Research Journal, vol. 18, no. 3, pp. 965–970, 2011. View at Google Scholar

Edem D.O, Amugo, C.I., Eka, O.U, 1990. Chemical composition of yam bean (Sphenostylis stenocarpa). Tropical Science, 55:215-219. (30:59-63).

Elsie Balafama Banigo, David Barine Kiin-Kabari. Effect of African Yam Bean (AYB) (*Sphenostylis stenocarpa*) on the Quality Characteristic of Extended Meat Ball. *Journal of Food and Nutrition Research*. Vol. 4, No. 2, 2016, pp 121-125. http://pubs.sciepub.com/jfnr/4/2/9

Emiola IA (2011). Processed african yam bean (*sphenostylis stenocarpa*) in broiler feeding performance characteristics and nutrient utilization. J. Environ. Issues Agric. Dev. Ctries 3(3):123- 131.

Emiola IA, Ologhobo AD (2006). Nutritional assessment of raw and different processed Legume seed in Broiler ration. J. Anim. Vet. Adv. 5(2):96-101.

Fasoyiro S.B, Ajibade S.R, Omole A.J, Adeniyan O.N and Farinde E.O (2006). Proximate, mineral and antinutritional factors of some underutilized grain legumes in south-western Nigeria, Nutrition Food Sciences, 36:18-23.

Hussein, T., Urge, M., & Animut, G.(2016). Effect of replacing soybean meal (Glycine max) with kidney bean (Phaseolus vulgaris) on egg quality parameter of white Leghorn layers. International Journal of Livestock Production, 7(6), 33-40.

James, C. S. Analytical Chemistry of Foods, Chapman & Hall, New York, NY, USA, 1st edition, 1995

Kine BB, Eka OU, Aremu cy, Ifon ET, (1991). Chemical evaluation of the nutritive value of African yam bean (*Sphenostylis stenocarpa*). Tropical journal of Applied Science 1:99-102.

Kumar, V., Abbas, A. K., & Aster, J. C. (2013). Robbins basic pathology (9th ed.). Saunders, Canada

Kumar R, (1992). Anti-nutritional factors, the potential risks of toxicity and method to alleviate them. Proceedings of the FAO expert consultation held at the Malaysian Agricultural Research and development Institute (MARDI) in Kuala Lumpur, Malaysia, 14th -18th October 1991. Andrew Speedy and Pierre-Luc Puglise (eds).

Leyva, J.A.M. Artiga, M.P.H. Méndez, M.M.A. and Pér, J.J.Q. “Atomic absorption and UV-VIS absorption spectrophotometric determination of oxalate in urine by ligand exchange extraction,” Clinica Chimica Acta, vol. 195, no. 1-2, pp. 47–56, 1990. View at Publisher · View at Google Scholar

Liday (2013). Protein from land plants potential resources for human nutrition and food security. *Trend in Food Science and Technology*, 32:25-42.

Moyib O.K, Gbadegesin M.A, Aina O.O, Odunola O.A (2008). Genetic variation within a collection of Nigerian asccessions of African yam bean (*Sphenostylis stenocarpa*) revealed by RAPD primers. Afr. J. Biotechnol, 7(12): 1839-1846.

Nalle CL, Ravindran V, Ravindran G (2010). Evaluation of favba beans, white lupins and peas as protein source in broiler rations. Int. J. Poult. Sci. 9 (6):567-573.

Nwinuka NM, Abbey BW, Ayalogu EO (1997). Effect of processing on flatus producing oligosaccharides in cowpea (Vigna unguiculate) and the tropical African yam bean (*Sphenostylis stenocarpa*). Pl Food Hum Nutri, 51: 209-218.

Nwokolo E. 1987. A nutritional assessment of African yam bean (*Sphenostylis stenocarpa*, Hoechst. Ex.A. Rich. Harms.) and bambara groundnut (Voandzeia subterranean L.) Journal of science, food and agriculture 41: 123-129.

Oboh HA, Muzquiz M, Burbano C, Cuadrado C, Pedrosa MM, Ayet G, Osagie AU (1998). Anti-nutritional constituents of six underutilized legumes grown in Nigeria. J. Chromato 82: 307-312.

OECD-FAO (2010). OECD and Food and Agriculture Organization of the United Nations. OECD-FAO Agricultural book Outlook 2010. OECD Publishing. pp. 147-158

Ojiako, O.A. Ogbuji, C.A. Agha, N.C. and Onwuliri, V.A. “The proximate, mineral, and toxicant compositions of four possible food security crops from Southeastern Nigeria,” Journal of Medicinal Food, vol. 13, no. 5, pp. 1203-1209, 2010. View at Publisher · View at Google Scholar ·View at Scopus

Okeola O.G, Machuka J (2001). Biological effects of African yam bean. Lectin on clavigralla tomentosicollis (Hemiptera: coreidae), J. Econ Ent, 94:28-34.

Oke M.O, Sobowale S.S and Ogunlakin G.O (2013). Evaluation of the effect of processing methods on the nutritional and anti-nutritional compositions of two under-utilized. Nigerian grain lugumes. *Pakistan Journal of Biological Sciences*, 16, 2015-2020.

Pugalenthi, M. V. Vadivel, P. Gurumoorthi, and K. Janardhanan, “Comparative nutritional evaluation of little known legumes, Tamarindus indica, Erythrina indica and Sesbania bispinosa," Tropical and Subtropical Agroecosystems, vol. 4, no. 3, pp. 107–123, 2004.

Reddy, N.R. Sathe, S.K. and Salunkhe, D.K. "Phytates in legumes and cereals, "Advances in Food Research, vol. 28, pp. 1–92, 1982. View at Publisher · View at Google Scholar

Sisay FM, Mengistu UL, Getachew A (2014). Effects of replacing soybean meal with processed kidney bean meal (Phaseolus vulgaris) on egg production of white leghorn hens. World Appl. Sci. J. 32(9):1918-1926.

Sisay FM, Mengistu UL, Getachew A (2015b). Effects of Replacing Soybean Meal with Processed Kidney Bean Meal (Phaseolus vulgaris) on egg fertility and chick quality of White Leghorn Hens. J. Adv. Vet. Anim. Res. 2(2):146-152

Sugano M, Goto S, Yaoshida K, Hashimoto Y, Matsno T, Kimoto M (1993). Cholesterol-lowering activity of various undigested fractions of soyabean protein in rats. J. Nutr. 120(9): Pp 977-985.

Uche Samuel Ndidi, Charity Unekwuojo Ndidi, Abbas Olagunju, Aliyu Muhammad, Francis Graham Billy, and Oche Okpe. Proximate, Anti-nutrients and Mineral Composition of Raw and Processed (Boiled and Roasted) *Sphenostylis stenocarpa* Seeds from Southern Kaduna, Northwest Nigeria ISRN Nutrition Volume 2014 (2014), Article ID 280837, 9 pages http://dx.doi.org/10.1155/2014/280837

Uguru M.I and Madukaife S.O (2001). Studies on the variability in agronomic and nutritive characteristics of African yam bean (*Sphenostylis stenocarpa* Hochst ex. A.Rich. Harms). *Plant Production and Research Journal*, 6, 10-19.

Vadivel V. and Janardhanan, K. "Nutritional and anti-nutritional attributes of the under-utilized legume, Cassia floribunda Cav.," Food Chemistry, vol. 73, no. 2, pp. 209–215, 2001. View at Publisher · View at Google Scholar · View at Scopus.