International Journal of Science and Advanced Innovative Research
ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 5, Number 2, June 2020
http://www.casirmediapublishing.com

THE PROXIMATE AND ANTI – NUTRIENT COMPOSITION OF AFRICAN OIL BEAN (*Pentaclethra macrophylla Benth*) SEED AT DIFFERENT MATURATION STAGES AND BOILING PERIODS

Duru, F.C, Ohaegbulam, P.O & Nwachukwu, C. A.
Department of Food Technology
Federal Polytechnic Nekede, Owerri, Imo – state
Email: durufaustina@gmail.com

ABSTRACT

The proximate and anti-nutrient composition of African oil bean seed at different maturation stages and boiling periods were investigated. The two months developed pods were harvested and seeds extracted with matchet, while the fully mature (exploded) seeds were picked from the surrounding bushes. Each of the seeds were boiled at different periods (4 h, 5 h, and 6 h) and blended differently than analyzed. The results of the proximate analysis indicate the moisture range of (33.76 - 42.28%) with exploded seed boiled for 6 hours having the highest (42.28%) and same exploded seed boiled for 4 hours having the lowest moisture content. The protein content was higher (25.65%) in two months developed seed boiled for 4 hours, while the ash content of two months developed seeds boiled for 5 hours was higher (1.24%) than others. The fat content of exploded seeds boiled for 4 hours were highest (11.50%) followed by two months developed seeds boiled for 4 hours (10.27%); the crude fibre values were highest (25.75%) in two months developed seed boiled for 6 hours and carbohydrate was highest in two months seed boiled for 5 hours. The result of the anti-nutrients showed that exploded seed boiled for 6 hours had the lowest (2.73%) phytic acid, while oxalate was lowest (2.28%) in two months developed seed boiled for 6 hours. Saponin was lowest (1.28%) in exploded seeds boiled for 6 hours and tannin content were lowest (0.56%) in 6 hours boiled exploded seeds.
Keywords: Proximate, Anti-nutrient, African oil bean seed, Maturation stages.

INTRODUCTION

The African oil bean tree (*Pentaclethra macrophylla Benth*) is one of the indigenous forest fruit trees in Nigeria. It belongs to the family of *Leguminosae*, and the tree can attain a height of about 21m and up to 6m in girth (Keay, 1989).

African oil bean tree thrives in the eastern and southern parts of Nigeria, where it is known by several names, such as 'Ugba' or 'Ukpaka' in Igbo for the seed as well as the fermented product; "Apara" in Yoruba and "Ukana" in Efik-speaking southern Nigeria (Enujiugha and Akanbi, 2005).

The main flowering seasons is between March – April with smaller flushes in June and November. Seeds are available at most periods of the year because the large woody pods are persistent. The pods are 40 – 50cm long and 5 – 10cm wide; and at maturity splits open explosively dispersing the seeds with the valves curling up. This is the form in which they appear on most trees. Usually, pods contain between 6 – 10 flat glossy brown seeds which may vary in size. The seeds which are up to 7cm long are the edible products and source of the oil hence the name "the oil bean tree" (NFT, 1995).

The seeds are composed of up to 44% proteins with all 20 essential amino acids, essential fatty acids, minerals and phytochemicals (Joker and Salaza, 2000).

Mears and Mabry (1981) reported that the unfermented seeds are bitter to taste and contain toxic alkaloids and saponins. Oboh (2007) reported that the seeds contain the growth-retardant alkaloid, Paucine (Caffeoyl – putrescine). African oil bean seeds are edible, however, they cannot be consumed without adequate processing. The processing methods vary from one producer to the other ranging from boiling, dehulling, and slicing to fermentation. However, whichever method that is applied, whether traditionally or otherwise, the first step is boiling to soften the cotyledon. Some people boil the oil bean seed overnight (Nwamarah and Madueke, 2010), while others boil from 1 – 12 hours (Okechukwu *et al.*, 2015; Ikhuoria *et al.*, 2008) resulting in the production of non-uniform product quality.

The pod of the African oil bean plant explodes at maturity to disperse the seeds, thereby giving everyone the opportunity to gather the seed manually around the tree bushes (Lucky pickers). The owners end up harvesting the pod prior to maturity, not considering the content of the seed at the time of harvest - Hence, the need to assess the nutrient and anti-nutrient (phytochemical) contents of African oil bean seeds from different maturity stages, boiled for different periods of time.

METHODOLOGY

Material Procurement and Preparation

African oil bean trees at the bank of Njaba River, Njaba Local Government Area, Imo State, were monitored from flowering, through the period of fruiting until fruit maturity. Within these periods, two months developed pods were harvested and the seed extracted by splitting with machetes. Fully matured (exploded) seeds from three-month upwards were picked from the surrounding bushes. Both samples were analyzed (control) and then boiled differently for different periods (4h, 5h and 6h). The proximate and anti – nutrient contents of the boiled samples were analyzed prior to further processing and the result recorded.

ANALYTICAL METHODS

Proximate analysis

The proximate composition (moisture, ash, crude protein, crude fat, crude fibre, carbohydrate) of the boiled samples was determined using the methods of the Association of Official Analytical Chemist (AOAC, 2005). All analyses were carried out in triplicates and the average values recorded.

Determination of Anti – Nutrient Factors

(Oxalate, Tannin, Phytate and Saponin)

- **Determination of Oxalate**

The titration method described by Harborn (1973) was modified and used to determine the Oxalate content.

- **Determination of Tannin**
  The Folin – Denis spectrophotometric method of Pearson (1976) was used for the determination of Tannins.
- **Determination of phytate**
  The Phytate content was determined using the methods of Young and Greaves (1940) as adopted by Lucas and Markakes (1975).
- **Determination of Saponins**
  The spectrophotometric method of Brunner (1984) was used for the determination of Saponins.

Results and Discussions

Table 1.0: Proximate Composition of African Oil Bean Seed Samples at different Maturation Stages and Boiling Periods.

Seed Maturation (Month)	Boiling Time (h)	Nutrient (%)					
		Moisture	Protein	Ash	Fat	Crude Fibre	Carbohydrate
2	4	34.37 ± 0.03[e]	25.65 ± 0.04[a]	0.73 ± 0.00[e]	10.27 ± 0.02[b]	18.80 ± 0.02[e]	9.97 ± 0.11[d]
	5	35.83 ± 0.02[d]	23.15 ± 0.03[b]	1.24 ± 0.01[c]	8.25 ± 0.02[d]	20.72 ± 0.02[d]	10.85 ± 0.09[b]
	6	36.00 ± 0.02[c]	16.87 ± 0.02[f]	1.08 ± 0.00[d]	6.84 ± 0.01[f]	25.72 ± 0.02[a]	13.49 ± 0.07[a]
	4	33.76 ± 0.02[f]	19.90 ± 0.02[c]	1.87 ± 0.02[a]	11.50 ± 0.02[a]	23.00 ± 0.02[b]	9.97 ± 0.09[d]
3*	5	38.25 ± 0.02[b]	18.27 ± 0.02[d]	1.71 ± 0.02[b]	9.00 ± 0.01[c]	22.50 ± 0.02[c]	10.28 ± 0.07[c]
	6	42.28 ± 0.02[a]	17.45 ± 0.03[e]	0.42 ± 0.02[f]	7.00 ± 0.02[e]	23.02 ± 0.01[b]	9.83 ± 0.05[e]
	LSD	0.028	0.037	0.019	0.026	0.024	0.113

Note:

(a) 3* Exploded seed pod
(b) Values are mean ± standard deviation from triplicate determination
(c) Values on the same column with different superscripts are significantly different at $P \leq 0.05$.

Table 2.0: Anti-nutrient Contents of African Oil Bean Seed Samples at different Maturation Stages and Boiling Periods.

Seeds Maturation (Months)	Boiling time (h)	Anti-nutrients (%)			
		Phytic acid	Oxalate	Saponin	Tannin
	0	**6.18**	**4.15**	**2.89**	**2.67**
2	4	4.20 ± 0.02[a]	2.86± 0.02[a]	2.75 ± 0.01[a]	2.63 ± 0.01[a]
	5	4.09 ± 0.02[b]	2.81 ± 0.03[b]	2.55± 0.03[b]	1.88 ± 0.01[b]
	6	4.04 ± 0.02[c]	2.28 ± 0.02[d]	2.21 ± 0.02[c]	1.48 ± 0.01[c]
	0	**4.79**	**3.63**	**1.67**	**1.66**
3*	4	3.44 ± 0.03[d]	2.81 ±0.02[b]	1.52 ± 0.02[d]	1.24 ± 0.02[d]
	5	3.27 ± 0.02[e]	2.80 ± 0.02[b]	1.47 ± 0.02[e]	0.82 ± 0.02[e]
	6	2.73 ± 0.02[f]	2.60 ± 0.02[c]	1.28 ± 0.02[f]	0.56 ±0.02[f]
	LSD	0.025	0.030	0.025	0.019

NOTE: 3* Exploded pod seed.

a) Values are mean ± standard deviation from triplicate determination.
b) Values on the same column with different superscripts are significantly different at $P < 0.05$

DISCUSSIONS

The Proximate Composition of African Oil Bean Seed Samples at different Maturation Stages and Boiling Periods.

The moisture content increased with the boiling time. The moisture content increased from 34.37 % in two months developed (premature) seed boiled for 4 h to 36.00 % in two months (premature) seeds boiled for 6 h while that of exploded (mature) seed increased from 33.76 % in 4 h to 42.28 % in 6 h boiled seed. (Table 1.0). The oil bean seeds when heated in the presence of water imbibed moisture that caused the softening of their hulls and the swelling of the cotyledons. The rate of water absorption is known to increase with period of boiling, till the beans reach their maximum water absorption capacity (Nakitto et al., 2015). The protein content of the samples decreased with increase in boiling period. The values for the two months developed seeds decreased from 25.65 % in 4 h boiled seed to 16.87 % in 6 h boiled seed, while the values for the exploded seed decreased from 19.90 % to 17.45 % in 4 to 6 h boiled seeds. This was as a result of change in the proximate composition of the seeds as the seeds absorbed more water which led to the lower solid content of the seeds. These results agreed with the findings of Akindahunsi (2004), who stated a decrease in the protein contents of African oil bean from 41.7% to 9.9 % in raw and soaked/cooked seed samples.

Nutrient loss is a consequence of nearly every cooking process. Boiling with water often reduced the amounts of nutrients as they get leached (washed out) in the water and are left behind in the water. However, boiling foods also has its advantages, including a reduction of the number of possible malignant microbes, an increase in digestibility and the increased availability of certain phytonutrients (Diaz, 2012). There were variations in the results of the ash contents of boiled African oil bean seed. For the two months developed (premature) seeds, the ash content of the African oil bean seed boiled for 4 h, 5 h and 6 h though significantly different ($P < 0.05$), but were between the range (0.73 – 1.24 %), while for the exploded (full mature) seeds the ash values decreased (1.87 – 0.42 %) with increase in boiling time (4 h – 6 h). The reduction in the ash contents might be due to solubilization and leaching of minerals as boiling was prolonged. It could equally be due to increase in the moisture content with consequent reduction in the solid content of the seeds. The decrease in ash content during boiling agreed with the findings of Akindahunsi (2004), where the ash contents reduced from 2.5 % in raw seed to 1.4 % in soaked/boiled seed.

There was consistent decrease in the fat contents of all the samples. For the two months developed (premature) seed the fat content decreased from 10.27 % in 4 h boiled sample to 6.84 % in 6 h boiled sample. For the exploded African oil bean seed, boiling for 4 h, reduced the fat content from 11.5 % to 7.00 % in 6 h boiled sample. The decrease may be due to the breakdown of fat into glycerol and fatty acid

(Ramadan, 2012); and their diffusion into boiling water (Hefneway, 2011). The crude fibre contents significantly increased from 18.80 to 20.72 % for two months developed (premature) seeds boiled for 4 h and 5 h, and finally to 25.72 % when boiled for 6 h respectively. There were significant (P < 0.05) variations in the crude fibre for exploded (mature) seed boiled for 4 h and sample boiled for 5 h, but all the crude fibre contents were similar in value (23 %).

Akindahunsi (2004) had reported a decrease in crude fibre values (19.0 and 12.40 %) for raw and boiled African oil bean seed while Enujiugha and Akanbi (2005) observed an increase in crude fibre value (2.13 and 3.26 %) for raw and boiled seeds. Hefneway (2011) opined that the increase in the crude fibre content of boiled seed was as a result of protein-fibre complexes formed after possible chemical modification induced by boiling of dry seeds. The carbohydrate contents increased with boiling time. For two months developed (premature) seeds, the values increased from 9.97 % at 4 h boiling to 13.49 % at 6 h boiling, while the carbohydrate in the exploded (mature) seeds increased from 9.97 % at 4 h boiling to 10.28 % at 5 h boiling. The carbohydrate contents of all the samples boiled for 4, 5 and 6 h were approximately the same (10 %). This was in agreement with carbohydrate contents (3.9 and 24.2 %) for raw and boiled African oil bean seeds as reported by Akindahunsi (2004). Boiling caused the granules to breakdown, softened the cellulose and made the starch more available, hence increasing the energy level after consumption (Agiang *et al.*, 2010).

The Anti-Nutrient Contents of African Oil Bean Seeds at different Maturation Stage and Boiling Periods.

Maturity decreased the phytic acid in African oil bean seed from a value of 6.81 % in two months developed (premature) seeds to 4.79 % in fully mature (exploded seeds) (Table 2.0). The phytic acid content of 6.81 % in the raw seed of two months developed African oil bean was reduced to 4.20 % by boiling at 4 h (a reduction of 32 %) (Table 2.0), while boiling the mature (exploded) seed for 4 h reduced its phytic acid content from 4.79 % (in raw mature seeds) to 3.44 % (a reduction of 28.20 %). Further boiling of the matured or exploded seeds for 6 h reduced the phytic acid to 2.73 % (a reduction of 43 %). Thus, both the period of maturity and the period of boiling influenced the amount of phytic acid in African oil bean seeds. Rehman and Shau (2001) reported that boiling reduced phytic acid content by 21 and 24 % in red and white kidney beans. Enujiugha and Akanbi (2003) also reported 57 - 58 % reduction of phytic acid after boiling beans that had been soaked 12 h prior to boiling.

Phytic acids are concentrated in the hulls of nuts, seeds and grain and the reduction or elimination of phytates below detection levels occurs after boiling and dehulling. Phytic acid was reported to decrease the availability of some divalent metals (minerals e.g Ca, Mg, Zn and Mn) as well as protein in the foods in which they are present (Enujiugha *et al.*, 2003). The period of maturity influenced the level of oxalates

in the African oil bean seed. The raw two-month developed (premature) seeds had an oxalate value of 4.15 %, while the raw mature (exploded) seeds had a value of 3.63 % (a reduction of 12.5%). Boiling of the raw seeds of African oil bean (irrespective of the stage or degree of maturity) for 4 h decreased the oxalate, but prolonged period of boiling (between 5 and 6 h) decreased the oxalate content further (2.81 and 2.28 %) in premature seed and in matured seeds (2.80 and 2.60 %). Specifically, boiling the two-months developed, raw (premature) seeds for 4 h reduced the oxalate level in the seeds from 4.15 % to 2.86 % (a reduction of 31.08 %). Further boiling for 6 h only reduced this component from the initial 4.15 % to 2.28 % (a reduction of 45.10 %). This implied a further reduction of 23 % for the extra two hours of energy spent for further 2 h of boiling. With regards to the effect of boiling on the mature (exploded) seeds, 4 h of boiling reduced the oxalate content from 3.63 % in the raw seed to 2.81 % in the boiled seed (22.6 % reduction). Then, boiling the mature seeds for 6 h reduced the oxalate value from 3.63 % in the raw seed to 2.60 % in the boiled seed (28.4% reduction). This implied a further reduction of 5.8 % for the 2 h of extra energy and time spent in boiling the seed.
Enujiugha and Akanbi (2003) also reported a reduction in the oxalate content of cooked African oil bean seeds. Oxalates are present in many plants and bind the calcium and prevent its absorption in the human body. That is, oxalates in the body combine with divalent cations, Ca^{2+}, Fe^{2+}, forming their insoluble salts. These insoluble salts obstruct kidney tubules leading to kidney stones. Hence, its reduction implies increased mineral bioavailability and reduction of renal dysfunction (Igwuenyi *et al.*, 2015).

The saponin value in raw two-month old (premature) African oil bean seed was 2.89 % while the raw mature seeds had a value of 1.67 %. This implied the period of maturity had remarkable effect on the saponin content of African oil bean seed samples studied. Four (4) hours of boiling effected a reduction of 4.88 % (2.89 to 2.75 %) in the two-month developed (premature) seeds, while boiling the mature seeds decreased their saponin contents, irrespective of the boiling period. For instance, boiling the mature seeds for 4 h resulted in the saponin content decreasing from 1.67 % in raw mature seed to 1.52 % in the boiled mature seed (a reduction of 8.98 %).

The same trend was noticed in the case of tannin, where the mature raw seeds had an average tannin value of 1.66 %, 4 h boiled seed, a value of 1.24 % and 6 h boiled samples, a value of 0.56 %. Considering that most of the African oil bean seeds processed to "ugba" were mature, it would have implied that boiling favourably affected reduction in the values of phytic acid, oxalates, saponin and tannin. Saponins and tannins are often bitter in taste and reduce the seed's palatability. It is therefore possible that their presence in the African oil bean slices account for the bitter taste often reported by the local processors of the African oil bean seed into "ugba" (Okorie and Olasupo, 2013). Saponins in plants may serve as anti-feedants while tannin causes discolouration of the seed and binds the protein through hydrogen binding and hydrophobic interaction, thereby reducing their nutritional availability/values. Dehulling eliminates phytates and tannins and increase protein digestibility. Cooking and soaking reduced the levels of anti-nutritional agents and have positive effects on protein digestibility – This improves the nutritive values of nuts, seeds and legumes (Ramadan, 2012).

CONCLUSION

The results of the study revealed that nutrient contents of African oil bean seeds increased with increase in maturity period; the treatment (boiling) of the seed causes leaching of nutrients, but also improves the edibility of the product; boiling for 5 and 6 hours reduced the anti-nutrient to a good extent and; with complete processing treatment, 'Ugba' will be completely free from inherent phytochemicals. However, the 'Ugba' seed should not be over-cooked or under-cooked and, when immature seeds are used for production, the boiling periods should be reduced. This will enhance uniformity of the end product.

REFERENCES

Agiang, M. A., Umoh, I. B., Essien, A. I. and Eteng, M. U. (2010). Nutrient changes and anti-nutrient contents of beniseed and beniseed soup during boiling using a Nigerian traditional method. *Pakistan Journal of Biological Science* **13**:1011 – 1015 http://setalertmet/abstract/?doc=pjbs. 2010.1011 - 1015.

Akindahunsi, A. A. (2004). Physicochemical studies on African oil bean (*Pentaclethra macrophylla*) seed. *J. Food Agric. Environ.* **2**:14 – 17.

AOAC (2005). *Official Method of Analysis.* Association of Official Analytical Chemists. 17th Ed. Horowitz W (Ed). Vols. 1 & 2 AOAC Intern. Maryland, ch. 45. 12 – 20

Brunner, J. H. (1984). Cereals - Spectrophotometric determination of Saponins. *Appl. Chem.* **3**: 1314 – 1323.

Diaz, S. G. (2012). The effect of boiling on nutrition. SELF Nutrition Data. www.nutritiondataself.com (Accessed 17/3/16).

Enujiugha, V. N. and Akanbi, C. T. (2005). Compositional changes in African Oil bean (*Pentaclethra macrophylla Benth*) seeds during thermal processing. *Pakistan Journal of Nutrition* **4**: 27 – 31.

Enujiugha, V. N., Adebanjo, A. B., Samuel, O. I. and Mathew, O. O. (2003). Effect of germination on the nutritional and functional properties of African oil bean (*Pentaclethra macrophylla Benth*) seed flour. *Food, Agric. and Environ. Journal* (**3** & **4**): 72-75. www.worldfood.net. WFL Publishers Science and Technology.

Harborn, J. B. (1973). Phenolic Compounds. In: *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis.* Champman and Hall Ltd, London, England, pp. 33 – 38.

Hefnawy, T. H. (2011). Effects of processing methods on nutritional composition and antinutritional factors in Lentils (*Lens culinaris*). *Annals of Agricultural Sciences* **5** (**2**): 57 - 61.

Igwenyi, I. O., Isiguzo, O. E. and Aja, P. M. (2015). Proximate composition, mineral content and phytochemical Analysis of African oil bean (*Pentaclethra macrophylla Benth*) seed. *American-Eurasian J. Agric and Environ. Sci.* **15** (**19**):125 – 129.

Ikhuoria, E. U., Aiwonegbe, A. E., Okolie, P. and Idu, M. (2008). Characteristics and composition of African oil bean (*Pentaclethra macrophylla Benth*). *Journal of Applied Science* **8**:1337 – 1339.

Joker, D and Salazar, R. (2000). *African Indigenous fruits with potential health benefits.* Danida forest seed center. www.dfsc.dk. Accessed 1/8/2020.

Keay, R. W. J. (1989). *Trees of Nigeria: A Revised Version of Nigerian trees* (1960 – 1964) by R. W. J. Keay, C. F. A. Onochie and D. P. Stanfield. Clarendon Press, Oxford. United Kingdom. p.476.

Lucas, G. M. and Markakes, P. (1975). Phytic acid and other phosphorous compounds of navy bean (*Phaseolous vulgaris*). *J. Agric. Food Chem.* **23**:13 -15.

Mears, J. A. and Mabry, J. J. (1981). *Alkaloids in the Leguminous. The Chemo-anatomy of the Leguminosae.* Harbone, J. B., Doulter, D. and Toner, D. L. (eds). Academic Press, New York. pp. 60 - 65.

Nakitto, A. M., Muyonga, J. H and Nakimbugwu, D. (2015). Effects of combined traditional processing methods on the nutritional quality of beans. *Food Science & Nutrition* **3** (**3**): 233 - 240.

NFT (Nitrogen Fixing Tree) Highlight (1995). *Pentaclethra macrophylla*: A Multipurpose tree from Africa with Potential for Agroforestry in the Tropics. NTFA 95-05. www.winrock.org/forestry/factnet.htm

Nwamarah, J. U. and Madueke, U. O. (2010). Graded fermentation effects on nutrient content of oil bean seed (*Pentaclethra macrophylla*) consumed in Umuayom Village, Awka. *JHER* **13**:16-23.

Oboh, G. (2007). *Pentaclethra macrophylla Benth.* In: Van-der-Vossen, H.A.M. and Mkamilo G. S. (Editors). Prota 4u: (*Plant Resources of Tropical Africa*) Wageningen, Netherlands. http://www.prota4u.org/search.asp>. (Accessed: 13/7/2013).

Okorie, P. C. and Olasupo N. A. (2013). Growth and extracellular enzyme production by microorganisms isolated from ugba - an indigenous Nigerian fermented food. *Afr. J. Biotechnol.* **12**: 4158 – 4167.

Pearson, D. A. (1976). *Chemical Analysis of Food.* 7th Edition. Churchill Living stone, Edinburgh.

Rehman, Z. U. and Shah W. H. (2001). Tannin content and protein digestibility of black grains (*Vigna mungo*) after soaking and boiling. *Plant Foods for Human Nutrition* **56**: 265-273.

Young, S. M. and Greaves, J. E. (1940). Influence of variety and treatment of phytic acid content of wheat. *Food Res.* **5**:109 - 195.