

Development and evaluation of a plantain-peanut sandwich for the Nigerian market

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Abstract: Protein-energy malnutrition is a common nutritional disorder in developing countries and constitutes a major public health problem in young children and elderly people. This project is aimed at evaluating the acceptability of plantain-peanut sandwich and roasted at different temperatures. A plantain-peanut sandwich consists of minced protein stuffed into a carbohydrate source made into a roll as a food product. The plantain was roasted at two different temperatures then later enriched with 5%, 10% and 15% peanut butter. The crude protein and crude fibre contents of the plantain samples roasted at 200°C and 240°C showed no significant difference ($P>0.05$) while the ash, fat and carbohydrate contents showed that there was a significant difference ($P<0.05$). Results of the proximate composition showed that there was significant difference ($P<0.05$) at the two different roasting temperatures of 200°C and 240°C when enriched at 5%, 10% and 15% levels with peanut butter. This pattern of significant increase was also observed with the amino acid profiles at the two different roasting temperature levels.

Keywords: Plantain Peanut Butter, Roasting, Sandwich, Enrichment, Amino Acid Profile

1. Introduction

1.1. Plantain

Nigeria is faced with the problem of malnutrition due to deficiency of protein and calories. The protein-calories sources of vegetable origin have been proposed as a solution to this problem. In Nigeria and many African countries, plantains (*Musa paradisiaca*) are used as an inexpensive source of calories [4]. It is an important starchy staple and commercial crop in the West and Central Africa where fifty per cent of the world's plantain crop is produced [38]. Cassava, plantain and sweet potato are among the major starchy crops which are used in many tropical countries [12]. According to FAO [18], over 2.3 million metric tons of plantains are produced in Nigeria annually. However, about 35 to 60% post-harvest losses had been reported and attributed to lack of storage facilities and inappropriate technologies for food processing.

Plantain is a popular dietary staple due to its versatility and good nutritional value. It is starchy, less sweet variety of banana that can be used either ripe or unripe; they are invaluable source of carbohydrate, comparable in nutritive

value to yam or potato and are useful as a variant on the usual staple foods. It is consumed mainly in Nigeria as snacks in form of chips, boli, dodo ikire among others..

Plantains (*Musa spp.*, *AAB genome*) are plants producing fruits that remain starchy at maturity [25],[34] and need processing before consumption. Plantain production in Africa is estimated at more than 50% of worldwide production [18]. The majority (82%) of plantains in Africa are produced in the area stretching from the lowlands of Guinea and Liberia to the central basin of the Democratic Republic of Congo. West and Central Africa contribute 61 and 21%, respectively [13]. It is estimated that about 70 million people in West and Central Africa derive more than 25% of their carbohydrates from plantains, making them one of the most important sources of food energy throughout the African lowland humid forest zone [38].

Plantain and bananas (*Musa spp.*) serve as important food crops in much of Africa. Together they provide over 25% of the carbohydrate needs and 10% of the daily calorie requirements for over 70 million people on the African

continent [14]. The annual world production of plantain and banana is estimated at 75 million tonnes [23]. In Nigeria plantain production is estimated at about 2.11 million metric tonnes in 2004 [15],[32]

Plantains are members of the banana family. They are a starchy, low in sugar variety that is cooked before serving as it is unsuitable raw. It is used in many savoury dishes somewhat like a potato would be used and is very popular in Western Africa and the Caribbean countries. It is usually fried or baked. Plantains are native to India and are grown most widely in tropical climates. Plantains are sometimes referred to as the pasta and potatoes of the Caribbean. Sold in the fresh produce section of the supermarket, they usually resemble green bananas but ripe plantains may be black in colour. This vegetable-banana can be eaten and tastes different at every stage of development. The interior colour of the fruit will remain creamy, yellowish or lightly pink. When the peel is green to yellow, the flavour of the flesh is bland and its texture is starchy. As the peel changes to brown or black, it has a sweeter flavour and more of a banana aroma, but still keeps a firm shape when cooked.

The plantain averages about 65% moisture content and the banana averages about 83% moisture content. Since hydrolysis, the process by which starches are converted to sugars, acts fastest in fruit of higher moisture content it converts starches to sugars faster in bananas than it does in plantains. A banana is ready to eat when the skin is yellow whereas a plantain is not ready to eat "out of hand" until hydrolysis has progressed to the point where the skin is almost black. Plantains grow best in areas with constant warm temperatures and protection from strong winds. They have been grown in scattered locations throughout Florida since the 16th century.

The consumption of plantain has risen tremendously in Nigeria in recent years because of the rapidly increasing urbanization and the great demand for easy and convenient foods by the non-farming urban populations. Besides being the staple for many people in more humid regions, plantain is a delicacy and favoured snack for people even in other ecologies.

1.2. Groundnut

Groundnut (*Arachis hypogea*) is a true pulse, a member of the Leguminosae family that has gained recognition as both snack and a health food. Groundnut is a small annual herb growing up to a foot above the ground. It is thought to have originated in the Central Americas and from where it spread to rest of the world through Spanish explorers. Today, the nuts are widely cultivated oil seeds and has established as prime commercial crop in China, India, African nations, and the United States of America.

Groundnut is a rich source of fat ranging from 36 to 54% [8]. Groundnuts and groundnut butter are energy rich and nutritious foods, providing a valuable supply of a wide range of vitamins, minerals and dietary fibre [22].

Groundnuts (*Arachis hypogea*) have various uses:-adds to

good nutritional value, as soup thickener and when cooked, roasted, dried or fried serve as snacks. Sometimes, paste used as margarine or butter. More so, there are less expensive, widely distributed easily cultivated, consumed and sold by the masses.

Peanut-containing foods have high consumer acceptance because of their unique roasted peanut flavour. Peanuts are continually applied for the preparation of new and improved food products [40]. A large proportion of peanut production in the world is destined to domestic foods such as peanut butter, snack products, confections and roasting peanut products showing positive results in relation to consumer acceptance and sensory and chemical stability [[3], [20], [29],[30],[31]. The rest of the peanut production is utilized as an edible oil source of high quality [3]. Peanuts contain high percentages of oil (45-54%) and protein [35],[20].

Due to their high oil content, peanuts are rich in energy but are susceptible to developing rancidity and off-flavors through lipid oxidation because of their composition rich in unsaturated fatty acid (approximately 80%), with 40-50% and 30-40% of the oil being oleic and linoleic acids, respectively [19].

Groundnut, *Arachis hypogea* L. also known as peanut or earthnut is a native to a region in eastern South America [42]. It is grown as an annual crop principally for its edible oil and protein rich kernels seeds, borne in pods which develop and mature below the soil surface. The groundnuts, an herbaceous plant of which there are varieties, common in the United States, grow up to 30-46 cm high do not spread. Runner varieties, the most common in the West Africa are shorter and run along the ground for 30-60 cm [9]. Peanut (*Arachis hypogea* L.) is now grown worldwide in the tropic and temperature zones primarily as an oilseed crop [10]. Peanut seeds make important contribution to the diet in many countries. The fatty acids composition of the endogenous fats ranges from 22 to 30%. And the average oil content may reach 50% [33],[11]. These play an important role in determining shelf life, nutrition and flavour of peanuts seeds.

Groundnut provides an inexpensive source of high quality dietary protein and oil. The vast food preparations incorporating groundnut to improve the protein level has helped in no small way in reducing malnutrition in the developing Countries [7].

Worldwide, protein deficiency is the most common form of malnutrition. In parts of Asia, Africa and Latin America, protein deficiency occurs in millions of children [36] and groundnut is an important source of protein for the people of those regions. They are rich in many important nutrients that can help the human body stay healthy and enable to combat a variety of disease and health conditions.

In Nigeria, children suffer from kwashiorkor, due to protein deficiency, whose symptoms includes reduced energy levels, reduced immune system functioning hair loss, fatigue, constipation, reduced blood pressure, mental problems, skin rashes, weight loss, diarrhoea, kwashiorkor and reduced ability to fight infectious diseases, ultimately leading to premature death.

2. Materials and Methods

2.1. Materials

Matured unripe plantain (*Musa paradisiaca*) and peanut (*Arachis hypogea*) was obtained from Sango market in Ogun state and were processed in the food processing laboratory of the food science and technology laboratory of the university.

2.2. Methods

2.2.1. Preparation of Boli (Roasted Plantain)

The plantain was washed, peeled and weighed before roasting in the oven. After roasting, the boli is weighed and cooled.

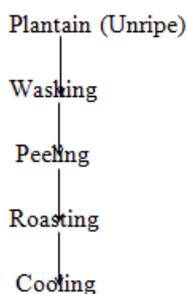


Fig 1. Flow chart for boli production

2.2.2. Preparation of Peanut Butter

The groundnut was washed, sorted and deshelled. The cleaned groundnut is soaked in 5% brine for 30 minutes, the brine is drained and oven dried and roasted at 80°C for 5 days. After roasting, the husk is removed and the groundnut is milled to produce peanut butter.

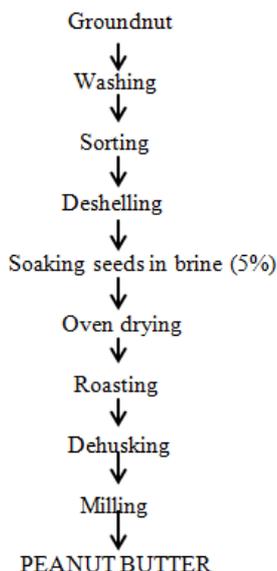


Fig 2. Flow chart of peanut butter production

2.2.3. Plantain-Peanut Mix (Burger) Production

The roasted plantain is weighed then 5%, 10% or 15% proportion of peanut butter is added to the roasted plantain. The plantain-peanut mix is then packaged and stored.

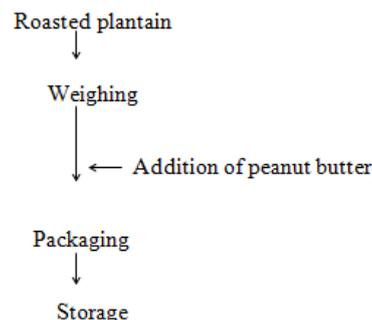


Fig 3. Flow diagram for the production of plantain-peanut mix

2.3. Proximate Analysis

2.3.1. Moisture Content Determination

The moisture content was determined using the procedure described in AOAC, [6], was used. The moisture content was determined by weighing 5g of the sample into the aluminum moisture can after the weight of the can has been gotten. The sample was dried in an oven for 3hours to a constant weight at 105°C.

$$\text{Moisture Content} = \frac{\text{weight of can with sample} - \text{weight of empty can} \times 100}{\text{Weight of sample}}$$

2.3.2. Ash Content Determination

3g of the plantain and peanut butter samples was weighed into a pre-weighed crucible and then placed in a muffle furnace to ash at 600oC for 3hours and then the ash content was calculated.

$$\text{Ash content} = \frac{(\text{weight of crucible} + \text{ash}) - \text{weight of empty crucible} \times 100}{\text{Weight of sample}}$$

2.3.3. Fat Content Determination

Crude fat was extracted in a soxhlet extractor with petroleum ether and quantified gravimetrically. 1g of sample was weighed into an extraction thimble and then stopped with grease-free cotton. Before the operation commenced, the extraction cans were dried, cooled and weighed. The thimble was placed in an extraction chamber and 80ml of petroleum ether was to the extraction can to extract the fat. The extraction was carried out at 135°C for 1hour 15minutes after which the fat collected in the extraction cans. The cans were dried in the oven, cooled in a desiccator and the weights were taken.

$$\text{Crude fat} = \frac{(\text{weight of can} + \text{fat}) - \text{weight of empty can} \times 100}{\text{Weight of sample}}$$

2.3.4. Crude Protein

The protein content was determined using a Foss TecatorTM protein digester and KJECTEC 2200 distillation apparatus (Kjedahl method) according to the procedure of AOAC, [6].

Concentrated H₂SO₄ and 2 tablets of catalyst were put into a kjedahl digestion flask containing 5g of the sample. The flask was placed in the digester in a fume cupboard and switched on and digestion was done for 45 minutes to obtain a clear colorless solution. The digestion was distilled with 4% boric acid, 20% sodium hydroxide solutions were automatically metered into it in the KJECTEC 2200 distillation equipment until distillation was complete. The distillate was then filtered with 0.1M HCl until a violet color formation indicating the end point. A blank was run under the same condition as with the sample. Total nitrogen content was then calculated according to the formula:

$$\text{Crude protein} = \frac{(\text{titre (of sample)} - \text{blank}) \times 0.01 \times 14.07 \times 6.25}{10 \times \text{weight of sample}}$$

2.3.5. Crude Fibre

2g of the sample was transferred into 1 litre conical flask. 100ml of sulfuric acid (0.255M) was heated to boiling and then introduced into the conical flask containing the sample. The contents were then boiled for 30 minutes and ensuring that the level of acid was maintained by addition of distilled water. After 30 minutes, the contents were then filtered through a muslin cloth held in a funnel. The residue was then transferred into a conical flask. 100ml of sodium hydroxide (0.313M) was then brought to boil and then introduced into the conical flask containing the sample. The contents were boiled for 30 minutes and ensuring that the level of the acid was maintained by the addition of distilled water. After 30 minutes, the contents were filtered through a muslin cloth held in a funnel. The residue was rinsed thoroughly into an already dried crucible and ashed at 600°C.

$$\text{Crude fibre} = \frac{\text{final weight of crucible} - \text{initial weight of crucible} \times 100}{\text{Weight of sample}}$$

2.4. Mineral Content Composition

The dry ashing procedure was used for mineral content determination. 5g of each sample were accurately weighed into porcelain crucibles and pre-ashed. The pre-ashed samples were thereafter ashed in the muffle furnace at 600°C till the ash was white for about 2 hours. After ashing, the crucibles were transferred into the desiccator to cool and then reweighed. Each sample was quantitatively transferred into volumetric flasks by carefully washing the crucibles having the samples with 30ml of 0.1M H₂SO₄ through a filter paper.

The solutions were diluted to volume with deionized water and were used for individual mineral determination using the appropriate standards and blank. The content of the minerals; magnesium, iron and copper, were determined with the Atomic Absorption Spectrophotometer (Buck Scientific, Model 210).

The percentage mineral content was calculated as follows:
Calculation:

$$\% \text{Mineral Element Concentration} = \frac{\text{meter reading} \times \text{slope} \times \text{dilution factor}}{1000}$$

2.5. Amino Acid Profile

The analysis of the amino acids was done using WATERS 616/626 LC High Performance Liquid Chromatography (HPLC) instrument.

Amino acid analysis is a method of estimating the concentration of each individual amino acid present in a given protein or peptide samples.

The sample preparation and determination were carried out in the following stages;

1. Hydrolysis
2. Derivatisation
3. Separation of the derivatised amino acids
4. Data processing /interpretation and calculations of the final results.

2.5.1. Step (1) Hydrolysis of the Samples

0.5g of the sample was weighed into sterile furnaces hydrolysis tube, 5nmols norleucine was added to the sample 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. This stage of hydrolysis of the samples lasted for between 20-30 hours at 108°C grade, containing ethylene diamine tetra acetic acid (EDTA). The EDTA chelates HPLC amino acids analyzer bottles for further analytical operations.

Step (2) Derivatisation; the hydrolyzed samples were derivatised automatically using the water 616/626 HPLC by reacting the five amino acid, under basic situations with phenylisothiocyanate (i.e. PITC) to get phenylthiocarbonyl (PTC) amino acid derivatives. The duration for this is 45 minutes per sample, as calibrated on the instrument.

These standards (0.0, 0.5, 1.0, 1.5, 2.0umol) were used to generate a calibration file that was to determine the amino acids content of the samples. After the derivatisation, a methanol solution (1.5N) containing the PTC-amino acid was transferred to a narrow bore waters 616/626 HPLC system for separation.

2.5.2. Step (3) the 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 chromo phone were automatically and digitally detected at the wavelength of 245nm.

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 concentration at the end of the gradient.

2.5.3. Step (4) Data Interpretation and Calculations

The intensity of the chromatography peaks areas were automatically and digitally identified and quantified using a Dionex chrome Leon 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 loaded into the HPLC, a response factor (Au/pmol) was calculated by the software that was interphase with the HPLC. This response factor was used to calculate the amount of each of the amino acid (in pmols) 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 intensity of the peak area of each (corrected for the differing molar absorptive 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 Pico mole by the intensity of the height of each amino acid has been ascertained by the software, the data, the digital chromatographic software extrapolate back to 5 nmoles of the internal standard (Norleucine), and displays for the total amount that was pipetted into the hydrolysis tube at the beginning of the analysis as below;

Calculations;

$$\text{mg/ml (in Extract)} = \frac{\text{Dilution factor} \times \text{peak height}}{\text{intensity}}$$

$$\text{mg/ml (in samples)} = \frac{\text{ug/ml in extract} \times \text{sample volume/wt.}}{\text{of sample.}}$$

3. Results and Discussion

3.1. Proximate Composition of Peanut Butter and Plantain Roasted at Different Temperatures

The results obtained from the proximate analysis in Table 1 showed a significant difference ($P > 0.05$) between the ash,

Table 2. Proximate composition of roasted plantain at different temperatures enriched with different proportions of peanut butter on dry weight basis.

	200°C P + 5%PB	200°C P + 10%PB	200°C P + 15%PB	240°C P + 5%PB	240°C P + 10%PB	240°C P + 15%PB
Ash	3.91±0.05 ^d	3.56±0.01 ^d	4.72±0.02 ^c	1.84±0.02 ^a	3.08±0.02 ^c	3.02±0.02 ^b
crude fibre	4.56±0.02 ^d	3.81±0.02 ^c	3.43±0.02 ^b	3.98±0.01 ^c	3.57±0.01 ^b	3.19±0.02 ^a
Fat	20.44±0.03 ^a	24.92±0.08 ^c	29.57±0.08 ^c	20.64±0.50 ^b	26.47±0.55 ^d	30.30±0.76 ^f
crude protein	4.77±0.29 ^a	6.39±0.06 ^b	7.99±0.10 ^c	5.01±0.05 ^a	6.70±0.09 ^b	8.09±0.04 ^c
Carbohydrate	66.30±0.35 ^b	61.30±0.33 ^c	54.27±0.31 ^a	68.50±0.36 ^d	60.17±0.50 ^c	55.38±0.33 ^c

Values within the same row with different superscript letters are significantly different from each other ($p < 0.05$)

LEGEND:

200°C P: PLANTAIN ROASTED AT 200°C

240°C P: PLANTAIN ROASTED AT 240°C

5% PB: ENRICHMENT WITH 5% PEANUT BUTTER

10% PB: ENRICHMENT WITH 10% PEANUT BUTTER

15% PB: ENRICHMENT WITH 15% PEANUT BUTTER

The result in Table 2 showed the enhanced plantain burger roasted at different temperatures of 200°C and 240°C showed appreciable increase in protein and fat components as the level of enhancement increases as compared to Abioye

fat and carbohydrate content of the plantains roasted at 200°C and 240°C and no significant difference ($P < 0.05$) between the protein and crude fibre content. However, the difference between the peanut butter in terms of protein content, fat and carbohydrate content and the roasted plantain at different temperatures of roasting were highly significant even at 1% level ($P < 0.01$). The protein component of peanut butter at 27.3% on dry weight basis as compared with the protein components of plantain roasted at 200°C and 240°C which is 2.37% and 2.41% respectively. Hence, that is the reason behind the enhancement of the plantain to produce "plantain-peanut burger or plantain-peanut sandwich" which is described as protein source (peanut butter) minced and stuffed into a carbohydrate source made into a roll as a food product. There was also a significant difference ($P < 0.05$) in the crude fibre and carbohydrate content between the peanut butter and plantain samples roasted at 200°C and 240°C.

Table 1. Proximate composition of peanut butter and plantain roasted at different temperatures on dry weight basis

	Peanut butter (%)	200°C plantain (%)	240°C plantain (%)
Ash	2.78±0.04 ^a	3.01±0.01 ^b	3.14±0.02 ^c
crude fibre	3.36±0.01 ^b	2.56±0.01 ^a	2.59±0.05 ^a
Fat	42.9±0.05 ^c	2.19±0.02 ^b	1.9±0.13 ^a
crude protein	27.3±0.10 ^b	2.37±0.01 ^a	2.41±0.01 ^a
carbohydrates	23.55±0.10 ^a	89.85±0.07 ^b	89.94±0.09 ^c

Values within the same row with different superscript letters are significantly different from each other ($p < 0.05$).

LEGEND:

200°C P: PLANTAIN ROASTED AT 200°C,

240°C P: PLANTAIN ROASTED AT 240°C

5% PB: ENRICHMENT WITH 5% PEANUT BUTTER

10% PB: ENRICHMENT WITH 10% PEANUT BUTTER

15% PB: ENRICHMENT WITH 15% PEANUT BUTTER

3.2. Proximate Composition of Roasted Plantain at Different Temperatures Enriched with Different Proportions of Peanut Butter

et.al.(2011) where the protein and fat contents increased with increasing level of soy flour substitution indicating nutrients enhancement with soy flour substitution ranging from 2.54% and 0.45% (0% soy flour substitution) to 8.40% and 7.05%

(40% soy flour substitution) respectively, [1]. The significant increase in the fat and protein content is obviously due to the significant quantity of protein and fat in peanut butter. There is a significant decrease ($P < 0.05$) in the carbohydrate content as the content of the peanut butter increases which is similar to a research by Adelakun *et al.* [2], the physical, compositional and sensory characteristics of soybean substitution in the production of kokoro, the protein and fat contents increased while the carbohydrate content decreased as the proportion of soybean flour mixture was increased. There is a significant increase in the ash content of the roasted plantain at 200°C and 240°C as the proportion of the peanut butter increased.

3.3. Essential Amino Acid Profile of Peanut Butter, Roasted Plantain at Different Temperatures and at Different Enrichment Levels

The result in Table 3 shows the amino acid profile of peanut butter, and plantain roasted at 200°C and 240°C respectively. For peanut butter, threonine had the highest percentage among the essential amino acid having 3.2%, this amino acid is needed to create other amino acids that aid the production of collagen and it is also important for antibody production (Travis, 2014) followed by lysine (2.37%). in the plantain samples roasted at 200°C and 240°C, there was a decrease in most of the essential amino acids except leucine and arginine. Lysine is the most vulnerable to stress of all the amino acids, because of the epsilon group which could easily be knocked off during processing [24].

The result in Table 4 shows the essential amino acid profile of plantain roasted at 200°C enriched with different 5%, 10% and 15% peanut butter. There is an appreciable increase in the percentage of the essential amino acids as the proportion of peanut butter increases. Also in the substitution of soy bean with pondo yam, the amino acid of pondo yam increased with increasing enrichment levels [12].

Table 3. Essential amino acid profile of roasted plantain at different temperatures.

AMINO ACIDS	Peanut butter	200°C plantain	240°C plantain
Threonine	3.20	2.03	1.85
Leucine	0.84	0.06	0.49
Isoleucine	0.41	1.06	0.90
Lysine	2.37	1.00	0.77
Methionine	0.77	0.49	0.45
Phenylalanine	0.85	1.46	1.10
Tyrosine	1.39	1.45	0.70
Valine	0.28	0.45	0.10
Arginine	0.74	0.13	0.99
Histidine	1.07	1.02	0.44

LEGEND:
 200°C P: PLANTAIN ROASTED AT 200°C
 240°C P: PLANTAIN ROASTED AT 240°C
 5% PB: ENRICHMENT WITH 5% PEANUT BUTTER
 10% PB: ENRICHMENT WITH 10% PEANUT BUTTER
 15% PB: ENRICHMENT WITH 15% PEANUT BUTTER

Table 4. Essential amino acid profile of 200°C roasted plantain enriched with different proportions of peanut butter.

AMINO ACID	200°C P + 5% PB	200°C P + 10% PB	200°C + 15% PB
Threonine	2.06	2.14	2.20
Leucine	0.09	0.13	0.18
Isoleucine	0.95	0.97	1.01
Lysine	1.06	1.12	1.19
Methionine	0.51	0.52	0.53
Phenylalanine	1.34	1.35	1.32
Tyrosine	0.48	0.52	0.58
Valine	0.13	0.14	0.15
Arginine	0.98	0.99	1.01
Histidine	0.33	0.37	0.41

LEGEND:
 200°C P: PLANTAIN ROASTED AT 200°C
 240°C P: PLANTAIN ROASTED AT 240°C
 5% PB: ENRICHMENT WITH 5% PEANUT BUTTER
 10% PB: ENRICHMENT WITH 10% PEANUT BUTTER
 15% PB: ENRICHMENT WITH 15% PEANUT BUTTER

Table 5. Essential amino acid profile of 240°C roasted plantain enriched with different proportions of peanut butter.

AMINO ACID	240°C P+ 5% PB	240°C P+ 10% PB	240°C P+ 15% PB
Threonine	2.00	2.03	2.11
Leucine	0.53	0.55	0.89
Isoleucine	0.82	0.85	0.87
Lysine	0.85	0.93	1.00
Methionine	0.46	0.47	0.49
Phenylalanine	1.06	1.07	1.08
Tyrosine	0.40	0.45	0.50
Valine	0.79	0.81	0.84
Arginine	0.93	0.94	0.97
Histidine	0.47	0.49	0.53

LEGEND:
 200°C P: PLANTAIN ROASTED AT 200°C
 240°C P: PLANTAIN ROASTED AT 240°C
 5% PB: ENRICHMENT WITH 5% PEANUT BUTTER
 10% PB: ENRICHMENT WITH 10% PEANUT BUTTER
 15% PB: ENRICHMENT WITH 15% PEANUT BUTTER

The result in Table 5 shows the essential amino acid profile of plantain roasted at 240°C enriched with 5%, 10% and 15% peanut butter, there is also an increase in the percentage of essential amino acids as the proportion of peanut butter increases.

3.4. Mineral Content Of Peanut Butter and Plantain Roasted at Different Temperatures

The mineral content of peanut butter and plantain roasted at 200°C and 240°C is shown in table 6.

The result showed a significant difference ($P < 0.05$) between peanut butter and plantain roasted at 200°C and 240°C in the magnesium content, the magnesium content of peanut butter is higher than the magnesium content in the plantain roasted at 200°C and 240°C. Also in the iron and copper content of peanut butter, 200°C roasted plantain and 240°C roasted plantain.

Table 7, showed a significant difference ($P < 0.05$) in the magnesium, iron and copper content of 200°C roasted

plantain enriched with 5%, 10% and 15% proportions of peanut butter.

Similarly following same pattern as in table 8, there was also a significant difference ($P < 0.05$) in the magnesium, iron and copper content of 240°C roasted plantain enriched with 5%, 10% and 15% proportions of peanut butter.

As already reported that fortification with soy flour was advantageous due to the increased nutritional value (higher mineral and protein content) (Morteza et.al, 2008). One would also expect that fortification or enrichment with peanut butter or any plant protein would follow similar trend.

4. Conclusion

Results from this study indicated that the peanut butter used in enriching the roasted plantain was able to increase the protein content as well as other proximate compositions except for the carbohydrate in the various combinations. Also the amino acid profile of the peanut burger increased with enrichment levels. The overall acceptability of the plantain roasted at 240°C enriched with 15% peanut butter received the highest rating.

In conclusion, the addition of peanut butter at 5%, 10% and 15% levels resulted in notable increase in protein content which could be a very good nutritional advantage to Nigerians as a result of the expensive cost of animal protein. The addition of peanut butter will have little or no effect on the final market price because of the ease of availability of peanut in the market.

Table 6. Mineral content of peanut butter and roasted plantain at different temperatures.

Sample	Magnesium mg/100g	iron mg/100g	copper mg/100g
Peanut Butter	101.00 ^b	2.40 ^b	0.71 ^a
200°C plantain	47.20 ^a	2.19 ^a	1.40 ^b
240°C plantain	47.20 ^a	2.22 ^a	1.50 ^b

Table 7. Mineral content of roasted plantain at 200°C enriched with different proportions of peanut butter.

Samples	Magnesium mg/100g	iron mg/100g	copper mg/100g
200°C CP+5%PB	47.55 ^a	2.19 ^a	1.41 ^a
200°C CP+10%PB	48.09 ^b	2.25 ^b	1.45 ^b
200°C CP+15%PB	48.85 ^c	2.55 ^c	1.51 ^c

Table 8. Mineral content of roasted plantain at 240°C enriched with different proportions of peanut butter.

Samples	Magnesium mg/100g	iron mg/100g	copper mg/100g
240°C CP+5%PB	47.23 ^a	2.24 ^a	1.46 ^a
240°C CP+10%PB	47.53 ^b	2.29 ^b	1.5 ^b
240°C CP+15%PB	48.35 ^c	2.7 ^c	1.57 ^c

LEGEND: 200°C P: PLANTAIN ROASTED AT 200°C,
240°C P: PLANTAIN ROASTED AT 240°C
5% PB: ENRICHMENT WITH 5% PEANUT BUTTER
10% PB: ENRICHMENT WITH 10% PEANUT BUTTER
15% PB: ENRICHMENT WITH 15% PEANUT BUTTER

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