ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 16 No. 2
June 2016
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

DOI: 10.18697/ajfand.74.15025

NUTRITIONAL AND AMINO ACID ANALYSIS OF RAW, PARTIALLY FERMENTED AND COMPLETELY FERMENTED LOCUST BEAN (*PARKIA BIGLOBOSA*) SEEDS

Oluwaniyi OO[1*] and IO Bazambo[1]

Omolara Oluwaniyi

*Corresponding author emails: laraoluwaniyi@yahoo.com ; oluwaniyiomolara@gmail.com

[1]Department of Industrial Chemistry, University of Ilorin, Ilorin, Nigeria

ABSTRACT

The nutritional and amino acid analysis of raw and fermented seeds of *Parkia biglobosa* were carried out. Parameters investigated include moisture, crude protein, crude fat, ash, crude fibre and mineral contents; and the effect of the degree of fermentation on these parameters was also investigated. The amino acid compositions of all the samples were evaluated and amino acid quality determined by calculating amino acid scores and the predicted protein efficiency ratio (P-PER). Results showed that the proximate composition was significantly affected by fermentation, although there was little difference between the parameters for the partially fermented and completely fermented samples. Based on dry matter percentage, protein content was in the 39.77 – 43.74 % range while crude fibre ranged between 5.55 – 7.42 %. The ash content was lowest in the raw sample (2.34 %), while the fermented samples had ash contents between 4.27 and 8.33 % for the fully fermented and the partially fermented seeds, respectively. The fat content increased from 8.65 % in the raw seed to 24.4 % and 27.6 % for the partially and completely fermented samples, respectively. Results of the amino acid analysis showed that the partially fermented sample had the lowest quantities of all amino acids determined and had lysine as the limiting amino acid, whereas the raw and completely fermented samples had very similar amino acid profile with amino acid scores of 100, indicating that there are no limiting amino acids. All the samples were rich in essential amino acids. The P-PER also showed that the partially fermented sample had the lowest protein efficiency while the raw seed had the highest. Mineral contents generally increased from the raw, through the partially fermented, to the completely fermented seeds and results showed the samples to be good sources of potassium (K), calcium (Ca), manganese (Mn) and copper (Cu) in addition to being complementary sources of other metals. Locust bean seed does not accumulate lead and is, therefore, safe for consumption without the potential of food poisoning.

Key words: Fermentation, amino acid, locust bean, *Parkia biglobosa*, proximate composition, nutritional value

DOI: 10.18697/ajfand.74.15025

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 16 No. 2 June 2016 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Fermentation is one of the oldest and most important traditional food processing and preservation techniques. It involves the use of microorganisms and enzymes for the production of foods with quality attributes that are quite different from the original raw material [1]. Fermented foods and beverages are increasingly becoming important in meeting the nutritional needs of consumers [2].

Fermented foods are fairly common in Nigeria and go by many different names, which may be based on the area of origin or the type of legume or oilseed used. *Iru* is a popular condiment among the Yorubas of South Western Nigeria. It is made from fermented *Parkia biglobosa.* The Hausas, who inhabit most of the northern part of Nigeria, call the same product, "*dawadawa*". "*Ogiri*" (fermented *Citrullus vulgaris*) is a common condiment among the Ibos of South Eastern Nigeria while "*Owoh*" (fermented *Gossypium hirstium*) is the popular condiment among the Urhobos and Itsekiris in the Niger Delta region. Fermented *Prosopis africana* is popular among the Igala and Idoma people of the Middle Belt region where it is known as "*okpehe*" [3].

Almost any edible plant material, especially leguminous seeds, can be used as a substrate for fermentation and a single condiment can be produced from many different substrates. For instance, *dawadawa* or *iru* is traditionally prepared from African locust bean (*Parkia biglobosa*), soybean (*Glycine max*) and bambara groundnut (*Vigna subterranea). Ogiri* is traditionally prepared by fermenting melon seeds (*Citrullus vulgaris*), fluted pumpkin (*Telferia occidentalis*) or castor oil seed (*Ricinus communis). Owoh* is processed from fermented seeds of the cotton plant (*Gossypium hirsitium*) and African yam bean (*Sphenostylis stenocarpa*) while *Okpehe* is prepared from the seeds of *Prosopis africana.* In most cases, the seeds that are fermented are inedible in their raw state [3].

Parkia biglobosa (Jack.) G. Don. is also known as *dawadawa* in Hausa, African locust bean in English, *Igba/Iyere* in Yoruba and *Nere* in Bambara. It is native to Africa and has been widely used for apiculture, fodder, tanning, food, and other uses. It is a medicinal plant, used extensively by the Hausa people of Northern Nigeria and other parts of West Africa against bronchitis, pneumonia, diarrhea, violent colic, vomiting, sores and ulcers. A decoction of the stem bark is used as a mouthwash to relieve toothache as well as a bath for fever [4]. The bark is also used with lemon for wounds and ulcers. An infusion of the bark is used as a tonic for diarrhea and as an enema [5]. The leaves are also used for burns and toothache and the root is used in lotions for sore eyes when combined with leaves. They are reported to be active against bronchitis, pile, cough, amoebiasis, dental carries and conjunctivitis [6, 7].

The fruit and shell are traditionally used as a source of substance used to harden natively made house floors. It is also rich in tannins and can be an important source of leather tanning. The yellow powdery substance (*ngolo*) is used in making a local drink (*kunu*) or fed to pigs [8]. The Parkia tree usually grows in the wild and helps to provide shade for farmers and prevent soil erosion by holding the soil particles with its roots.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 16 No. 2
June 2016
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

It also helps in the recycling of nutrients from deep soils [9]. It is used as timber for making pestles, mortars, bows, hoe handles and seats.

The seed of African locust bean, which is a grain legume, is one of the most useful parts of the plant and serves as a source of useful ingredients for consumption. The seeds are known to be rich in protein, edible oil and contain easily digestible calcium, hence the locust bean is important especially for Third World countries where protein malnutrition is a problem and there is a growing need for protein supplementation among both adults and infants [10].

Processing of locust bean fruits to the condiment involves many different post-harvest operations such as pod and pulp removal to produce the seeds, cleaning, boiling, de-hulling, washing, recooking, and then fermentation of the seeds to produce the condiment. The fermented seed is used as soup seasoning/spices (flavoring agent) [10].

There is some information available on the nutritional values of the raw and fermented locust bean [11 – 13]. However, available information usually does not distinguish between the partially fermented and the completely fermented seeds and these two are different in texture and consistency and possibly in composition too. There is, therefore, the need to look into the nutritional composition of the raw, partially fermented and completely fermented seeds as well as the amino acid composition. The seed is known to be rich in protein and many locals eat it as a major protein source in their diets. Therefore, the aim of this work was to determine the quality of the protein and amino acids and how these may be affected by fermentation.

MATERIALS AND METHODS

Parkia biglobosa seeds were obtained from Ilorin, North Central part of Nigeria and handpicked to remove stones and defective seeds. The two types of fermented samples (partially and completely fermented) were obtained from a local market in Ilorin. The partially fermented beans (known and sold as *iru woro*), though soft, have distinct beans, which are not mushy while the completely fermented beans (known and sold as *iru pete*) are much softer and paste-like in consistency. All the chemicals used were of high purity and of analytical grade while all solvents were distilled before use.

Proximate and Nutritional Analysis: Standard Methods of the Association of Official Analytical Chemists [14] were used to determine the moisture, crude protein, crude fat, total ash and crude fibre contents of the raw seed and fermented *Parkia biglobosa* seed samples. All determinations were done in triplicates and data obtained analysed by one way analysis of variance (ANOVA). Means were compared by the Duncan's multiple range tests and significance was accepted at the 5% level.

Titratable Acidity (TA) or Total Titratable Acidity (TTA): This was done using the Nielsen method [15]. One gram (1 g) of the ground sample was soaked in 50 ml of distilled water. Five milliliters of the filtrate was titrated against 0.01 M NaOH solution using phenolphathalein indicator. The total titratable acidity was calculated as % phytic acid.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 16 No. 2 June 2016 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Amino Acid Analysis
Amino acid analysis was done by ion exchange chromatography (IEC), using the Technicon Sequential Multisample (TSM) Amino Acid Analyser (Technicon Instruments Corporation, Dublin, Ireland). Two grams (2 g) of each sample was defatted using chloroform/methanol and then hydrolysed using 6 M HCl. The hydrolysate was then injected into the amino acid analyser for separation and characterisation. Tryptophan was not determined.

Estimation of amino acid quality
The amino acid score for the essential amino acids was calculated using the FAO/WHO formula [16]:

$$\text{Amino acid score} = \frac{\text{Amount of amino acid per sample protein [mg/g]}}{\text{Amount of amino acid per protein in reference protein [mg/g]}}$$

The total essential amino acids (TEAA), the percentage of the total essential amino acids in the total amino acids (%TEAA), total acidic amino acids (TAAA), total sulphur-containing amino acids (TSAA) and total aromatic amino acids (TArAA) were calculated and the predicted protein efficiency ratio (P-PER) was determined using the equations adapted by Oluwaniyi *et al.* [17] (that is P-PER = - 0.468 + 0.454(Leu) - 0.105(Tyr)).

Mineral Analysis
Two grams (2g) of sample was digested with 24 cm^3 mixture of nitric/perchloric/sulphuric acids using the ratio 9:2:1, respectively. The digestates were analysed for minerals using atomic absorption spectroscopy [14].

RESULTS

Results of the various determinations carried out on different samples - unfermented parkia seeds (ALBS), partially fermented parkia seeds (PFALB) and completely fermented parkia seeds (CFALB) are presented below.

Proximate Analysis: The results of the proximate analysis are presented in Table 1 on wet weight basis and expressed as g/100g of sample.

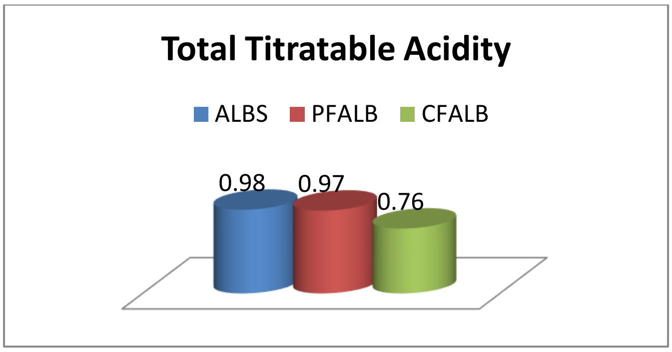
The moisture content of the samples increased with the extent of fermentation with 7.17±0.29 %, 44.74±0.49 %, and 51.54±0.31 % recorded for raw, partially fermented, and completely fermented seed samples, respectively. The ash content was found to increase initially with fermentation from 2.17±0.29 % for the raw seed powder to 4.61±0.23 % for the partially fermented sample, and then decreased to 2.07±0.11 % for the completely fermented sample. An increase in the fat content was observed for the fermented samples from 8.03±0.27 % in the raw seeds to 13.48±0.22 % in the partially fermented seeds and 13.37±0.19 % in the completely fermented seeds. There was significant reduction in the crude fiber content with fermentation, from 6.89±0.38 % for the raw unfermented seeds to 3.07±0.21 % and 3.12±0.19 % for the partially fermented and completely fermented seeds, respectively. Results of crude protein

DOI: 10.18697/ajfand.74.15025

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 16 No. 2
June 2016
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

analysis showed that the protein content reduced with fermentation from 40.60±0.51 % in the raw seed powder to 22.08±0.16 % in the partially fermented sample and 19.27±0.22 % in completely fermented sample. There was also a reduction in the carbohydrate content of the samples with fermentation from 42.04±1.06 % (for raw seed) to 15.09±0.42 % (for partially fermented seed) and 13.75±0.52 % (for completely fermented seed).

The results also showed that the total titratable acidity content (Fig. 1) decreased with fermentation from 0.98 % for unfermented seed to 0.97 % for the partially fermented sample before falling sharply with increasing fermentation period to 0.76 % for completely fermented sample.



Key: ALBS – Unfermented parkia seeds; PFALB – Partially fermented parkia seeds; CFALB – Completely fermented parkia seeds

Figure 1: Total Titratable Acidity of the three samples

Statistical analysis showed that the moisture, ash and carbohydrate contents of the samples varied significantly ($p < 0.05$). On the other hand, the lipid and fiber contents (of the wet matter) and protein and carbohydrate contents (of the dry matter) did not vary significantly between the two fermented samples ($P > 0.05$). There was, however, a significant difference between those of the unfermented sample and the fermented samples.

Amino Acid Composition

The amino acid compositions of the samples (raw and fermented seeds) are shown in Table 3. From the results, the partially fermented sample had a lower total amino acid (TAA) content when compared with the raw and completely fermented samples. The TAA of the raw sample was also slightly higher than that of the completely fermented samples. The TEAA, TAAA, TSAA and TArAA amounts were highest in the raw seeds and lowest in the partially fermented seeds. The proportions of these components, however, do not follow the same trend. For example, the %TEAA, %TAAA and %TrAA were all highest in the partially fermented seeds. The differences observed in all cases, however, were minimal.

DOI: 10.18697/ajfand.74.15025

Mineral Composition
The results of the mineral analysis are presented in Table 5 and 6 for the wet and dry matter, respectively.

Manganese contents of the wet samples were 0.92, 0.90 and 0.98 mg/100g for ALBS, PFALB and CFALB, respectively, which showed that the Mn contents decreased slightly with the onset of fermentation before rising again as fermentation progressed. Copper contents were 0.13, 0.26 and 0.25 mg/100 g for the unfermented, partially fermented and completely fermented samples, respectively, showing that the partially fermented sample had a slightly higher copper content than the completely fermented sample. The amounts of iron in the three samples were 2.49, 1.94 and 2.41 mg/100g for ALBS, PFALB and CFALB, respectively. The unfermented sample had a higher iron content than the partially fermented and completely fermented sample. The magnesium contents of the samples were 24.92, 13.97 and 12.73 mg/100 g, while the zinc contents of the samples were 0.35, 0.29, 0.11 mg/100 g for ALBS, PFALB and CFALB, respectively. The unfermented sample had the highest zinc content among the three samples. The sodium contents of the samples were 48.80, 51.78 and 45.41 mg/100 g for the unfermented, partially fermented and completely fermented samples, respectively. The partially fermented sample had the highest sodium content. Potassium contents of the samples were 34.93, 27.56 and 32.23 mg/100 g for the unfermented, partially fermented and completely fermented samples, respectively. The unfermented sample had a slightly higher potassium content than the two fermented samples. The results also showed that the calcium contents of the samples were 96.30, 55.84 and 57.81 mg/100 g for the unfermented, partially and completely fermented samples, respectively.

The amounts of lead in all three samples were found to be same as that of the blank sample, thus implying that the samples do not contain any detectable or significant amount of lead.

DISCUSSION

The observed increase in moisture content may be due to boiling and subsequent soaking in water of the fermented samples. It may also be as a result of metabolic activities of microorganisms during fermentation period, which gives out moisture as their product. The low moisture content of the raw seed (7.17±029 %) is similar to those reported by Odebunmi *et al.* (8.67 ± 0.70 %), and Omafuvbe *et al.* (8.6 ± 0.6 %) [18, 19]. The high moisture content for the fermented seed (51.54±0.31 %) is similar to that reported by Omafuvbe *et al.* (52.0 ± 5.0 %) [19]. The increase in the fat content observed for the fermented samples may be as a result of the loss of some other constituents of the seed due to heat treatment involved in the fermentation process leading to an overall increase in the fat content of the fermented seeds. The results of the ash content determination show that the completely fermented samples have lower ash content than the partially fermented samples. This may be as a result of the loss of some minerals into the water. Partial fermentation made the seeds softer and the minerals more available; however, further fermentation led to the leaching of these minerals into the water hence the drop in the ash content of the fully fermented samples. This shows that fermented locust beans seed is a ready source of energy in diets. The reduction in crude fibre content with fermentation may be attributable to boiling and microbial fermentation.

Reduction in protein content may be attributed to the higher moisture and fat contents of the fermented samples compared with the unfermented sample. On the basis of dry matter (Table 2), there was minor difference in the protein content, further corroborating the fact that the differences observed on the wet matter was not as a result of loss of protein to processing, but rather as a result of the increase in the moisture content of the samples with fermentation. The change in carbohydrate content is also due to the lower moisture content of the unfermented samples in comparison with the fermented samples. The results are similar to the 41.10 % obtained by Elemo *et al.* [20].

The nutritive value of plant proteins is usually assessed by comparing its essential amino acid content with a reference standard or "ideal" protein set by the World Health Organization [21]. This is based on the amino acid needs of children aged 2-5 years. The essential amino acids cannot be manufactured in human bodies, but can be obtained from food. Eight amino acids are generally regarded as essential for humans: phenylalanine, valine, threonine, tryptophan, isoleucine, methionine, leucine and lysine [22]. Additionally, cysteine (or sulphur-containing amino acids), tyrosine (or aromatic amino acids), histidine and arginine are required by infants and growing children and play a vital role in human nutrition and metabolism [23]. Arginine is also known to become conditionally essential at times of trauma and disease. Deficiency in these amino acids may hinder the healing and recovery processes. All these essential amino acids were found to be present in the locust bean seeds.

The predicted protein efficiency ratio (P-PER) for all samples ranged from 2.86 in the partially fermented seeds to 3.21 in the raw seeds. The standard reference for the PER is based on casein, a cow's milk protein, which has a PER of 2.5 and the values obtained for all samples are greater than 2.5 [24]. Generally, a PER below 1.5 approximately describes a protein of low or poor quality and none of the locust bean samples had such low P-PER [25].

The amino acid scores of raw and fermented locust bean seeds are presented in Table 4 and the limiting amino acid, where present is indicated in bold letters. The table shows that only the partially fermented locust bean has lysine as the limiting amino acid while both raw and completely fermented seeds have amino acid score of 100 since all values greater than 100 are considered to be 100 [26].

Manganese is a microelement essential for human nutrition. It acts as an activator of many enzymes [27]. Copper is a micro mineral that facilitates the absorption of iron and the formation of red blood cells. Copper is also required in the body for enzyme production and biological electron transfer [27].

DOI: 10.18697/ajfand.74.15025

Iron is required for blood hemoglobin formation as well as for energy metabolism. It is a trace element needed by the body. Iron deficiency in the body results in anaemia [28]. Magnesium is believed to support the immune system, regulates blood sugar levels and is involved in the production of energy and cell reproduction. Manganese works with vitamin K and B complex vitamins to support blood clotting. Manganese also helps to control the effects of stress. Birth defects can possibly result when an expectant mother does not get enough of this important element [29]. The body requires sodium in order to maintain acid-base balance, osmotic balance between cells and interstitial fluid and nerve function. Its absence causes muscle cramps, mental apathy and reduced appetite. The recommended daily allowance of sodium is no more than 2.3 g / day for healthy adults although WHO had recommended a reduction to < 2g / day [30].

The body also requires potassium for the maintenance of acid-base balance, body water balance and nerve function; its absence may result in muscular weakness and paralysis [31]. Calcium plays an important role in building and maintaining strong bones and teeth, large parts of human blood and cellular fluids. Calcium is also necessary for normal functioning of cardiac muscles, blood coagulation, clotting and regulation of cell permeability. Calcium deficiency causes rickets, back pain, osteoporosis, indigestion, irritability, pre-menstrual tension, and uterus cramping [27].

The above results show that the samples were good K, Ca, Mn and Cu sources. They also constitute a good complementary source of other minerals. The observed haphazard trend in the mineral content among the samples may be attributed to the difference in the moisture contents between the samples. On the basis of dry matter, the mineral content showed a general increase with fermentation, except Mg, Zn and Ca, further corroborating the fact that the observed trend on the wet matter was not as a result mineral loss during processing, but rather as a result of the increase in sample moisture content with fermentation (except for zinc, which increases as fermentation commences, before reducing as fermentation progresses).

Locust bean seed does not accumulate lead and is, therefore, safe for consumption without the fear of food poisoning. Lead is a poisonous metal that can damage nerve connections especially in young children. Increased lead absorption may give rise to negative effects on both the central and peripheral nervous systems [32]. In adults, lead affects the brain, kidney and ultimately leads to death while in pregnant women high lead contents can cause pregnancy miscarriage and respiratory problems as well as restrict the flow of blood into the body system [33].

CONCLUSION

This study has shown that fermentation did not adversely affect the nutrient composition of raw and fermented seeds of *P. biglobosa* and is necessary to make the seeds edible and the nutrients available. Fermented *P. biglobosa* is consumed mainly for its protein content and this work has shown that the protein contents of both partially and completely fermented seeds are within the same range and only slightly lower than the values recorded for the raw seeds. The completely fermented seeds appear to have

DOI: 10.18697/ajfand.74.15025

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 16 No. 2
June 2016
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

a better amino acid profile than the partially fermented seed and have no limiting amino acid whereas the partially fermented seeds have lysine as the limiting amino acid. The fermented seeds are good sources of nutritionally-important mineral elements.

Table 1: Result of Proximate Analysis

Sample	Nutritional Composition (g/100g)						
	Moisture	Ash	Fat	Crude Fibre	Protein	Carbohydrate (+ Fibre)	TTA
ALBS	7.17±0.29^{a}	2.17±0.31^{a}	8.03±0.27^{b}	6.89±0.38^{a}	40.60±0.51^{a}	42.04±1.06^{a}	0.98±0.08^{a,b}
PFALB	44.74±0.49^{b}	4.61±0.23^{b}	13.48±0.22^{a}	3.07±0.21^{b}	22.08±0.16^{b}	15.09±0.42^{b}	0.97±0.00^{a}
CFALB	51.54±0.31^{c}	2.07±0.11^{a}	13.37±0.19^{a}	3.12±0.19^{b}	19.27±0.22^{c}	13.75±0.52^{c}	0.76±0.04^{b}

Values are mean ± s.d of triplicate determination. Values followed by same superscript along the columns are not significantly different at p = 0.05; ALBS = unfermented parkia seeds; PFALB = partially fermented parkia seeds; CFALB = completely fermented parkia seeds; TTA = Total Titratable Acidity

Table 2: Result of Proximate Analysis on Dry Weight Basis

Sample	Nutritional Composition (g/100g)				
	Ash	Fat	Crude Fibre	Protein	Carbohydrate (+ Fibre)
ALBS	2.34±0.31^{a}	8.65±0.27^{a}	7.42±0.38^{a}	43.74±0.51^{a}	45.28±1.06^{a}
PFALB	8.33±0.23^{b}	24.40±0.22^{b}	5.55±0.21^{b}	39.96±0.16^{b}	27.31±0.42^{b}
CFALB	4.27±0.11^{c}	27.60±0.19^{c}	6.45±0.19^{c}	39.77±0.22^{b}	28.37±0.52^{b}

Values are mean ± s.d of triplicate determination. Values followed by same superscript along the columns are not significantly different at p = 0.05; ALBS = unfermented parkia seeds; PFALB = partially fermented parkia seeds and CFALB = completely fermented parkia seeds

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 16 No. 2 June 2016 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Table 3: Amino Acid Composition of Samples (g/100g)

AMINO ACIDS	ALBS	PFALB	CFALB
Lysine (Lys)[a]	6.79	4.99	6.63
Histidine (His)[b]	3.88	3.04	3.76
Arginine (Arg)	6.98	4.47	6.89
Aspartic acid (Asp)	11.03	9.54	10.53
Threonine (Thr)[a]	4.8	3.88	4.24
Serine (Ser)	5.02	4.24	4.72
Glutamic acid (Glu)	18.02	15.94	17.36
Proline (Pro)	5.52	4.88	5.31
Glycine (Gly)	5.49	4.11	4.84
Alanine (Ala)	5.94	5.01	5.37
Cystine (Cys)[a]	2.45	1.92	2.18
Valine (Val)[a]	5.92	5.32	5.64
Methionine (Met)[a]	1.82	1.41	1.48
Isoleucine (Ile)[a]	4.55	3.99	4.08
Leucine (Leu)[a]	9	8.07	8.46
Tyrosine (Tyr)[a]	3.86	3.22	3.54
Phenylalanine (Phe)[a]	5.66	4.99	5.33
Tryptophan (Try)[a]	ND	ND	ND
Total Amino acids (TAA)	106.73	89.02	100.36
Total Essential amino acids (TEAA)	42.42 (39.75%)	35.69 (40.09%)	39.62 (39.48%)
Total Acid amino acids (TAAA)	29.05 (27.22%)	25.48 (28.62%)	27.89 (27.79%)
Total Sulphur amino acids (TSAA)	4.27 (4.00%)	3.33 (3.74%)	3.66 (3.65%)
Total Aromatic amino acids (TArAA)	13.4 (12.56%)	11.25 (12.64%)	12.63 (12.58%)
P-PER	3.21	2.86	3.00

Values are expressed as g/100 g dry weight of sample. ND = Not determined. Values in parenthesis are % of TAA

[a] Essential amino acids according to FAO/WHO [34]

[b] Indispensable amino acid in human adult according to FAO/WHO/UNU [35].

ALBS = unfermented parkia seeds; PFALB = partially fermented parkia seeds; CFALB = completely fermented parkia seeds; and P-PER = predicted protein efficiency ratio

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 16 No. 2 June 2016 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Table 4: Essential Amino Acid Score of Locust Bean Seed

Amino Acid	*Standard FAO/ WHO (1991) (g/100g protein)*	*ALBS*	*PFALB*	*CFALB*
Ile	2.8	163	143	146
Leu	6.6	136	122	128
Lys	5.8	117	**86**	114
Met + Cys	2.5	171	133	146
Phe + Tyr	6.3	151	130	141
Thr	3.4	141	114	125
Try	1.1	ND	ND	ND
Val	3.5	169	152	161
His	1.9	204	160	198

ND = Not determined; ALBS = unfermented parkia seeds; PFALB = partially fermented parkia seeds and CFALB = completely fermented parkia seeds

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 16 No. 2
June 2016
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 5: Result of Mineral composition on wet weight basis (mg/100 g)

Samples	*ALBS*	*PFALB*	*CFALB*
Manganese (Mn)	0.92	0.90	0.98
Copper (Cu)	0.13	0.26	0.25
Lead (Pb)	-	-	-
Iron (Fe)	2.49	1.94	2.41
Magnesium (Mg)	24.92	13.97	12.73
Zinc (Zn)	0.35	0.29	0.11
Sodium (Na)	48.80	51.78	45.41
Potassium (K)	34.93	27.56	32.23
Calcium (Ca)	96.30	55.84	57.81

ALBS = unfermented parkia seeds; PFALB = partially fermented parkia seeds and CFALB = completely fermented parkia seeds

DOI: 10.18697/ajfand.74.15025

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 16 No. 2 June 2016 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Table 6: Result of Mineral composition on dry weight basis (mg/100 g)

Samples	*ALBS*	*PFALB*	*CFALB*
Manganese (Mn)	0.99	1.63	2.03
Copper (Cu)	0.14	0.48	0.51
Lead (Pb)	-	-	-
Iron (Fe)	2.68	3.51	4.98
Magnesium (Mg)	26.84	25.28	26.28
Zinc (Zn)	0.37	0.52	0.22
Sodium (Na)	52.57	93.70	93.70
Potassium (K)	37.63	49.88	66.50
Calcium (Ca)	103.74	101.05	119.30

ALBS = unfermented parkia seeds; PFALB = partially fermented parkia seeds and CFALB = completely fermented parkia seeds

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 16 No. 2 June 2016 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

REFERENCES

1. **Aworh OC** The Role of Traditional Food Processing Technologies In National Development: The West African Experience. **In:** Robertson GL and JR Lupien (Eds). Using Food Science and Technology to Improve Nutrition and Promote National Development ©International Union of Food Science & Technology, 2008.

2. **Steinkraus KH** Nutritional significance of fermented foods. *Food Res Int*. 1994; **27:** 259-267.

3. **Achi OK** The upgrading of traditional fermented foods through biotechnology. *Afr. J. Biotechnol*. 2005; **4:** 375-380.

4. **Ajaiyeoba EO** Phytochemical and antibacterial properties of *Parkia biglobosa* and *Parkia bicolor* leaf extracts. *Afr. J. Biomed. Res.* 2002; **5(3):** 125 -129.

5. **Duker- Eshun GD, Beni CT, Asonaming WA and RA Akwamoah** Chemical investigation of the stem bark of *Parkia clappertoniana Keay. J. Ghana Sci. Assoc.* 2001; **3:** 2-8.

6. **Banwo GO, Abdullahi I and M Duguryil** The antimicrobial activity of the stem bark of *Parkia clappertoniana* Keay family Leguminosae against selected microorganisms. *Nig.J. Pharm. Res.,* 2004; **3(1):** 16-22.

7. **Millogo-Kone H, Guisson IP, Nacoulna O and AS Traore** Study of the antibacterial activity of the stem bark and leaf extracts of *Parkia biglobosa* (Jacq) Benth on *Staphylococcus aureus*. *Afr. J. Trad. Compl. Alter Med*., 2006; **3(2):** 74- 78.

8. **Musa HL** Ginger and Locust Bean Tree: History, Growth, Use and Potentials. Paper presented at Tuk Ham Symposium, Kurmin. 1991; 267.

9. **Campbell-Platt G** African locust bean (Parkia species) and its West African fermented food products, Dawadawa. *Ecol. Food Nutr*., 1980; **9:** 123-132.

10. **Akande FB, Adejumo OA, Adamade CA and J Bodunde** Processing of locust bean fruits: Challenges and prospects. *Afr. J. Agr. Res.*, 2010; **5(17):** 2268-2271.

11. **Eka OU** Effect of fermentation on the nutrient status locust beans. *Food Chem*., 1980; **5:** 305-308.

12. **Hassan LG and KJ Umar** Protein and Amino acid Composition of African Locust bean (*Parkia biglobosa*). *Tro. Subtr. Agroeco.*, 2005; **5:** 45-50.

13. **Ijarotimi OS and OO Keshinro** Comparison between the amino acid, fatty acid, mineral and nutritional quality of raw, germinated and fermented African locust bean (*Parkia biglobosa*) flour. *Acta Sci. Pol. Technol. Aliment.*, 2012; **11(2):** 151-165.

14. **Association of Official Analytical Chemists (AOAC)** Official Methods of Analysis (14th ed.) Arlington, VA, 1990.

15. **Nielsen SS** Food Analysis Laboratory Manual. 3rd edn. Kluwer academic /plenumpublishers, New York. 2003; 87-88.

16. **FAO/WHO.** Energy and protein requirements. Technical report series no. 522. Geneva, Switzerland: WHO, 1973.

17. **Oluwaniyi OO, Dosumu OO and GV Awolola** Effect of local processing methods (boiling, frying and roasting) on the amino acid composition of four marine fishescommonly consumed in Nigeria. *Food Chemistry*, 2010; **123:** 1000 – 1006.

18. **Odebunmi EO, Oluwaniyi OO and MO Bashiru** Comparative Proximate Analysis of Some Food Condiments. *J. Appl. Sci. Res.*, 2010; **6(3):** 272 – 274.

19. **Omafuvbe BO, Falade OS, Osuntogun BA and SRA Adewusi** Chemical and Biochemical Changes in African Locust Beans (*Parkia biglobosa)* and Melon (*Citrullus vulgaris*) Seeds during Fermentation to Condiments. *Pak. J. Nutr.*, 2004; **3(3):** 140 – 145.

20. **Elemo GN, Elemo BO, Oladunmoye OO and OL Erukainure** Comprehensive investigation into the nutritional composition of dehulled and defatted African locust bean seed (*Parkia biglobosa*). *Afr. J. Plant Sci.*, 2011; **5(5):** 291-295.

21. **FAO/WHO/UNU.** Protein Quality Evaluation. Food and Agricultural organization of the United Nations: Rome, Italy, 1991.

22. **Young VR** Adult amino acid requirements: The case for a major revision in current recommendations. *Journal of Nutrition*, 1994; **124(8 Suppl):** 1517S–1523S.

23. **Imura K and A Okada** Amino acid metabolism in paediatric patients. *Nutrition*, 1998; **14(1):** 143–148.

24. **FAO/WHO/UNU.** Energy and protein requirement, WHO technical report series no. 724. Geneva, Switzerland: WHO, 1985.

25. **Friedman M** Nutritional value of protein from different food sources: A review. *J. Agric. Food Chem.*, 1996; **44(1):** 6–29.

26. **Harper AE and NN Yoshimura** Protein quality, amino acid balance, utilization, and evaluation of diets containing amino acids as therapeutic agents. *Nutrition*, 1993; **9(5):** 460–469.

27. **Soetan KO, CO Olaiya and OE Oyewole** The importance of mineral elements for humans, domestic animals and plants: A review. *African Journal of Food Science*, 2010; **4(5):** 200-222.

28. **Adeyeye EI and ED Fagbohon** Proximate Mineral and Phytate Profile of some Selected Spices found in Nigeria. *Pak. J. Sci. Res.*, 2005; **48**: 14-22.

29. **Anhwange BA, Ajibola VO and SJ Oniye** Chemical Studies of the Seeds of *Moringa oleifera and Detarium microcarpum* . *J. Bio. Sci*, 2004; **4(6):** 711-715.

30. http://www.who.int/nutrition/publications/guidelines/sodium_intake/en/index.html (Accessed 13th May, 2016).

31. **Akpabio UD, Akpakpan AE, Udo UE and UC Essien** Physicochemical Characterization of exudates from Raffia Palm (*Raphia hookeri*). *Adv. Appl. Sci. Res.*, 2012; **3(2):** 838-843.

32. **Lin-Fu JS** Proceedings of the International Conference on Heavy Metals in Environment, Toronto, 27-31 October 1975 *Electric Power Research Institute* (Califonia), 1976.

33. **Niosh A** The Long Term Effect of Exposure to Low Doses of Lead in Childhood. United States National Institute for Occupational Safety and Health. (http://www.cdc.gov/niosh/topics/ABLES/descriptions.html). (Accessed 4th August, 2015).

34. **FAO/WHO**. Energy and protein requirements. PAG Bulletin, 5, 30–35, 1975.

35. **FAO/WHO/UNU**. Energy and protein requirement, WHO technical report series no. 724. Geneva, Switzerland: WHO, 1985.

DOI: 10.18697/ajfand.74.15025