Comparative Evaluation of Nutritive Value of Okro (*Abelmoschus esculentus*) and Bush Mango (*Irvingia gabonensis*) Fruits Grown in Nasarawa State, Nigeria

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Abstract

The proximate, mineral and amino acid compositions of okro (*Abelmoschus esculentus*) pod and bush mango (*Irvingia gabonensis*) seed were determined using standard analytical techniques. Moisture, ash, crude fat, crude fibre, protein and carbohydrate (by difference) contents (%) of *A. esculentus* and *I. gabonensis* were: 25.9 and 2.1, 9.0 and 11.5, 17.2 and 62.0, 4.3 and 0.9, 21.8 and 7.4, and 21.8 and 26.1, respectively. The most abundant minerals were Ca (170.6 and 431.5 mg/100g sample), K (108.5 and 161.0 mg/100g), Mg (83.6 and 171.1 mg/100g) and Na (88.0 and 113.5 mg/100g), respectively. Generally, the two samples were found to be good sources of essential minerals while harmful metals such as Pb and Cd were not at detection limit of AAS. The levels of Na/K and Ca/P ratios were desirable compared with the recommended values. The amino acid profile revealed that samples of *A. esculentus* and *I. gabonensis* contained nutritionally useful quantities of most of the essential amino acids with total essential amino acids (TEAA) of 35.4 and 38.1 g/100g crude protein or 40.6 and 47.8% of the total amino acid (TAA), respectively while the limiting amino acids (LAA) were Val and Thr. The calculated isoelectric points (pI) and predicted protein efficiency ratios (P–PER) were 5.1 and 4.8, 2.5 and 4.1 for *A. esculentus* and *I. gabonensis,* respectively. However, dietary formula based on these fruits may require amino acids supplementation.

Keywords: *Abelmoschus esculentus, Irvingia gabonensis,* nutritional composition.

1 Introduction

Vegetables and fruit seeds are of great important in the tropic and subtropics as food and also as commercial products (Tindall, 1965). In nutrition, vegetables and fruits seeds are very good sources of most vitamins such as vitamin A, B, and C and some organic acid like folic acids. Most mineral, such as iron, calcium and phosphorus are obtained from vegetables and fruit seeds, sometimes vegetables and fruit seeds are important sources of protein which is frequently in short supply in humid tropics. Vegetables are often cooked and eaten in form of soup and salad (Philips & Rix, 1993). They are consumed as cooked complement to major stable such as cassava, cocoyam, guinea corn, maize, rice, etc. Vegetables and fruit seeds are of interest economically from several points of view. Where there are opportunities for sale, they are among the most profitable agricultural products (Ejiofor *et al.,* 1987). Vegetables contain indigestible fibre which can calm the irregular or irritable bowel and by triggering regular bowel movement preventing constipation. Consumption of vegetables and fruit seeds can help prevent heart disease like stroke, high blood pressure and accumulation of cholesterol (Etudeko, 2003). Fruits also lower the chance of developing cardiovascular disease (Apple *et al.,* 1970). Vegetables and fruit seeds consumption is far from being sufficient in almost all least developed countries (FAO, 1970).

Irvingia gabonensis is a non–timber forest product made up of tree trunk (stem), leave, roots and fruits. The fruit comprises of fleshy part and the nut, which consists of a hard shell and the kernel/seed. Its seeds have an outer brown testa (hull) and two varieties have been identified in Nigeria. *Irvingia excelsa,* now known as *Irvingia wombolu.* They belong to the genius *Irvingia* species and *Irvingia gabonensis* (Kochhar, 1986). *Irvingia gabonensis* common names are bush mango, wild mango, African mango or dika nut plant and the local name is “ogbono”. The most important product from these species (*Irvingia gabonensis*) is however the kernel of the nut, which is extracted, dried and can be stored for a long period. The seeds are processed by grinding and separating the residue from the fat. The residue is used as food addition to thicken soups and stews, as it produces a viscous consistency when added a few minutes before serving. The worldwide used versatile vegetable called 'okro' (*Abelmoschus esculentus*) is characterized by green colour, elongated and tapering pods infused with double row of seed slimy texture when cut open. This integral member of the cotton family is indigenous to regions around the Nile in North Africa and Middle East for it was discovered dating far as 3500 years ago in Ethiopia. Early Egyptians are known to love its taste (Ndjovenkeu *et al.,* 1996). Okro later transcended to North America enroute slave trade and then to Europe, Asia and South and Central America. Okro belongs to the family of Malvaceae. It is a vegetable valued for many of its properties. The fruits are also used as boiled or fried vegetable and added to soup and stews. Mature pods of okro contain C mucilaginous substance. Besides being low in calories, it is plenty with vitamins of the category A, thiamine, B_6, folic acid, riboflavin, calcium, zinc and dietary fibre (Babatola & Lawal, 2000).

This work gives information on the proximate, mineral and amino acid compositions of bush mango (*Irvingia gabonensis*) seed and okro (*Abelmoschus esculentus*) pod with the hope that it will further enhance the knowledge on nutritional values of the plant foods.

2 Materials and Methods

2.1 Collection and treatment of samples

Twenty seeds of bush mango (*Irvingia gabonensis*) were collected directly from a farmer in Toto local government area of Nasarawa State, Nigeria in March, 2011 while thirty mature pods of okro (*Abelmoschus esculentus*) were purchased from Keffi main market in Keffi local government area (Nasarawa State) in the same month of the year. They were brought to the laboratory and rinsed with distilled water to remove any attached dirt. *Irvingia gabonensis* seeds were fermented at 26 – 29^{o}C for three weeks and dehulled to obtain the seeds which were then dried in an oven at 45^{o}C for 48 h. The pods of *Abelmoschus esculentus* were chopped into slice and oven dried at 50^{o}C for 72 h. The two samples were ground into fine powder using Kenwood food blender and kept in polyethylene bags prior to analyses.

2.3 Proximate analyses

The proximate analyses of sample for moisture, crude fat, crude fibre and total ash were carried out in triplicate according to the methods of Association of Official Analytical Chemists (AOAC, 2000). Nitrogen was determined by the micro–Kjeldahl method and the percentage nitrogen converted to crude protein by multiplying by 6.25. The total carbohydrate content was determined by difference (AOAC, 2000).

2.4 Mineral analysis

Sodium and potassium were determined using a flame photometer (Corning, UK, Model 405), other metals were determined by means of atomic absorption spectrophotometer (Buck Scientific Inc., Connecticut) while phosphorus was determined colorimetrically (AOAC, 2000). All the chemicals used were of analytical grade and obtained from British Drug House (BDH, London).

2.5 Amino acid analysis

Amino acid analysis was by Ion Exchange Chromatography (IEC) (FAO/WHO, 1991) using the Technicon Sequential Multisample (TSM) amino acid analyzer (Technicon Instruments Corporation, New York). The period of analysis was 76 min for each sample. The gas flow rate was 0.50 mL/min at 60^{o}C with reproducibility consistent within ± 3 min. The net height of each peak produced by the chart recorder of the TSM (each representing an amino acid) was measured and calculated. The amino acid values reported were the averages of two determinations. Nor–leucine was the internal standard. Tryptophan was not determined.

2.6 Determination of isoelectric point (pI), quality of dietary protein and predicted protein efficiency ratio (P–PER)

The predicted isoelectric point was evaluated according to Olaofe and Akintayo (Olaofe & Akintayo, 2000):

$$\mathbf{pIm} = \sum_{i=1}^{n=1} pI_i X_i$$

Where:

pIm = The isoelectric point of the mixture of amino acids.

pI_i = The isoelectric point of the i^{th} amino acids in the mixture.

X_i = The mass or mole fraction of the amino acids in the mixture.

The quality of dietary protein was measured by finding the ratio of available amino acids in the sample protein compared with needs expressed as a ratio. Amino acid score (AAS) was then estimated by applying the FAO/WHO [12] formula:

$$\textbf{AAS} = \frac{mg\ of\ amino acid\ in\ 1g\ of\ test\ protein}{mg\ of\ amino\ acid\ in\ 1g\ reference\ protein}\ x\ \frac{100}{1}$$

The Predicted Protein Efficiency Ratio (P–PER) of the seed sample was calculated from their amino acid composition based on Alsmeyer *et al.* (1974) equation as stated thus; P–PER = –0.468 + 0.454 (Leu) –0.105 (Tyr).

3 Results and Discussion

Proximate composition of *Irvingia gabonensis* and *Abelmoschus esculentus* is presented in Table 1. The moisture content of 2.1% for *I. gabonensis* seed is low which is within the range value of most seeds and legumes (Robertson & Eastwood, 1981). The low moisture value ensures a long life of the seed without microbial spoilage. But in the case of *A. esculentus*, the moisture content of 25.9% is high. The result implies that this vegetable has low storage capacity or can be easily perishable, highlighting the problems of conservation in warm climate condition. The high water content in vegetable can help enhance food digestion and peristaltic movement on consumption (Al–Wander, 1983). Ash content of 11.5% for *I. gabonensis* was high and this high value predicts the presence of an array of minerals as well as high molecular weight elements (Ejiofor *et al.,* 1987). In *A. esculentus*, the ash content of 9.0% was relatively high, but this value is slightly lower than those of bitter leaf (15.86%) and *Moringa oleifera* (15.09%) (Ramola & Raw, 2003).

The crude fat content of 62.0% in bush mango is relatively high, compared with pumpkin seed (47.0 – 49.2%) (Olaofe *et al.,* 1993). This qualifies the sample as oil rich plant food (Aremu *et al.,* 2008). *A. esculentus* with crude fat content of 17.2% indicates that *A. esculentus* is moderate in fat and could be regarded as a good source of plant crude fat. Crude protein value of 7.4% for bush mango is low compared to some commonly consumed plant protein in Nigeria and this does not qualify the seeds as protein rich plant food. The observed low value in this study may be due to the genotype and the environmental condition under in which they were grown. Crude protein value of 21.8% for *A. esculentus* is high and compared favorably with 24% in *Amaranthus vividis;* 20.72% in *Moringa oleifera;* 21.0% in *Lasianthera africana* and 15.0% in *Heinsia crinata* (Ramola & Raw, 2003; Udoka *et al.,* 1998). The result indicates that *A. esculentus* can provide more than 12% of its energy from protein if consumed and are therefore considered good source of protein. Crude protein value (7.4%) obtained for *I. gabonesis* was low. Crude fibre (0.9%) of *I. gabonensis* showed a low crude fibre which can be attributed to decrease in microbiological metabolism of lingo polysaccharide in the crude fibre and may be due to non–utilization of the sugar in the seeds metabolic activities leaving it with lower percentage of fibre content (Giami *et al.,* 1994). The crude fibre value 4.3% of *A. esculentus* compares favourably with crude fibre values of some legume seeds in the literature (Olaofe *et al.,* 2008; Aremu *et al.,* 2010; Oshodi & Ekperigin, 1989). It has been reported that intake of dietary fibre can lower cholesterol level, risk of coronary heart disease, hypertension, diabetes and breast cancer (Ramola & Raw, 2003). *I. gabonensis* and *A. esculentus* have 26.1 and 21.8%, respectively. Therefore, these samples will participate well in these functions. The calculated fatty acid values obtained for the two samples suggest that the oil may be suitable as edible oil and industrial purposes (Aremu *et al.,* 2011) and also the calculated metabolizable energy values showed that the samples have energy concentrations favourably compared to cereals (Adeyeye & Fagbohun, 2005).

The mineral composition (mg/100g sample) is shown in Table 2. The most abundant mineral was calcium in *A. esculentus* and *I. gabonensis* with values of 170.6 and 431.5 mg/100g sample, respectively. This was contrary to the observations of some researchers who had reported that potassium is the most abundant mineral in agricultural products (Olaofe & Sanni, 1988; Aremu *et al.,* 2005; Shills & Young, 1992). The least abundant mineral was iron (3.6 mg/100g) in *A. esculentus* and zinc (4.9 mg/100g) in *I. gabonensis*. Sodium, potassium and magnesium were abundantly high in both samples while phosphorus was of moderate values. The presence of phosphorus, calcium and magnesium would make *A. esculentus* and *I. gabonensis* samples suitable for bone formation for children since the deficiencies of these minerals (P, Ca and Mg) can lead to abnormal bone development (Shills & Young, 1992). Magnesium is also an activator of many enzyme systems and maintains the electrical potential in nerves (Shills & Young, 1992). Phosphorus is always found with calcium in the body, both contributing to the blood formation and supportive structure of the body. Modern foods rich in animal protein and phosphorus can promote the loss of calcium in urine (Shills & Young, 1992). This led to the concept of calcium/phosphorus ratio. If the Ca/P ratio is low, calcium will be low and there will be high phosphorus intake which leads to calcium loss in the urine more than normal. If the Ca/P ratio of any food is above one, that food is considered "good", and poor if the ratio is less than 0.5, while a Ca/P ratio above two helps to increase the absorption of calcium in the small intestine. The results of Ca/P ratios in both samples were very high especially in *A. esculentus*. Sodium and potassium are required for the maintenance of osmotic balance of the body fluids, the pH of the body to regulate muscles and nerves irritability, control glucose absorption and enhance normal retention of protein during growth (NRC, 1989). The sodium to potassium ratio in the body is of great concern for the prevention of high blood pressure. The Na/K ratio of less than one is recommended. However, Na/K ratios in *A. esculentus* and *I. gabonensis* (0.7) are less than one; therefore, this suggests that the two samples have capacity to prevent blood pressure. The iron contents (3.6 – 19.7 g/100g sample) and chromium contents (76.2 – 101.2 mg/100g sample) were relatively high in the samples (Table 2). Iron is required for blood formation and also an important for normal functioning of the central nervous system (Shills & Young, 1992). Chromium is essential for life; its deficiency results in diabetic mellitus and increases the toxicity of lead (Aremu *et al.,* 2010). Harmful metals such as lead and cadmium were below the detection limit of AAS.

The amino acid profile is presented in Table 3. Arginine and leucine were the most concentrated essential amino acids in *A. esculentus* and *I. gabonensis,* respectively while glutamic acid was the most concentrated amino acid in both samples which is in excellent agreement with many reports on legume seeds (Aremu *et al.,* 2008; Olaofe *et al.,* 2008; Aremu *et al.,* 2011; Oshodi *et al.,* 1998; Aremu *et al.,* 2010). Tryptophan concentrations could not be determined. The least concentrated amino acids in *A. esculentus* and *I. gabonensis* were histidine (1.2 g/100g crude protein) and methionine (1.4 g/100g crude protein, cp), respectively. The calculated isoelectric points (pI) were 5.1 (*A. esculentus*) and 4.8 (*I. gabonensis*). This is useful in predicting the pI for protein in order to enhance a quick precipitation of protein isolate from biological samples (FAO/WHO, 1991). The predicted protein efficiency ratio (P–PER) is one of the quality parameters used for protein evaluation. The P–PER in this report are higher than reported P–PER values of flours of cowpea (1.21), pigeon pea (1.82) and *Lathyrus sativus* (1.03) (Salunkhe & Kadam, 1998), and therefore satisfied FAO requirement (FAO/WHO/UNU, 1985). The nutritive value of a protein depends primarily on the capacity to satisfy the needs for nitrogen and essential amino acids (Oshodi *et al.,* 1998; Aremu *et al.,* 2010). The total essential amino acids (TEAA) (with histidine) were 40.6 and 47.8% for the two samples, respectively (Table 4). These are comparable with values obtained for selected oil seeds which ranged between 33.3 to 53.6% (Olaofe *et al.,* 1993) and soybean (46.5%) (Oshodi *et al.,* 1998), suggesting that these food samples under study are as good as food supplements. Essential alphatic amino acids (EAAA), Ile, Leu, and Val, which constitute the hydrophobic regions of proteins, were more abundant in the *I. gabonensis* than in the *A. esculentus* seed flour. This means that better emulsification properties may be expected in the *I. gabonensis* compared with *A. esculentus.* Table 4 also depicts percent of total acid amino acids (TAAA) which was found to be greater than the percent of total basic amino acids (TBAA) in both samples indicating that the protein is probably acid in nature (Aremu et al., 2006).

Results of the amino acid scores are shown in Table 5. Based on the provisional amino acid scoring pattern (FAO/WHO/UNU, 1985), the essential AA scores (EAAS) greater than 1.0 were Ile, Met + Cys (TSAA), Phet + Tyr and Thr (*A. esculentus*) and Ile, Leu, Lys and TSAA for *I. gabonensis* samples. The limiting AA for the samples of *A. esculentus* and *I. gabonensis* were Val and Thr, respectively. This agrees with the report of FAO/WHO/UNU (1985) that the EAA most often acting in a limiting capacity are Met (and Cys), Lys, Thr and Try. Try was not determined in this report.

5 Conclusion

This work has presented the nutritional quality of okro (*Abelmoschus. esculentus*) and bush mango (*Irvingia gobonensis*) flour. The study showed that the two samples contained nutritionally valuable minerals and useful quantities of most of the essential amino acids; however dietary formula based on them may require some essential amino acids supplementation.

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Table 1: Proximate composition (%)[a] of *Abelmoschus esculentus* and *Irvingia gabonensis* flour

Parameter	*Ablemoschus esculentus*	*Irvingia gabonensis*
Moisture	25.9 ± 0.75	2.1 ± 0.80
Ash	9.0 ± 1.18	11.5 ± 0.60
Crude fat	17.2 ± 0.66	62.0 ± 1.05
Crude fibre	4.3 ± 0.25	0.9 ± 0.10
Crude protein	21.8 ± 2.10	7.4 ± 0.04
[b]Carbohydrate	21.8 ± 0.22	26.1 ± 0.22
[c]Fatty acid	13.8	41.6
[d]Energy (kJ/100g)	1377.6	2493.5

[a]Values are mean ± standard deviation of replicate determination; [b]Carbohydrate percentage calculated as the (100 – total of other components); [c]Calculated fatty acids (0.8 x crude fat); [d]Calculated metabolizable energy (protein x 17 + fat x 37 + carbohydrate x 17)

Table 2: Mineral composition (mg/100g) of *Abelmoschus esculentus* and *Irvingia gabonensis* flour

Mineral	*Ablemoschus esculentus*	*Irvingia gabonensis*
Sodium	88.0	113.5
Potassium	108.5	161.0
Calcium	170.6	431.5
Magnesium	83.6	171.1
Manganese	22.7	33.5
Zinc	18.8	4.9
Copper	30.9	47.3
Iron	3.6	19.7
Chromium	76.2	101.2
Lead	ND	ND
Cadmium	ND	ND
Phosphorus	9.5	44.5
Na/K	0.8	0.7
Ca/P	18.6	9.7
[K/(Ca + Mg)]	0.426 meq*	0.26 meq*

ND = Not detected; **Na/K =** Sodium to potassium ratio; **Ca/P =** Calcium to phosphorus ratio;
***meq =** Milliequivalent

Table 3: Amino acid composition (g/100g crude protein) of *Abelmoschus esculentus* and *Irvingia gabonensis* flour

Amino acid	*Ablemoschus esculentus*	*Irvingia gabonensis*
Lysine (Lys)[a]	4.1	7.3
Histidine (His)[a]	1.2	1.9
Arginine (Arg)[a]	6.4	4.7
Aspartic acid (Asp)	3.2	5.1
Threonine (Thr)[a]	4.4	3.2
Serine (Ser)	1.3	2.8
Glutamic acid (Glu)	18.5	15.2
Proline (Pro)	3.1	3.4
Glycine (Gly)	4.6	5.4
Alanine (Ala)	2.7	8.6
Cystine (Cys)	3.4	2.4
Valine (Val)[a]	1.7	4.6
Methionine (Met)[a]	2.3	1.4
Isoleucine (Ile)[a]	4.0	4.5
Leucine (Leu) [a]	6.1	8.3
Tyrosine (Tyr)	3.1	3.7
Phenylalanine (Phe)[a]	5.2	2.2
Isoelectric point (pI)	5.1	4.8
P–PER	2.5	4.1

[a]Essential amino acid; **P–PER =** Predicted protein efficiency ratio

Table 4: Classification of amino acid composition (g/100g crude protein) of *Abelmoschus esculentus* and *Irvingia gabonensis* flour

Parameter	*Ablemoschus esculentus*	*Irvingia gabonensis*
Total amino acid (TAA)	87.0	79.7
Total essential amino acid (TEAA)		
With His	35.4	38.1
Without His	34.2	36.2
% TEAA		
With His	40.6	47.8
Without His	39.3	45.4
Total non–essential amino acid (TNEAA)	51.6	41.6
% TNEAA	59.3	52.2
Essential alphatic amino acid (EAAA)	16.2	20.6
Essential aromatic amino acid (EArAA)	5.2	2.2
Total neutral amino acid (TNAA)	41.9	45.5
% TNAA	48.1	57.1
Total acidic amino acid (TAAA)	21.7	20.0
% TAAA	27.9	25.3
Total basic amino acid (TBAA)	11.7	13.9
Total sulphur amino acid (TSAA)	5.7	3.8
% Cystine in TSAA	59.5	63.1

Table 5: Amino acid scores of *Abelmoschus esculentus* and *Irvingia gabonensis* flour

AAC	[a]PAAESP	*Abelmoschus esculentus*		*Irvingia gabonensis*	
		EAAC	**AAS**	**EAAC**	**AAS**
Ile	4.0	4.0	1.0	4.5	1.12
Leu	7.0	6.1	0.87	8.3	1.18
Lys	5.5	4.1	0.74	7.3	1.32
Met + Cys (TSAA)	3.5	5.7	1.62	3.8	1.08
Phe + Tyr	6.0	8.3	1.38	5.9	0.98
Thr	4.0	4.4	1.10	3.2	0.80
Try	1.0	nd	na	nd	na
Val	5.0	1.7	0.34	4.6	0.92
Total	**36.0**	**34.3**	**7.05**	**37.6**	**7.4**

[a]**Source:** Belschant *et al.*(1975); **AAC =** Amino acid composition; **PAAESP =** Provisional amino acid (egg) scoring pattern; **EAAC =** Essential amino acid composition; **AAS =** Amino acid scores; **nd =** Not determined; **na =** Not available.