Amino Acid Profile and Sensory Attributes of Flour Blends from Bambara Groundnut, African Arrowroot Lily and Soybean for *Akpekpa* Production

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ABSTRACT

This study evaluated the amino acid profile of flour blends produced from Bambara groundnut, African arrowroot lily and soybean, as well as the sensory quality of akpekpa prepared from these blends. Akpekpa was produced by mixing the flour blends with wet-milled pepper, onions, seasoning and salt, after which 20 ml palm oil and 60 ml hot water (70 °C) were added and stirred into a uniform paste. The paste was allowed to stand for 30 minutes, stirred again then dispensed into stainless cups (400ml capacity) to ¾ full, cooked for one hour and allowed to cool. Amino-acid analysis showed that blending improved both essential and non-essential amino-acid contents, with glutamic acid (1.34%) being the most abundant and arginine (0.18%) the least. Incorporating African arrowroot lily and soybean flours slightly reduced the sensory scores of the products; however, the blend containing 90% Bambara groundnut, 5% soybean and 5% African arrowroot lily was the most acceptable overall. The findings indicate that adding African arrowroot lily and soybean to Bambara groundnut flour enhances its amino-acid profile and can still yield an acceptable akpekpa product.

Keywords: Akpekpa, Flour blends, Amino-acid, sensory attributes

INTRODUCTION

Legumes are important major sources of plant protein and fats in tropical countries. They are good sources of essential amino acids and fats. There industrial application depends on the knowledge of nutritional importance and functional properties while the acceptability by the consumer depends on its sensory quality. Bambara groundnut [*Vigna subterranea* (L.) *verde*], one of these grain legumes, is widely cultivated in west and central Africa. A high carbohydrate (65%) and relatively high protein (18%) content as well as sufficient quantities of fat (6.5%) make the bambara groundnut rank highly as a complete food. However, lack of adequate processing techniques to overcome the hard-to-cook effect has limited its utilization and hence reduced its production (Christina, 2009). In addition, insufficient protein of good quality is a serious problem in many developing countries because of the prohibitive cost of protein from animal sources. Alternative sources of proteins which could alleviate this problem include the proteins from different legumes.

Akpekpa is a proteineous traditional steamed gel product prepared from bambara groundnut flour. It is a delicacy and well cherished food eaten by over five million people including children and adults in North Central Nigeria particularly among the Tiv tribe (Igbabul *et al*., 2013). Bambara groundnut (*Voandzeia subterranea*) is a seed crop of African origin and the third most important grain after groundnut and cowpea (Ojimelikwe and Ayernor, 1992). It is widely produced in the Northern part of Nigeria and contains all the essential amino acids, but it does not meet the recommended amino acid patterns specified by FAO/WHO Expert Consultation (FAO/WHO, 2013). Despite this fact, it could play an important role in meeting the people's protein needs in combined meals, especially in developing countries. The essential amino acid content of bambara groundnut such as lysine 6.82g/16gN, methoinine 1.85g/16gN and cysteine 1.24g/16gN is comparable to that of soyabean (6.24g/16gN lysine, 1.14g/16gN methionine and 1.80g/16gN cysteine) (Fetuga et al 1975). Lysine, Leucine, Glutamic and Aspartic acids were its predominant amino acids (Mune *et al*., 2011, Yao et al., 2015). Researchers have reported bambara groundnut flour in the making of bread in Zambia, produced imitation milk that gave a flavour preferred to that of milks from cowpea, pigeon pea and soybean and also for preparing baby foods, animal feeds, snacks,

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relish and medicine and as well made into a traditional steamed gel product known as *akpekpa* (Atiku *et al.*, 2004; Igbabul *et al*., 2013).

However, the competing demand on bambara groundnut for human consumption and animal feed and its attendant high price has led to the utilization of composite flours from soybeans, cassava, maize, cocoyam, and guinea corn for *akpekpa* preparation (Igbabul *et al*., 2013). This could affect its protein content thereby resulting to variation in its amino-acid composition. African arrowroot lily (*Tacca involucrata*), which is affordable and readily available could be used in making *akpekpa* owing to its binding property. It is with the view to harness these edible and abundant starch and protein sources that this research was aimed at incorporating African arrowroot lily (*Tacca involucrata*) and Soybean flours in *akpekpa* production to enhance its amino-acid composition and sensory attributes.

MATERIALS AND METHODS

Source of Materials

Bambara groundnuts and soybeans were purchased from Modern market, Makurdi. African arrowroot lily tubers were harvested from a local farm in *Ihugh, Vandeikya* Local Government Area of Benue State. The ingredients such as fresh pepper, onions, seasoning, palm oil and salt were purchased from North bank market in Makurdi, Benue State. All the chemicals used were of analytical grade.

Sample Preparation

Preparation of African Arrowroot Lily (*Tacca involucrata*) Flour

The method described by Igbabul *et al*. (2013) was used with a little modification (i.e. without wet milling of samples). African arrowroot lily (*Tacca involucrata*) tubers were peeled, rinsed, sliced into cubes and soaked in a closed container for fermentation to take place within 72 hours. The cubes were later drained and oven dried at 60^{o}C for 10 hours. The dried cubes were milled into flour using hammer mill, sieved through a 250µm mesh size and then packed in an air tight container.

Preparation of Bambara Groundnut Flour

The method of Okafor *et al*. (2014) was used. Bambara groundnut was manually sorted and winnowed to remove stones, debris and defective seeds. Thereafter, soaked for 24 hours to ease removal of the outer coat, oven dried the seed for 8 hours at 60^{o}C, milled using an attrition mill and sieved through a sieve 250 µm mesh, then packaged in an air tight container prior to use.

Preparation of Soybean Flour

The method of Fabiyi (2006) was adopted. Soybeans were soaked (1:5 w/v) for 12 hours, cleaned and washed to remove the testas. Thereafter, oven dried for 8 hours at 60^{o}C, milled using an attrition mill and sieved through a 250µm mesh, then packed in an air tight container prior to use.

Table 1: Formulation of bambara groundnut, African arrowroot lily and soy flour blends

Composition (%)				
Samples	Bambara groundnut flour	African arrowroot lily flour	Soybean flour	
A	100	0	0	100
B	90	5	5	100
C	80	10	10	100

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D	70	15	15	100
E	60	20	20	100
F	50	25	25	100
G	40	30	30	100

Preparation of *Akpekpa*

Akpekpa was prepared using the method described by Igbabul *et al*. (2013). The flour blend (Bambara groundnut, soybean and African arrowroot lily) sample (200g) was measured into a bowl. Ten grams each of fresh pepper and onion was ground and added to the flour. The seasoning (2g) and 1g of salt were also added to give taste. Thereafter, 20ml of palm oil and 60ml of hot water (70^{o}C) was added to the mixture and stirred thoroughly to mix the ingredients properly. The paste was allowed to stand for 30 minutes to gel properly and was stirred again. The paste was dispensed into stainless cups (400ml capacity) to ¾ full. The cup was covered with the lid and cooked for one hour. The *akpekpa* was cooled to ambient temperature (30^{o}C) and stored prior to analysis. The flow chart for the production of akpekpa is shown in Figure 1.

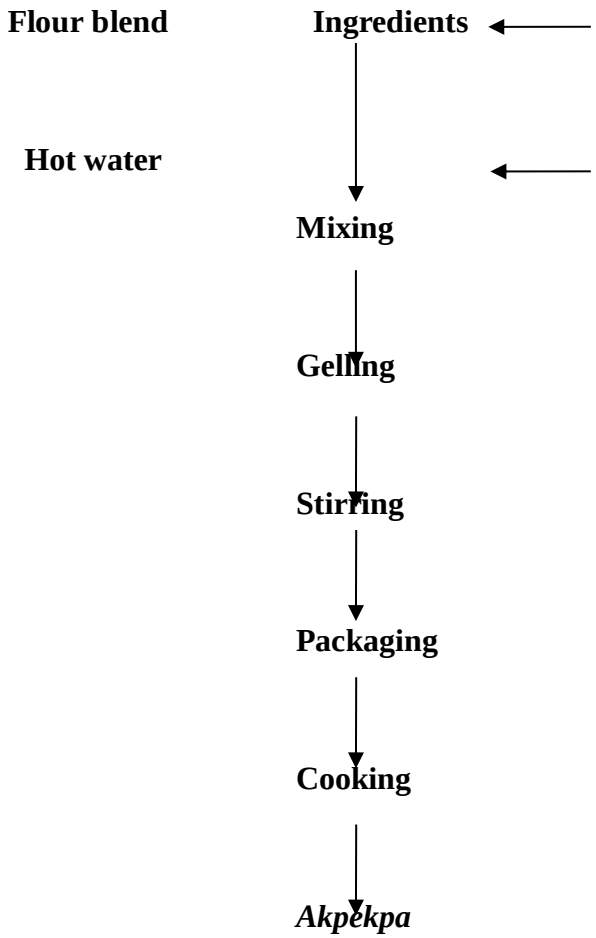

Figure 1: Flow diagram for preparation of *Akpekpa*.

Source: Igbabul *et al.* (2013)

Determination of Amino Acid Composition of *Akpekpa* flour blends

The determination of the amino acid composition of the flour formulations was done on Waters 616/626 LC (HPLC) in four stages i.e. (i) hydrolysis (ii) derivatisation (iii) separation of the derivatised amino acid and (iv) data processing, interpretation and calculation of the final results.

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Sample Hydrolysis

The method described by Kabaha *et al.* (2011) was used for the hydrolysis of the samples. The sample (0.5g) was weighed into sterile furnace hydrolysis tube and 5 Nmol leucine was added to the samples and then dried under a vacuum. The tube was again placed in a vial containing 10.05N HCL with a small quantity of phenol, thereby hydrolyzing the protein by the HCL vapours under vacuum. The stages of hydrolysis of the samples lasted for between 20-23 hours at 108^0C. After the hydrolysis, the samples were dissolved in ultra-pure water (HPCL) grade, containing ethylene diamine tetraacetic acid (EDTA). The EDTA chelates the metals was present in the samples. The hydrolysed samples were stored in HPLC amino acid analyzer bottles for further analytical operations.

Sample Derivatisation

The hydrolysed samples were derived automatically on the 616/626 HPLC by reacting the five amino acid, under basic situations with phenylisothiocyanate (i.e. PITC) amino acid derivatives. The duration was 45 minutes per sample as calibrated on the instrument. A set of standard solutions of the amino acids was prepared from Pierce Reference standards H (1000umol) into auto-sampler crops and they were also derived. These standards (0.0, 0.5, 1.0, 1.5, 2.0 µmol) were used to generate a calibration file that was used to determine the amino acids contents of the samples. After the derivatisation, a methanol solution (1.5N) containing the PTC-amino acids were transferred to a narrow bore waters 616/626 HPLC system for separation.

HPLC Separation and Quantization

The separation and quantization of the PTC-amino acids were done on a reverse phase, 18 silica column and the PTC chromophone were automatically and digitally detected at the wavelength of 254nm. The elution of the whole amino acids in the samples took 30 minutes. The buffer system used for separation was 140mm sodium acetate pH 5.50 as buffer A and 80% acetonitrile as buffer B. The program was run using a gradient of buffer A and buffer B concentration and ending with a 55% buffer B concentrations at the end of the gradient.

Data interpretation and calculation: The intensity of the chromatographical peak areas were automatically and digitally identified and quantified using a Dionex chromeleon data analysis system which is attached to the waters 616/626 HPLC system. The calibration curve or file prepared from the average values of the retention times (in minutes) and areas (in Au) at the amino acids in 5 standards runs was used. Since a known amount of each amino acid in the standard loaded into the HPLC, a response factor (Au/pmol) was calculated by the software that was inter-phased with HPLC. This response factor was used to calculate the amount of each of the amino acid (in pmol) in the sample and displayed on the system digitally. The amount of each amino acid in the sample is finally calculated by the software by dividing the intensity of the peak area of each (corrected for the differing molar absorptivities of the various amino acids) by the internal standard. (I.e. pierce) in the chromatogram and multiplying this by the total amount of internal standard added to the original sample. After the picomole by the intensity of the height of each amino acid ascertained by the software, the data, the digital chromatographic software extrapolate back to 5nmoles of the Internal Standard (Norleucine), and displays for the total amount that was pipette into the hydrolysis tube at the beginning of the analysis as below:

Mg/ml (in Extract) = Dilution factor x Peak height intensity

$$\text{Mg/ml (in sample)} = \frac{\text{µg/ml in extract x Sample volume}}{\text{Weight of sample}}$$

To convert to %, the product of the above equation was divided by 10,000.

Sensory Evaluation

A panel of 10 students from Food Science and Technology Department, University of Agriculture Makurdi were randomly selected. A 9-point Hedonic scale (1-dislike extremely, 5- neither like nor dislike and 9-like extremely) was used to rate the sensory attributes of appearance, texture, taste, aroma and overall acceptability of the products (Ihekoronye and Ngoddy, 1985). The 7 samples were 3-digit coded and presented randomly to the

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panellist with fresh tap water for mouth rinsing in between evaluations.

Statistical Analysis

The mean and standard deviation of triplicate samples were determined. The data were subjected to the Analysis of Variance as prescribed by Abu *et al.* (2006), Means were significantly different were separated using the Duncan Multiple Range Test. Significance were accepted at $p < 0.05$.

RESULTS DISCUSSION

Results

The amino acid composition of Bambara groundnut, African arrow lily and Soybean flour blends were presented below (Table 2). All essential amino acids increased significantly except methionine and histidine with increased levels of bambara groundnut and African arrowroot lily flours. Arginine increased significantly ($p<0.05$) from 0.98mg/ml to 4.62mg/ml for samples A, B, C, D, E, F and G respectively. Threonine increased significantly ($p<0.05$) from 0.08mg/ml in sample A to 0.98mg/ml in sample G. Leucine increased from 3.05mg/ml sample A to 6.60mg/ml in sample G. isoleucine increased from 0.35mg/ml in sample A to 1.63mg/ml in sample G. Lysine increased significantly ($p<0.05$) from 0.71mg/ml in sample A to 1.53mg/ml in sample G. Methionine content increased from 0.66mg/ml in 100% bambara groundnut flour to 0.68mg/ml in 40% bambara groundnut, 30% African arrowroot lily and 30% soy flour. Phenylalanine increased from 2.96mg/ml in sample A to 3.28mg/ml in G. Valine increased from 2.69mg/ml in sample A to 4.19mg/ml in sample G. Tyrosine content increased from 0.23mg/ml in sample A to 1.02mg/ml in G. Alanine increased significantly ($p<0.05$) from 1.35mg/ml in sample A to 4.14mg/ml in sample G. However, Histidine decreased significantly ($p<0.05$) from 1.87mg/ml in sample A to 0.46mg/ml in sample G. As well, aspartic acid decreased from 5.01mg/ml in sample A to 4.43mg/ml G while asparagine decreased from 0.66mg/ml in sample A to 0.46mg/ml in sample G. Glutamic acid increased significantly ($p<0.05$) from 9.22mg/ml in sample A to 12.44mg/ml in sample G but glutamine decreased from 2.86mg/ml in sample A to 1.36mg/ml G. Glycine increased from 0.88mg/ml in sample A to 1.73mg/ml in sample G, as well as proline from 1.02mg/ml in sample A to 2.01mg/ml in sample G and serine from 0.63mg/ml in sample A to 1.66mg/ml in sample G. Tryptophan decreased from 1.02mg/ml in sample A to 0.30mg/ml in sample G and cystine increased from 1.02mg/ml in sample A to 1.06 mg/ml in sample G.

Table 2: Amino Acid Profile of Bambara Groundnut, African Arrowroot Lily and Soybean flour blends

Sample	**A**	**B**	**C**	**D**	**Composition E**	**(%) F**	**G**	H	I
Arginine	$0.18^{g}\pm0.02$	$0.42^{f}\pm0.02$	$0.63^{e}\pm0.02$	$0.71^{d}\pm0.02$	$0.75^{c}\pm0.02$	$0.89^{b}\pm0.02$	$0.98^{a}\pm0.02$	$0.07^{h}\pm0.02$	$0.98^{a}\pm0.02$
*Threonine	$0.98^{b}\pm0.02$	$0.08^{f}\pm0.02$	$0.11^{ef}\pm0.03$	$0.13^{e}\pm0.02$	$0.15^{e}\pm0.02$	$0.45^{d}\pm0.02$	$0.88^{c}\pm0.02$	$0.80^{f}\pm0.02$	$1.69^{a}\pm0.02$
*Leucine	$0.60^{g}\pm0.02$	$0.89^{f}\pm0.02$	$1.05^{e}\pm0.02$	$1.25^{d}\pm0.02$	$1.63^{c}\pm0.15$	$1.96^{b}\pm0.02$	$2.05^{a}\pm0.02$	$0.12^{h}\pm0.02$	$1.03^{e}\pm0.02$
*Isoleucine	$0.35^{g}\pm0.02$	$0.58^{f}\pm0.02$	$0.72^{e}\pm0.02$	$0.85^{d}\pm0.02$	$1.11^{c}\pm0.02$	$1.38^{b}\pm0.02$	$1.63^{a}\pm0.02$	$0.06^{h}\pm0.02$	$1.65^{a}\pm0.02$
*Lysine	$0.71^{de}\pm0.54$	$0.49^{e}\pm0.02$	$0.61^{e}\pm0.02$	$0.71^{de}\pm0.02$	$0.98^{cd}\pm0.02$	$1.08^{c}\pm0.15$	$1.53^{b}\pm0.02$	$0.07^{f}\pm0.02$	$2.34^{a}\pm0.02$
*Methionine	$0.65^{d}\pm0.02$	$0.26^{f}\pm0.02$	$0.47^{e}\pm0.02$	$0.73^{c}\pm0.02$	$0.75^{c}\pm0.02$	$0.98^{b}\pm0.02$	$1.04^{a}\pm0.02$	$0.09^{g}\pm0.02$	$0.66^{d}\pm0.02$
*Phenylalanine	$0.86^{c}\pm0.02$	$0.28^{h}\pm0.02$	$0.33^{g}\pm0.02$	$0.48^{f}\pm0.02$	$0.59^{e}\pm0.02$	$0.76^{d}\pm0.02$	$0.98^{b}\pm0.02$	$0.24^{i}\pm0.02$	$1.96^{a}\pm0.02$
*Valine	$0.41^{c}\pm0.02$	$0.19^{g}\pm0.02$	$0.24^{f}\pm0.02$	$0.28^{e}\pm0.02$	$0.34^{d}\pm0.02$	$0.49^{b}\pm0.02$	$0.69^{a}\pm0.02$	$0.24^{f}\pm0.02$	$0.69^{a}\pm0.02$
*Histidine	$0.42^{d}\pm0.02$	$0.46^{d}\pm0.02$	$0.69^{d}\pm0.02$	$0.85^{cd}\pm0.02$	$0.99^{bcd}\pm0.02$	$1.14^{bc}\pm0.02$	$1.32^{b}\pm0.02$	$0.03^{e}\pm0.02$	$1.87^{a}\pm0.02$

Tyrosine	$0.23^{h}\pm0.02$	$0.48^{g}\pm0.02$	$0.56^{f}\pm0.02$	$0.69^{e}\pm0.02$	$0.81^{d}\pm0.02$	$0.98^{c}\pm0.02$	$1.02^{b}\pm0.02$	$0.06^{i}\pm0.02$	$2.01^{a}\pm0.02$
Alanine	$0.28^{h}\pm0.02$	$0.24^{f}\pm0.02$	$0.29^{e}\pm0.02$	$0.38^{d}\pm0.02$	$0.49^{c}\pm0.02$	$0.62^{b}\pm0.02$	$0.36^{d}\pm0.02$	$0.09^{g}\pm0.02$	$1.35^{a}\pm0.03$
Aspartic acid	$1.02^{b}\pm0.02$	$0.23^{f}\pm0.02$	$0.34^{e}\pm0.02$	$0.49^{d}\pm0.02$	$0.63^{c}\pm0.02$	$0.62^{c}\pm0.02$	$0.65^{c}\pm0.02$	$0.12^{g}\pm0.02$	$2.01^{a}\pm0.02$
Asparagine	$0.69^{h}\pm0.02$	$0.36^{g}\pm0.02$	$0.48^{f}\pm0.02$	$0.69^{e}\pm0.02$	$0.81^{d}\pm0.02$	$0.92^{c}\pm0.02$	$1.86^{a}\pm0.02$	$0.09^{h}\pm0.02$	$1.66^{b}\pm0.02$
Glutamic acid	$1.34^{h}\pm0.02$	$0.44^{g}\pm0.02$	$0.51^{f}\pm0.02$	$0.74^{e}\pm0.02$	$0.91^{d}\pm0.02$	$0.98^{c}\pm0.02$	$1.25^{b}\pm0.02$	$0.13^{i}\pm0.02$	$1.92^{a}\pm0.02$
Glutamine	$0.86^{b}\pm0.02$	$0.28^{g}\pm0.02$	$0.39^{f}\pm0.02$	$0.58^{e}\pm0.02$	$0.78^{c}\pm0.02$	$0.89^{b}\pm0.02$	$0.96^{a}\pm0.02$	$0.14^{h}\pm0.02$	$0.62^{d}\pm0.02$
Glycine	$0.88^{e}\pm0.02$	$0.59^{g}\pm0.02$	$0.79^{f}\pm0.02$	$0.98^{d}\pm0.02$	$1.07^{c}\pm0.02$	$1.35^{b}\pm0.02$	$1.73^{a}\pm0.02$	$0.06^{h}\pm0.02$	$0.77^{c}\pm0.02$
Proline	$1.02^{e}\pm0.02$	$0.81^{g}\pm0.02$	$0.98^{f}\pm0.02$	$1.08^{d}\pm0.02$	$1.77^{c}\pm0.02$	$1.98^{b}\pm0.02$	$2.01^{a}\pm0.02$	$0.87^{h}\pm0.15$	$1.69^{c}\pm0.02$
Serine	0.63 ± 0.02^{h}	$0.66^{g}\pm0.02$	$0.87^{f}\pm0.02$	$1.11^{e}\pm0.02$	$1.32^{c}\pm0.02$	$1.44^{b}\pm0.02$	$1.66^{a}\pm0.02$	$0.52^{i}\pm0.02$	$1.28^{d}\pm0.02$
*Tryptophane	$1.02^{c}\pm0.02$	$0.45^{g}\pm0.02$	$0.52^{f}\pm0.02$	$0.76^{e}\pm0.02$	$0.98^{d}\pm0.02$	$1.07^{b}\pm0.02$	$1.24^{a}\pm0.02$	$0.42^{g}\pm0.02$	$1.23^{a}\pm0.03$
Cystine	$1.02^{bc}\pm0.02$	$0.29^{g}\pm0.02$	$0.38^{f}\pm0.02$	$0.52^{e}\pm0.02$	$0.75^{d}\pm0.02$	$0.98^{c}\pm0.02$	$1.06^{ab}\pm0.02$	$0.08^{h}\pm0.02$	$1.08^{a}\pm0.02$

Values are means ± SDs of triplicate determinations. Means with the same superscript within the same row are not significantly different ($p > 0.05$).

A = 100% Bambara groundnut flour

B = 90% Bambara groundnut flour, 5% African arrowroot lily flour and 5% Soy flour

C = 80% Bambara groundnut flour, 10% African arrowroot lily flour and 10% Soy flour

D = 70% Bambara groundnut flour, 15% African arrowroot lily flour and 15% Soy flour

E = 60% Bambara groundnut flour, 20% African arrowroot lily flour and 20% Soy flour

F = 50% Bambara groundnut flour, 25% African arrowroot lily flour and 25% Soy flour

G = 40% Bambara groundnut flour, 30% African arrowroot lily flour and 30% Soy flour

H = 100% African arrowroot lily flour

I = 100% Soybean flour

The mean sensory scores of *Akpekpa* prepared from the flour blends were presented in Table 3. Addition of African arrowroot lily flour and Soy flour decreased the mean scores for all the sensory parameters which includes appearance (8.70 to 5.00), taste (8.50 to 4.00), aroma (8.80 to 5.50), texture (8.90 to 4.15) and general acceptability (8.95 to 4.40) for samples A to G respectively. There were significant difference ($p<0.05$) among the samples in all the parameters tested.

Table 3: Mean Sensory Scores of *Akpekpa* Produced from Bambara Groundnut, African Arrowroot Lily and Soybean Flour Blends

Parameter	A	B	C	D	E	F	G

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Appearance	8.70[a]	8.00[a]	7.70[b]	6.80[c]	6.65[c]	5.05[d]	5.00[d]
Taste	8.50[a]	7.30[b]	6.85[b]	5.50[c]	5.05[c]	4.45[d]	4.00[d]
Aroma	8.80[a]	7.30[b]	7.05[b]	6.65[c]	6.45[c]	5.75[d]	5.50[d]
Texture	8.90[a]	8.00[a]	7.85[b]	6.15[c]	5.05[d]	4.30[e]	4.15[e]
Acceptability	8.95[a]	8.05[a]	7.60[b]	6.40[c]	5.35[d]	4.80[e]	4.40[e]

Means with the same superscript within a row were not significantly different ($p > 0.05$).

Samples were evaluated in 9-point Hedonic scale (1 = disliked extremely and 9 = liked extremely)

A = 100% Bambara groundnut flour

B = 90% Bambara groundnut flour, 5% African arrowroot lily flour and 5% Soy flour

C = 80% Bambara groundnut flour, 10% African arrowroot lily flour and 10% Soy flour

D = 70% Bambara groundnut flour, 15% African arrowroot lily flour and 15% Soy flour

E = 60% Bambara groundnut flour, 20% African arrowroot lily flour and 20% Soy flour

F = 50% Bambara groundnut flour, 25% African arrowroot lily flour and 25% Soy flour

G = 40% Bambara groundnut flour, 30% African arrowroot lily flour and 30% Soy flour

DISCUSSION

The increase observed in the amino acid content of flour blends could result from the soybean addition due to its high quality content of amino acid especially lysine and leucine with glutamic acid having the highest content, helps in building muscles and supporting brain functions while arginine is the least content. The amino acid content is in agreement with that reported by Ihekoronye and Ngoddy (1985) showing that the Bambara groundnut is rich in essential amino acids, such as isoleucine, leucine, lysine, methionine, phenylalanine, threonine and valine. There were significant differences ($p>0.05$) in the lysine and leucine contents of the samples with lysine being the basic building block of all proteins while leucine is essential for growth, stimulates the production of muscle tissue and protects the liver from the damaging effects of alcohol. In accordance with previous literatures, glutamic and aspartic acids are the major non-essential amino acids, while leucine and lysine are the principal essential amino acids, thus indicating a protein quality very similar to that assessed for different legumes (Mune et al., 2011, Pastor-Cavada *et al*., 2014). Arginine which has being noted to be responsible for children growth (Aremu et al., 2006) was the least concentrated amino acid in bambara groundnut flour but increased with addition of soybean and African arrowroot lilly flour. This non-essential amino acid is required in muscle metabolism, maintaining the nitrogen balance and helping with weight control as it facilitates the increase of muscles mass while reducing body fat. Contrary to the report of Yao et al., (2015), tryptophan has high amount in bambara groundnut which increase when added to the flour blends. The high content of alanine would help the body to convert glucose to energy and also eliminate excess toxins from the liver while

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Phenylalanine is an essential amino acid that can elevate mood, decrease pain, aid in memory and learning and suppress the appetite in children.

The mean scores for all the sensory attributes evaluated decreased with increased level of soybean and arrowroot lily flours in the *akpekpa*. *Akpekpa* prepared from 100% bambara groundnut flour (sample A) had the highest score for all the sensory parameters. This may be due to the familiarity of the panellists to its appearance, taste, texture and aroma as compared to those prepared from the flour blends. Since samples A to E scored above 5 for all the sensory parameters which is the minimum sensory score acceptable on a 9-point Hedonic scale, therefore up to 20% substitution each of African arrowroot lily and soybean flour could be adopted to prepare *akpekpa*. Akubor and Oguche (2011) reported similar observation. Poor taste and aroma response samples F and G could be attributed to increasing level of soybean resulting to diminished distinct taste and characteristic aroma of *akpekpa*. In addition, the poor texture for samples F and G may be associated with sogginess of *akpekpa* due to increasing level of African arrowroot lily and soybean flour. However, the scores of general acceptability were significantly different ($p<0.05$) among samples the flour blends except for samples A and B which were the most acceptable.

CONCLUSION

The incorporation of African arrowroot lily and soybean flours into Bambara groundnut flour enhanced the amino-acid composition of the blends and supported the production of akpekpa with desirable sensory qualities. Among the formulations tested, the blend containing 90% Bambara groundnut, 5% soybean flour and 5% African arrowroot lily flour achieved the highest overall acceptability. This study demonstrates that nutritionally improved and organoleptically acceptable akpekpa can be successfully produced using flour blends of Bambara groundnut, African arrowroot lily and soybean, offering a viable approach to enhancing the nutritional quality of traditional foods.

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