Direct Research Journal of Agriculture and Food Science
Vol. 10(10) Pp. 241-247 October 2022
ISSN 2354-4147
DOI: https://doi.org/10.26765/DRJAFS40367884
Article Number: DRJAFS40367884

Full Length Research Paper

Comparative Study on the Proximate Composition of the Main African Legumes

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Received 13 August 2022; Accepted 28 September 2022; 1 October 2022

ABSTRACT: Nigeria's rising population necessitates the study of underutilized legumes, particularly those that can adapt to our challenging environmental conditions and have high disease and pest resistance. Leguminous crops have a reputation for providing a good source of protein, vitamins, and minerals. It is claimed that a grain legume has a protein content that is two to three times higher than that of a grain cereal. To shed light on their potential as food sources for a larger population in the nation, this study examined the nutritional profile of Ethiopian lima beans and other legumes found in Nigeria. Comparing the proximate composition of Ethiopian Lima Bean with indigenous pulses (Common Bean (Phaseolus vulgaris L.), 'Akidi' (Vigna unguiculata unguiculata), Groundnut, (Arachis hypogaea L.), Asparagus Beans – Foi Foi (Vigna sesquipedalis), and Bambara groundnut – Okpa (Vigna subterrenea L.)), protein content was respectively Akidi (31.25 %), Okpa (27.15 %), Asparagus bean (21.70 %), Lima bean (20.17 %), Common bean (17.70 %) and Groundnut (12.81 %). Vignea subterranean (Okpa) and Akidi (Vignea unguiculata unguiculata) had the highest protein content among the sampled underutilized legumes 27.15 % and 31.25 % of dry matter which was significantly different ($p<0.05$) from other samples. Based on our findings, we conclude that the nutritive value of common bean seeds from Nigeria can be regarded as a good source of energy, even though Nigeria Akidi and Bambara groundnut (Okpa) seeds are the richest sources of protein among underutilized legumes and, if improved, will provide quality nutrition in Nigeria and Africa as a whole. Ethiopia Lima bean seeds, despite being a good source of protein and carbohydrates with little fat, have the highest moisture content, exposing them to high perishability, a significant disadvantage for legume production.

Keywords: Indigenous pulses, high perish-ability, under-exploited legumes, daily consumption, global production

INTRODUCTION

The developing world is still battling with the challenge of food production and preservation coupled with problems of producing food with right nutritive value to meet daily consumption. Nwosu, (2010), mentioned the measure by which the world has stressed on the role of beans in population diet especially in countries where protein is deficient and the ongoing promotion in research involving various species and aspects of beans consumption. The increasing population growth in Nigeria, calls for a focused research directed towards the study of underexploited legumes especially those that could adapted to our adverse environmental conditions with high resistant to disease and pest (Ade-Omowaye *et al.*, 2015). Leguminous crops have been known for its

supplies of energy, vitamins and mineral as well as its protein supply. A grain legume is stated to be 2-3 times richer protein wise than its grain cereal counter parts (Usensi *et al.,* 2011). Although grain legumes are recognized cheap source of protein to the poor countries of the world Nigeria inclusive, it can be stored easily, and its transportation to both rural and urban settlements can be done in its unprocessed forms (Ndidi *et al.,* 2014). Lima Bean (*Phaseolus lunatus*) is considered as a minor legume, with other legumes in FAOSTATA bringing about its negligence in global production (Baudoin, 2006). Records showed that Lima Bean production in African, is about 120,000 to 200,000 ha of around the sub-humid and humid areas of Sierra Leone, Liberia, Cote d"Ivoire, Ghana, Nigeria and DR Congo (Nwokolo, 1996). Nigerian when producing Lima Bean produces it solely for its dry seeds and consumption with only 4% of the land area devoted for its production and no attention for its improvement technically and otherwise. Knowledge of this bean is very poor among academia, and peasant farmers. A few that have knowledge of the crop usually intercrop it with cassava, yam, cocoyam and pepper because of it nitrogen-fixing ability (Saka, *et al.,* 2004 and Akande and Balogun, 2007). Therefore, underutilization of this Lima Bean is highly pronounced (Yellavila, *et al*., 2015 and Farinda *et al.,* 2018). A hundred grams seed of Lima contains 338 calories with a daily recommended protein intake of 21.46 g (38%). Groundnut, although one of the oil crops but has high quality dietary protein and has solved the problem of malnutrition in the developing countries (Asibuo *et al.,* 2008). 31 states out of the 37 states in Nigeria grows groundnut with FCT, Kano and Niger state accounting for about 19.6% and 10.7%, respectively followed by Kaduna, Benue, Zamfara, Taraba, Bauchi, Borno, Katsina, and Nasarawa, with over 80% of the total area of groundnut production covering 10 states in Nigeria (Abate, 2011). As a Brazilian crop introduced into West Africa solely for the amount of oil it produces groundnut became a replacement to Bambara groundnut (Mayes *et al.,* 2009). The Black turtle beans also known as Akidi in the Eastern Nigeria is a member of the Fabaceae family. An annual herbaceous plant usually cultivated for its fruit edibility which could be either in a dried seed form or in its unripe fruit state (Ikezu *et al.,* 2015). Sampling akidi flours, the proximate composition of the different 'akidi' flour sampled should a result revealing that the protein content of 'akidi' was 22.8% for both whole and dehulled, while boiling reduced the protein content to 18.3%. Fat content of 'akidi' was found to be slightly lower in whole sample (1.5%) than in the processed samples (1.7%), may be due to the utensils used in processing. Fiber content was reduced on processing from 2.2 % for whole to 1.3% and 1.2% for dehulled and boiled, respectively. 'Akidi' seed was found to be low in magnesium, potassium, sodium and calcium but contains appreciable amount of iron (14.6). *Vigna subterranea* L. (Bambara groundnut) is a pulse known to possess a subterranean fruit set with a high carbohydrate content of about (65%) and relatively high protein (18%) content (Ndidi *et al*., 2014). Among all the food that *V. subterranean* is processed into, Okpa by the Igbo's in the South Eastern region of Nigeria is used in making a doughy paste usually wrapped and steamed in banana leaves or aluminum foil is the always the Igbo man choicest food. Asparagus bean (*Vigna sesquipedalis*) also known as "akidi Oji or Foi Foi" in the Igbo speaking regions usually used in making if "moi moi". It is an annual vegetable that belongs to the leguminous family and sub–family of papilonaceae. The bean is mostly grown in far East, mostly for its immature pods. It is eaten in many part of Eastern Nigeria like Anambra and Enugu states. Asparagus beans are vital food resources which contribute to the nutritional wellbeing of humans. These products provide essential nutrient and high level of protein with moderate level of energy and dietary fibre. Asparagus bean is believed to be very rich in protein and low in carbohydrate. The starch or carbohydrate component of Asparagus bean is not as significant as widely believed (Nwosu, 2010). It is also said that its major nutrients are protein and carbohydrate with its variability in protein influenced by genotype as well as environmental factors (Bliss, 1975). Common bean *(Phaseolus vulgaris* L.*)* one of the traditional foods of mankind, has low fat and very rich in proteins, vitamins, complex carbohydrates, and minerals. Among all the nutritional contribution of common bean, its consumption in dried form is been associated with reduction of risk of heart disease (Anderson *et al.,* 1984), and cancer (Geil and Anderson, 1994). According to Mesquita and Giada (2005) ash content ranged between 3.7 and 3.8% for ash content in common beans seed. A Mexican researcher Carmona-Garcia *et al.* (2007), reported its ash content as 3.79 and 4.54%. Carbohydrates in common beans was 67.9% (Mesquita and Giada, 2005), while 43.5% was reported by Carmona-Garcia *et al.* (2007). Groundnut as a grain legume is highly recommended in human nutrition, and its contribution as regards to protein intake is outstanding. Grain proteins is said to contain relatively more amino-acids lysine and tryptophan, and so usefully complement the amino-acids supplied by cereals in which the contents of lysine and tryptophan are relatively minute. The peanut, or groundnut *(Arachis hypogaea),* is a species in the legume Fabaceae has its nativity from South America, Mexico and Central America. It is an annual herbaceous plant. Groundnuts also known as peanut, earthnuts, goobers, goober peas, pindas, jack nuts, pinders, manila nuts, cockesnuts, and monkey nuts grows best in light, sandy loam soil. They require five months of warm weather, and an annual rainfall or the

equivalent in irrigation water. Poor storage of peanuts can lead to an infection by the mold fungus Aspergillus flavus, releasing the toxic substance aflatoxin. The aflatoxin-producing molds exist throughout the peanut growing areas and may produce aflatoxin in peanuts when conditions are favorable to fungal growth, damage in storage can be avoided only by maintaining the moisture content or the temperature or both at level so fungi cannot grow. Nutritionally, legume seeds are esteemed for their advantages which include high crude protein content, and nitrogen fixation. They display low lipid contents and are free of cholesterol with many other minerals and vitamin in place. Legumes can also serve as a quality source of complex carbohydrates to all animals especially monogastrics (Sebastiá *et al.,* 2001; Deka and Sarker, 1990; Kandelwal *et al.,* 2009; Elhardallou and Walker, 1994). Therefore, the aim of this present study was to evaluate the nutritional profile of Ethiopian Lima Bean and other legumes found in Nigeria to provide enlightenment on their potential as food sources for a wider populace in the country.

MATERIALS AND METHODS

Sources of materials

1 kg of Lima Bean seeds (*Phaseolus luntus*) collected from Ethiopia Biodiversity Centre, and 1 kg samples of the Common Bean (*Phaseolus vulgaris* L.), 'Akidi' (*Vigna unguiculata unguiculata*), Groundnut, (*Arachis hypogaea* L.), and Bambara nut (*Voandzeia subterrenea*) seeds where bought from Nkwogbe Market, Ihiala Local Government Area. The research was carried out from January to February, 2021.

Processing of the legume samples

Processing of the Legume seeds was carried out at Springboard Research Laboratory, Awka, Anambra State, Nigeria. The seeds were ground to flour using a Wiley Mill with the 0.5 mm mesh sieve and stored at –4°C until analysis.

Determination of moisture content

2 g of each of the sample was weighed into dried weighed crucibles. The sample was put into a moisture extraction oven at 105°C and heated for 3h. The dried sample was put into desiccators, allowed to cool and reweighed. This process was repeated until a constant weight is obtained. The difference between the weight was calculated a % of the original sample.

$$\% \text{ moisture} = \frac{W2 - W3 \times 100}{W2 - W1}$$

Where
W1 = Initial weight of empty dish
W2 = Weight of dish + undried sample
W3 = Weight of dish + dried sample.

Determination of crude lipid

Crude lipid content was assayed by extraction with petroleum ether (b.p. 40-60°C) in a Soxhlet extractor (AOAC, 2005).

Determination of total nitrogen

Total nitrogen (N) was determined by the standard micro-Kjeldahl method (AOAC, 2005) using a digestion apparatus (Kjeldatherm System KT 40, Gerhardt Laboratory Instruments, Bonn, Germany) and a titration system (T110-TR160-TA-TM120, Schott-Geräte GmbH, Hofheim, Germany). Germany)

Determination of crude fat

Crude fat was determined by Solvent extraction method AOAC (2005). Juice powder (10g) and dried powdered mushroom (10 g) were weighed into 3 different beakers and 50ml petroleum ether was added to each of the beakers and left for 1 h in the fume cupboard and swirled every now and then. The petroleum ether was then decanted into an empty petri dish and allowed to evaporate, this process was repeated for the other 2 samples. The petri dishes were weighed after evaporation and the weight of fat was calculated. The % of crude fat content was also calculated:
Weight of fat = Weight of petri dish after evaporation – weight of empty petri dish

Determination of crude fiber

Total amount of Fiber was determined using AOAC method (2005). The defatted samples were weighed and put into a flat bottom flask and H_2SO4 (50 mL) was added and the mixture was boiled for 30 min after which it was sieved and washed with distilled water and put back into the flat bottom flask. KOH (50 mL) was added to the residue and the mixture was boiled for another 30 min, sieved and washed with distilled water. The residue was put into a beaker containing 10 ml of acetone and left for 20 min and then filtered. The samples were dried in the oven for 30 min at 130^{o}C. The difference in the weights (Wa - Wb) represents the weight of crude fiber.

$$\text{Crude Fiber (\%)} = \frac{w3 - w2}{w1}$$

Where
w3= Weight of filter paper and sample after heating;

w2= weight of filter paper;
w1= Weight of defatted sample

Determination of total carbohydrate

The Total Carbohydrate was determined by difference method AOAC (2005). It was calculated with the following equation:

Crude Carbohydrate (%) = [100 − (% Total moisture + % Crude protein + % Crude fat + % Crude fiber + % Total ash)]

Determination of total ash

Total amount of fiber was determined by using AOAC method (2005). Residues from the crude fiber were weighed into porcelain crucibles which were previously ignited and weighed. The crucible was placed in a muffle furnace and maintained at 55 ºC for 6 h. It was then cooled in a desiccator until ash is obtained, weighed and the ash content was calculated following AOAC (2005).

Determination of crude protein

Crude proteins content was calculated by multiplying % N by factor 6.25.

Energy valve determination

The energy value was calculated based on their content of crude protein, fat and carbohydrate as follows:
Energy value (kcal/100 g) = (2.62 x %protein) + (8.37 x %fat) + (4.2 x % carbohydrate) (Crisan and Sands, 1978)

Statistical analysis

Data were subjected to Analysis of variance (ANOVA) and means were separated using with Duncan Multiple range test using SAS (2018 version 9.3). Significance was accepted at $P \leq 0.05$ level of probability.

RESULTS

Comparing the proximate composition of Phaseolus lunatus with other indigenous legumes like Common Bean (*Phaseolus vulgaris* L.), 'Akidi' (*Vigna unguiculata unguiculata*), Groundnut, (*Arachis hypogaea* L.), Asparagus Beans – Foi Foi (*Vigna sesquipedalis*), and Bambara groundnut – Okpa (*Vigna subterrenea* L.), (Table 1 and Figure 1).

DISCUSSION

Ade-omowaye *et al.* (2014) reported crude protein content in underutilized *Vignea subterranean* to range from 18.3 and 24% which is similar to the result reported in this present work. *Vignea subterranean* (Okpa) and Akidi (*Vignea unguiculata unguiculata*) has the highest protein content among the sampled underutilized legumes 27.15 % and 31.25 % of dry matter which was significantly different ($P<0.05$) from other samples. Udensi *et al.* (2011), reported similar proximate composition as this on the legume *Vigna unguiculata unguiculata* as well as the protein content of brown asparagus beans as similar to these findings in the study. Crude Protein in common beans seed ranged between 17.0 and 39.4% (Monti and Grillo, 1983), while 15.9 and 20.9% was reported by Mesquita and Giada (2005). A study by Yoshida *et al.* (2005) reported that crude protein was 21.4 and 23.1% which is similar with the protein content of common bean in this work. Moisture, ash, protein, and carbohydrate of Bambara groundnut as reported in this work is similar with that as reported by Ndidi *et al*. (2014). Ash content in this work is similar to the report of Giada (2005), who reported a range for ash content between 3.7 and 3.8% in common beans seed and Carmona-Garcia *et al. (*2007) who reported 3.79 and 4.54% in common beans from Mexico. Ash content in Akidi and groundnut seeds with dry matter values of 9.09 and 3.63 % was significantly different ($P<0.05$) from other samples. Results on carbohydrate content 67.14 % similar to Mesquita and Giada, (2005) report. Carbohydrate content of the samples varied from 43.07 to 60.30 %. Common bean has the highest carbohydrate content while groundnut has the lowest carbohydrate content. Analysis of variance (ANOVA) showed that samples are non-significant ($P>0.05$) shown in Table 1. According to Ihekoronye and Ngoddy, (1985) and Adeyanju and Abimbola, (2015) hydrophilic groups in carbohydrate molecules caused it to take up moisture in proportion to the relative humidity of the environment. This characteristic behavior encouraged moisture uptake and apparent reduction in % of carbohydrate. One advantage Lima bean has over other legumes is its fat free quality of protein (Laro and Rafael, 2001). It has high fibre content as well as serves as a very good sources of cholesterol-lowering fibre therefore can be used to mainatin blod sugar levele (Obiakor-Okeke, 2009). Agugo *et al.* (2013), commended *Vigna unguiculata unguiculata* (Akidi) seed as a low anti nutritional factors legume with a potentiality to serve as good sources of protein, energy and iron when adequately consumed. Sampling akidi flours, the proximate composition of the different 'akidi' flour sampled should a result revealing that the protein content of 'akidi' was 22.8% for both whole and dehulled, while boiling reduced the protein content to 18.3%.

Table 1: Proximate composition (% dry matter) of Lima Bean (*Phaseolus lunatus*), Common Bean (*Phaseolus vulgaris* L.), 'Akidi' (*Vigna unguiculata unguiculata*), Groundnut, (*Arachis hypogaea* L.), Asparagus Beans – Foi Foi (*Vigna sesquipedalis*), and Bambara groundnut – Okpa (*Vigna subterrenea* L.)

	Moisture (%)	Ash (%)	Fibre (%)	Protein (%)	Carbohydrate (%)	Fat (%)	Energy (kcal/100 g)
"Akidi"	5.45 ± 0.05ab	9.09 ± 0.09ac	2.59 ± 1.50dc	31.25 ± 0.25ac	51.37 ± 0.37ac	0.08 ± 0.00d	300.34 ± 0.34a
Asparagus Beans	6.04 ± 0.04 b	5.44 ± 0.02abc	2.16 ± 1.93abcd	21.70 ± 0.70bc	60.30 ± 0.30dc	1.27 ± 0.07e	323.25 ± 1.25b
Groundnuts	2.67 ± 0.11c	2.20 ± 0.20ac	0.22 ± 0.01a	12.81 ± 0.14cd	43.07 ± 0.07bc	38.23 ± 0.23ae	538.59 ± 1.41e
Common Bean	7.42 ± 0.42 c	3.63 ± 0.05cd	1.62 ± 0.12abcd	17.70 ± 0.15af	67.14 ± 0.64c	1.04 ± 0.04ef	2901.31 ± 1.31c
Okpa	5.27 ± 0.03d	3.85 ± 0.05b	0.46 ± 0.02ef	27.15 ± 0.15bc	58.48 ± 0.08b	4.09 ± 0.09ac	351.98 ± 0.55d
Lima Bean	14.27 ± 0.03f	4.09 ± 0.01e	6.88 ± 0.08abc	20.17 ± 0.07cd	52.63 ± 0.13ac	1.38 ± 0.08bcd	286.45 ± 0.45f

Each value is an average of two replications determinations ± standard error. Means with the same letter along the same column are not significantly different (P>0.05).

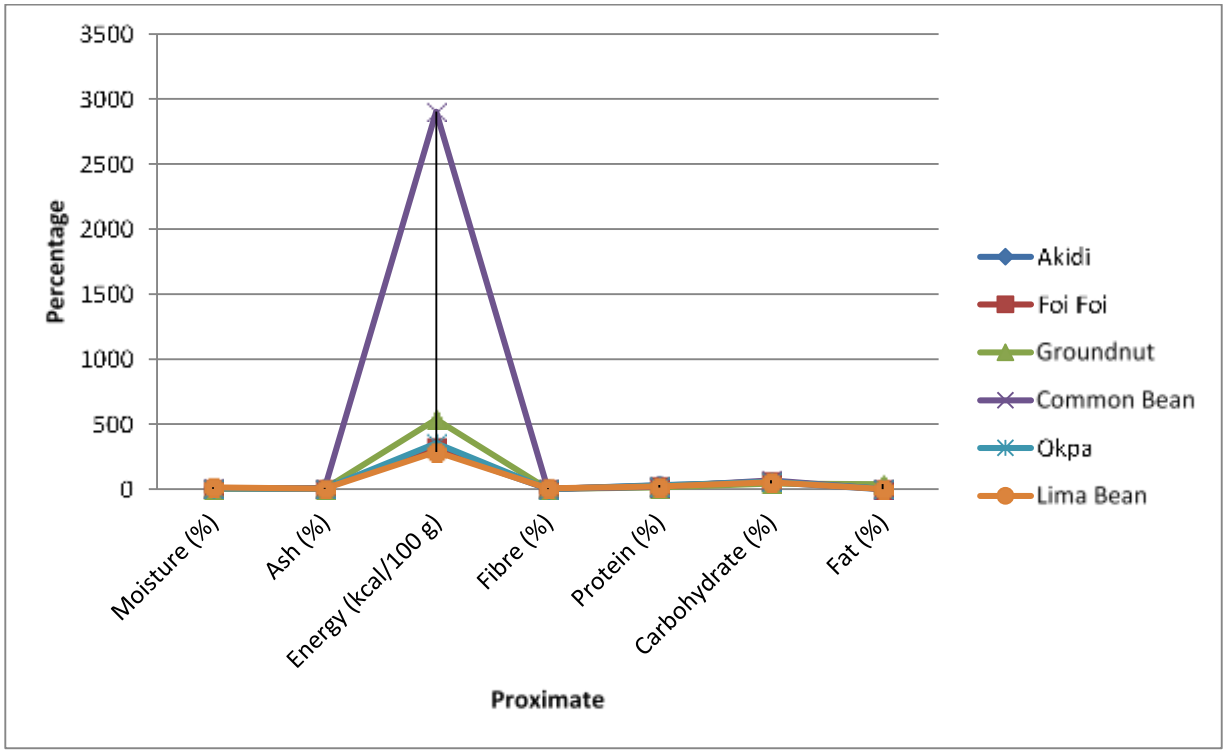

Figure 1: Showing Comparative Proximate Composition of Legumes Lima Bean (*Phaseolus lunatus*), Common Bean (*Phaseolus vulgaris L.*), 'Akidi' (*Vigna unguiculata unguiculata*), Groundnut, (*Arachis hypogaea* L.), Asparagus Beans – Foi (*Vigna sesquipedalis*).

Its moisture content was in its highest when boiled and at its lowest moisture content when dehulled and this could be due to the treatment applied when drying. Like many other legumes, asparagus beans are important source of dietary protein which complements proteins obtained from cereals. Nnayelugo *et al. (1995) and* Nwosu (2010), stated the chemical composition of Asparagus bean to contain about 23% protein, 62% carbohydrate and minute amount of other nutrients. Report on common beans seed crude protein ranged between 17.0% and 39.4% (Monti and Grillo, 1983), while 15.9 and 20.9% was reported by Mesquita and Giada (2005). Yoshida *et al.* (2005) in their report, stated its crude protein as 21.4 and 23.1%. Crude fiber was 8.55% as reported by (Mesquita and Giada, 2005), 16.4% as reported by Carmona-Garcia *et al.* (2007), while 22.2% was reported by Kahlon *et al*. (2005). Ether extract was found to range between 1.26 and 22.2% (Mesquita and Giada, 2005), a range between 1.26 and 2.49% was reported by De Almeida Costa *et al.* (2006). A range between 1.98 — 2.12% was reported by

Carmona-Garcia *et al.* (2007). Fasoyiro *et al*. (2006) in their research where proximate analysis of some underutilized grain legume in south-western Nigeria is compared crude protein in the legumes was in the range of 22–37%, crude fat 1.47–4.96%, crude fibre 1.92–7.21% and ash 3.33–5.61% a similar result as this masterpiece.

Conclusion

This work has enabled us to conclude that the nutritive value of common beans seeds from Nigeria can be considered as a good source of energy while Nigeria Akidi and Bambara groundnut (Okpa) seeds are the richest sources of protein among the under-utilized legumes and it is expected that this will aid to fight the ranging war against malnutrition as regards to protein – calorie, malnutrition and will bring about quality nutrition and health in Nigeria and Africa as a whole if enhanced. Ethiopia Lima bean seeds although one of the good sources of protein, and carbohydrate with minimal fat has the highest moisture content which will expose it to high perishability a great disadvantage for the legume production.

Data availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of interest

The author declares no conflicts of interest regarding to publication of these work.

Acknowledgments

The authors appreciate the effort of Dr. Ukpah, Chukwujekwu, J. for assistance and his encouragement in seeing that this research was conducted. This research was sole funded by the authors and no organization will take credit of funding this research work.

REFERENCES

Ade-Omowaye, B.I.O., Tucker, G. A. and Smetanska, I. (2015). Nutritional potential of nine underexploited legumes in Southwest Nigeria. *International Food Research Journal*. 22(2): 798-806.

Adeyanju J. A., and Abimbola A. O. (2015). Some Engineering and Chemical Properties of Cooked Bambara Groundnut. *Donnish Journal of Food Science and Technology.* 1(3): 022 – 026. http://www.donnishjournals.org/djfst

Agugo, U. A, Okere, T. O and Anya, K. M. (2013). Investigating the nutrient composition and anti-nutritional factors of 'Akidi' (*Vigna unguiculata unguiculata*). *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT). 5(4):32-35. www.Iosrjournals.Org. e-ISSN: 2319-2402, p- ISSN: 2319-2399.*

Anderson, J. W., Story, L., Sieling, B., Chen, W. J., Petro, M. S., and Story, J. (1984). Hypocholesterolemic effects of oat-bran or bean intake for hypercholesterolemic men. *American Journal of Clinical Nutrition;* 40:1146-55.

Bliss, F.A. (1975). Cowpea in Nigeria. In: *proceedings of a symposium on Nutritional improvement of Legumes by breeding* 3- 5 July 1975 New York, United Nations, proteins Advisory Group 1975: 71- 82.

Carmona-Garcia R., Osorio-Diaz P., Agama-Acevedo E., Tovar J., & Bello Perez L.A. (2007). Composition and effect of soaking on starch digestibility of *Phaseolus vulgaris* (L.) cv., 'Mayocoba'. *International Journal of Food Science and Technology., 42*, 296-302.

Deka, R. K. and Sarkar, C.R. (1990). Nutrient composition and anti-nutritional factors of *Dolichos lablab* L seeds. *Food Chemistry*. *38*: 239-246.

Elhardallou, S. B., and Walker, A. F. (1994). Phytic acid content of three legumes in the raw, cooked and fibre forms. *Phytochemical Analysis*, 5:243-246.

Fasoyiro, S.R., Ajibade, A.J. Omole, O.N. Adeniyan and Farinde, E.O. (2006). Proximate, minerals and antinutritional factors of some underutilized grain legumes in south-western Nigeria*, Journal of Institute of Agricultural Research and Training,* ObafemiAwolowo Universi*ty*, P.M.B 5029, Moor-Plantation, Ibadan, Nigeria *Nutrition and Food Science,* 36(1),18-23.

Geil, P. B., and Anderson, J. W. (1994). Nutrition and health implications of dry beans: a review. J. Am Coll. *Nutrition*; 13(6): 549-558

Ihekoronye, A. L., and Ngoddy, P. O. (1985). Integrated Food Science and Technology for Tropics, Macmillan Publishers London.

Kandelwal, S., Udipi, S.A. and Ghugre, P. (2009). Polyphenols and tannins in Indian pulses: Effect of soaking, germination and pressure cooking. *Food Research International* (2009): Article in press, available on line journal homepage: www.elsevier.com/locate/foodres.

Mayes, S., Basu, S., Murchie, E., Roberts, J. A., Azam-Ali, S. N., Stadler, F., Mohler, V., Wenzel, G., Massawe, F., Kilian, A., Bonin, A., Beena, A., and Sheshshayee, M. S. (2009). BAMLINK—a cross disciplinary programme to enhance the role of bambara groundnut (*Vigna subterranea* L. Verdc.) for food security in Africa and India. *Acta Horticulture*. https ://doi.org/10.17660 /actah ortic .2009.806.15

Mesquita, V. L. V., and Giada, M. L. R. (2005). Organic-mineral content of the main Brazilian cereals and legumes. *Nutrition in Food Science, 35(4),* 264-270

Monti, L. M., and Grillo, S. (1983). Legume seed improvement for protein content and quality. *Qual. Plant Foods Hum. Nutr., 32*, 253-266.

Ndidi, U. S., Charity, U. N., Idowu, A. A., Obed, Y. B., Mary, M., and Zainab, A. (2014). Effects of Processing (Boiling and Roasting) on the Nutritional and Antinutritional Properties of Bambara Groundnuts (*Vigna subterranea* L. Verdc.) from Southern Kaduna, Nigeria. Hindawi Publishing Corporation Journal of Food Processing. 472129:1-9

Nnayelugo, S. O., King, J., Ene-Obong, H. N, Ngoddy, P. O. (1995). Seasonal variations and the contribution on cowpea (*Vigna unguiculata*) and other legumes to nutrient intake in Anambra state, Nigeria. *Ecology Journal of Food Nutrition*. (17): 271- 287.

Nwokolo, E. (1996). The need to increase consumption of pulses in the developing world. In: Nwokolo, E., Smartt, J. (Eds.), Food and Feed from Legumes and Oilseeds. Chapman and Hall, London, pp. 3-11.

Nwosu, J. N. (2010). The Effects of Steeping with Chemicals (Trona and Alum) on the Functional Properties and Proximate Composition of Asparagus Bean (*Vigna sesquipedalis). Nature and Science. 8(9):1-10.*

Obiakor-Okeke, P. N. (2009). Effects of Processing Technique on Chemical, Functional and Microbial Properties of two varieties of Lima Bean (Phaseolus Lunatus) and Maize (Zea Mays) Flours and Sensory Properties of Their Products. A Thesis Submitted to the Department of Home Science, Nutrition and Dietetics, Faculty of Agriculture, Univeristy of Nigeria, Nsukka 2 (6):168-172. doi:

10.11648/j.jfns.20140204.21.
SAS, (2018). Statistical Analysis System Institute Inc. User guide Statistic Version. 9.3th Edn, Carry, North Carlina, USA Sebastia, V., Barbera, R., Farre, R. and Lagarda, M. J. (2001). Effects of legume processing on calcium, iron and zinc contents and dialysabilities. Journal of Science Food and Agriculture, 81: 1180-1185.
Sebastiá, V., Barbera, R., Farre, R. and Lagarda, M. J. (2001). Effects of legume processing on calcium, iron and zinc contents and dialysabilities. Journal of Science Food and Agriculture, 81: 1180-1185.
Udensi, O., Umana, E. J., Edu, E. A., and Ikpeme, E. V. (2011). Screening Locally Grown Pulses for Proximate, Anti-nutritive and Mineral Compositions: Indices for Conservation and Improvement. *International Journal of Agricultural Research.* 6(6):504-510.
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): 69-94.
Yoshida, H., Tomiyama, Y., Kita S., and Mizushina, Y. (2005). Lipid classes, fatty acid composition and triacylglycerol molecular species of kidney beans (*Phaseolus vulgaris* L.). *European Journal of Lipid Science and Technology.107*, 307-315.