Original Research Article

STUDIES ON THE MINERAL COMPOSITIONS AND ORGANOLEPTIC PROPERTIES OF FERMENTED AND EXTRUDED RIPE PLANTAIN AND GROUNDNUT BLEND.

Abstract

Extrusion cooking is one of the most efficient and versatile food processing technologies that can be used to produce pre-cooked and dehydrated food products. This study aimed at investigating the mineral compositions and organoleptic properties of fermented and extruded ripe plantain and groundnut blend. Ripe plantain and groundnut samples were obtained from Oja Oba market, Akure. The dehauled groundnut seeds were milled to give a paste after which the oil was removed to give fine flour, plantains were dried and milled and both were kept in an airtight container before use. The unripe plantain and groundnut flours were formulated in the ratio of (ripe plantain: groundnut) 100:0; 80:20; 60:40; 50:50 and 0:100 Sample A (100:0) = 100% ripe plantain flour Sample B (80:20) = 80% ripe plantain flour and 20% groundnut flour, Sample C (60:40) = 60% ripe plantain flour and 40% groundnut flour, Sample D (50:50) = 50% ripe plantain flour and 50% groundnut flour and Sample E (0:100) =100% groundnut flour. A batch of the flour blends were fermented using submerged state fermentation method for 96 hours. The fermentation process was terminated by oven drying at 60°C for 24 hours and later extruded. The sensory evaluation was carried out on the products. The study revealed that fermentation had significant ($p<0.05$) effects on high sodium contents (ranging from 37.90±0.00 to 44.80±0.01 mg/g) of the blends, potassium (K) content was highest in fermented blends with values ranging from 115.23±0.31 to 125.06±0.06 mg/g, extrusion and fermentation increased magnesium and calcium contents ranging from 18.00±0.57 to 150.0±0.00 and 50.01±0.24 to 220.0±0.57 mg/g respectively of the blends significantly ($p<0.05$) while there was no significant difference ($p<0.05$) in iron content between all the blends. Fermented blends had the highest overall acceptability. The investigation so far revealed that the blending of ripe plantain and groundnut has the potential of producing enriched complementary food for teeming malnourished children of developing countries.

Keywords: fermentation, extrusion, blends, mineral composition, sensory evaluation

INTRODUCTION

Plantain, (*Musa paradisiaca*) is loosely applied to any banana cultivar that is eaten when cooked. However, there is no formal botanical distinction between bananas and plantains. Cooking is also a matter of custom, rather than necessity. Ripe plantains can be eaten raw, since the starches are converted to sugars as they ripen. In some countries, there may be a clear distinction between plantains and bananas, but in other countries, where many cultivars are consumed, the distinction is not made in the common names used. In more formal usage, the term ‘plantain’ is used only for ‘true’ plantains, while other starchy cultivars also used for cooking are called ‘bananas’(Cronauer *et al.*, 2012). Plantains are a major staple food in West and Central Africa, the Caribbean islands, Central America and Northern Coastal parts of South America. They are treated as a starchy fruit with a relatively neutral flavor and soft texture when cooked. As with all bananas, part of the attractiveness of plantains as food is that they fruit all year round, making them a reliable all-season staple food. (Valmayor *et al*., 2000).

Mature, yellow plantains can be peeled like typical dessert bananas, the pulp is softer than in immature green fruit and some of the starch has been converted to sugar (Egbebi and Badamosi, 2011). The chemical compositions of plantains vary due to the following such as maturity, degree of ripeness, soil type, variety and climate (Zakpaa *et al*., 2010). Prior to its consumption plantain can be roasted, boiled with beans or tomatoes, cooked, baked, sliced and fried into chips, dehydrated for preservation and to serve as composite ingredients in industries for making baby foods (Odenigbo *et al*., 2013).

In traditional medicine, plantain is very useful in the cure of different diseases such as cardio vascular and kidney problems, dehydration in infants and diabetic patients or people with arthritis and gastro-intestinal ulcers (Opeke, 2006).

It has also been used in treatment of asthma and bronchitis, diarrhea and constipation; the peel of ripe plantain has antiseptic properties and is used to prepare a poultice for wounds or even applied directly to a wound in an emergency; leaves of plantain have been used medicinally for a range of disorder from headache to urinary tract infections, the stem juice was considered as a remedy for gonorrhoea (Skinner, 2005).

Groundnut (*Arachis hypogaea)* belongs to the family Fabaceae/Leguminosae, it is commonly known as the bean or pea family. It is a legume crop grown mainly for its edible seed. It is widely grown in the tropics and subtropics, being important to both small and large commercial producers. It is classified as both a grain legume and, because of its high oil content, an oil crop. (Seijo *et al*., 2007). It is an herbaceous plant of which there are different varieties such as Boro light, Boro Red, Mokwa, Campala, Guta and Ela (Anyasor, 2009).Groundnut (*A. hypogaea*) is the fifth most produced oil crop worldwide (USDA, 2013). Groundnut production worldwide is reported to be greater than 36 million tons per year (USDA, 2013). Based on current statistics, 42million tonnes of groundnuts are produced. Typically among crop plants, groundnut pods develop underground rather than aboveground. The major producers are China, United States, Nigeria and *S*udan (FAOSTAT, 2014).

Most groundnut are processed into groundnut cake and edible oil and processed into animal feed and as soil fertilizer while others are used for industrial purposes such as soaps, polish, insecticides and nitroglycerin (Heuze *et al*., 2017). In previous study as reported by Yu *et al*., (2007), the functional properties of defatted groundnut flour such as emulsification, bulk density, viscosity, and water and oil absorption were essential in food processing and formulation of food product. The regular consumption of groundnut and groundnut products help to lower the blood cholesterol level (Lokko *et al*., 2007). Kris-etherton *et al* (2008) reviewed the scientific data concerning groundnut consumption and coronary heart disease and concluded that regular consumption of groundnuts significantly reduces risk.

Fermentation in food processing is the process of converting carbohydrates to alcohol or organic acids using microorganisms under anaerobic conditions. Fermentation usually implies that the action of microorganisms is desired. The science of fermentation is known as zymology or zymurgy (McGovern *et al.,* 2004). The term fermentation sometimes refers specifically to the chemical conversion of sugars into ethanol, producing alcoholic drinks such as wine, beer, and cider. However, similar processes take place in the leavening of bread (CO_2 produced by yeast activity), and in the preservation of sour foods with the production of lactic acid, such as in sauerkraut and yogurt.

Fermentation is a very important process that allows the utilization of microorganisms to breakdown complex compounds to yield a unique tasting and aromatic foods, meet the requirements of low-cost, prevent food spoilage and foodborne diseases (Ojokoh, 2014). Not only does process of fermentation preserve foods, fermentation also improve digestibility by breaking down proteins within various foods and have been known to enrich substrates with nutritional essentials, such as vitamins, amino acids and fatty acids (Achi, 2005). All over the world, fermented foods are known to provide an important part of human diet. Fermented foods and beverages provide about 20- 40% of human food supply (Fagbemi *et al*., 2005).

Extrusion cooking is one of the most efficient and versatile food processing technologies that can be used to produce pre-cooked and dehydrated food products such as snacks food, baby foods, breakfast cereals, noodles, pastas and cereal based blends. Cereals in turn are the customary, traditional snacks ingredient due to their high starch content (Perez-Navarret *et al*., 2006).

During extrusion a set of mixed ingredients are forced through an opening in a perforated plate or die with a design specific to the food, and is then cut to a specified size by blades. Extrusion cooking was adopted for use in nutrition intervention projects mostly for malnourished individuals in many less developed continents like Asia, Latin America and Africa (Osundahunsi, 2006). The machine which forces the mix through the die is an extruder, and the mix is known as the extrudate. Many food extrusion processes involve a high temperature over a short time. The first extruder was designed to manufacture sausages in the 1870s (Karwe *et al*., 2008). Extrusion enables mass production of food via a continuous efficient system that ensures uniformity of the final product. This is achieved by controlling various aspects of extrusion process. It has also enabled the production of new processed food products and revolutionized many conventional snack manufacturing processes (Riaz c*et al*., 2000).

MATERIALS AND METHODS

Collection of Raw Materials

Ripe plantain and groundnut sample were obtained from Oja Oba market in Akure, Ondo State, Nigeria. The samples were kept in a sterile transparent polythene bag and then transported to microbiology laboratory FUTA, for further analysis.

Processing of Ripe Plantain Flour

Ripe plantain was sorted for maturity and washed with water. The healthy ripe plantain were peeled and sliced thinly into 3mm diameter and oven dried at 40°C for 72hours. The dried ripe plantain was then fed into an attrition mill. The milled flour was sieved with a mesh sieve into fine flour and kept in an airtight container before use.

Processing of Groundnut Flour

Groundnut seeds were cleaned by sorting out dirt and stones. The cleaned groundnut seeds were coarsely milled to separate the coat from the cotyledon. The husk was separated from the seed by blowing air into it. The dehauled groundnut seeds were milled to give a paste after which the oil was removed to give fine flour using an attrition mill after which it was sieved through a mesh. The groundnut flour was kept in an airtight container before use.

Formation of Groundnut-Plantain flour

The unripe plantain and groundnut flours were formulated in the ratio of (ripe plantain: groundnut) 100:0; 80:20; 60:40; 50:50 and 0:100 Sample A (100:0) = 100% ripe plantain flour Sample B (80:20) = 80% ripe plantain flour and 20% groundnut flour, Sample C (60:40) = 60% ripe plantain flour and 40% groundnut flour, Sample D (50:50) = 50% ripe plantain flour and 50% groundnut flour and Sample E (0:100) =100% groundnut flour.

Fermentation of Ripe Plantain and Groundnut Blends

A batch of the flour blends were fermented using submerged state fermentation method for 96 hours. The fermentation process was terminated by oven drying at 60°C for 24 hours.

Extrusion of the Samples

The extrusion process was carried out in a Brabender 20DN single screw laboratory extruder (Brabender OHG, Duisburg, Germany) having a uniform tapered screw with a nominal compression ratio of 2:1, diameter 19mm, length to diameter 20:1, die diameter 3mm and screw speed at feed inlet which was kept constant at 30rpm. Electrical heating was applied to the three barrel zones along the screw. The screw speed was maintained at 200rpm.

Two batches of samples were subjected to extrusion cooking. The first batch consists of the unfermented blends while the second batch was the fermented blends. The blends were hydrated and preconditioned by adding 10ml of water to 100g of the sample and manually mixed in a sterile bowl to ensure even distribution of water and form a dough. The dough were extruded using a Brabender 20DN single screw laboratory extruder (Brabender OHG, Duisburg, Germany). All the extrudates were air dried for 12hours after which they were stored at 38±2°C in sterile polyethylene bags and kept in properly labelled air tight containers

Mineral Compositions

The mineral content were analysed from the solutions obtained by first dry-ashing the sample. The ash in 10% (vol/vol) HCl was filtered and made up to the mark in a 100ml volumetric flask using distilled de-ionised water. Sodium and potassium were determined by flame photometry while calcium, magnesium and iron were determined by atomic absorption spectrophotometer (AAS) (AOAC, 2012).

Sensory Evaluation

The sensory evaluation was done by the method of panel of 15 judges, samples of the raw flour blend, extruded unfermented (EUF), fermented extruded (FE) flour blend and fermented unextruded flour blend (FUE), and were served to the panel. The panels rated the samples based on the colour, aroma, texture, taste and overall acceptability by grading them on a nine-point hedonic scale.

Like extremely = 9
Like very much = 8
Like moderately = 7

Like slightly	= 6
Neither Like nor Dislike	= 5
Dislike slightly	= 4
Dislike moderately	= 3
Dislike very much	= 2
Dislike extremely	= 1

RESULTS

Changes in the Mineral Compositions of Ripe Plantain and Groundnut flour blends

a. Sodium content of the ripe plantain-groundnut flour blends

The changes in the sodium content of the blends are represented in Table 1. The sodium content for the raw blends ranged from 0.50±0.09 to 7.20±0.05. Fermented blends exhibited values ranging from 37.90±0.00 to 44.80±0.01. Extruded unfermented blend had sodium content of 4.70±0.01 to 18.00±1.73. Extruded fermented blends exhibited sodium content ranging from 6.20±0.00 to 22.63±0.00.

b. Potassium content of the ripe plantain-groundnut flour blends

The potassium contents of the blends were shown in Table 1. There was a significant difference ($p \leq 0.05$) in all the samples. Potassium (K) content was highest in Fermented blends with values ranging from 115.23±0.31 to 125.06±0.06. Raw flour blends exhibited lowest potassium content with values ranging from 60.31±0.03 to 73.51±0.16.

c. Magnesium content of the ripe plantain-groundnut flour blends

Magnesium content of the samples is shown in Table 1. There was no significant difference ($p \leq 0.05$) in the raw blends. Fermented blends exhibited values ranging from 12.03±0.03 to 120.00±0.00. Extruded unfermented blend exhibited values ranging from 4.14±0.00 to 5.00±0.57. Extruded fermented blends had values ranging from 18.00±0.57 to 150.0±0.00.

d. Calcium content of the ripe plantain-groundnut flour blends

The calcium content of plantain-groundnut blends are shown in Table 1. The raw blends recorded values ranging from 33.80±0.05 to 41.47±0.15. Fermented blend exhibited values ranging from 40.03±0.03 to 200.00±0.00. Extruded unfermented blend had calcium content ranging from 36.58±0.55 to 45.31±0.06. Extruded fermented blends ranged from 50.01±0.24 to 220.0±0.57

e. Iron content of the ripe plantain-groundnut flour blends

The iron content of ripe-plantain-groundnut blends are shown in Table 1. There was no significant difference (p≤0.05) between all the blends**.** The raw blends had values ranging from1.82±0.02 to 2.61±0.06. Fermented blends exhibited values ranging from 1.02±0.01 to 5.61±0.03. Extruded unfermented blends had iron content ranging from 0.66±0.06 to 1.24±0.14. Extruded fermented samples had values ranging from 0.87±0.03 to 2.90±0.01.

Table 1: Mineral composition of ripe plantain and defatted groundnut blends

SAMPLE	Na(mg/g)	K(mg/g)	Mg(mg/g)	Ca(mg/g)	Fe(mg/g)
RA	2.78±0.01^{c}	67.90±0.01^{c}	4.53±0.05^{ab}	33.80±0.05^{d}	2.61±0.06^{a}
RB	2.40±0.01^{b}	69.00±0.00^{d}	4.60±0.08^{ab}	29.47±0.14^{c}	2.11±0.06^{a}
RC	6.00±0.00^{d}	62.70±0.03^{b}	5.09±0.03^{b}	41.47±0.15^{i}	1.97±0.00^{a}
RD	0.50±0.00^{a}	60.31±0.03^{a}	4.51±0.05^{ab}	27.60±0.00^{b}	1.82±0.02^{a}
RE	7.20±0.01^{e}	73.51±0.16^{f}	4.15±0.08^{a}	23.40±0.00^{a}	2.52±0.01^{a}
FA	39.53±0.00^{b}	125.06±0.06^{q}	120.00±0.00^{k}	200.00±0.00^{p}	2.93±0.04^{a}
FB	40.70±0.00^{c}	118.11±0.28^{n}	72.00±0.00^{i}	140.02±0.41^{o}	1.02±0.01^{a}
FC	37.90±0.00^{a}	115.23±0.31^{m}	48.06±0.18^{g}	140.00±0.57^{o}	5.61±0.03^{b}
FD	42.24±0.01^{d}	120.53±0.31^{o}	12.03±0.03^{c}	120.01±0.22^{m}	1.08±0.00^{a}
FE	44.80±0.01^{e}	123.33±0.20^{p}	24.00±0.00^{e}	40.03±0.03^{g}	2.21±0.66^{a}
EUA	18.00±1.73^{e}	84.14±0.43^{k}	5.00±0.57^{b}	45.31±0.06^{j}	1.24±0.14^{a}
EUB	6.90±0.00^{a}	80.70±0.00^{j}	4.60±0.10^{ab}	40.22±0.06^{gh}	1.16±0.09^{a}
EUC	4.70±0.01^{a}	72.07±0.20^{e}	3.88±0.00^{a}	38.70±0.06^{f}	0.66±0.06^{a}
EUD	14.54±0.00^{c}	79.00±0.00^{i}	4.45±0.01^{ab}	36.58±0.55^{e}	0.91±0.00^{a}
EUE	10.90±0.00^{b}	76.00±0.57^{h}	4.14±0.00^{a}	40.92±0.01^{hi}	0.70±0.00^{a}
EFA	22.63±0.00^{e}	88.28±0.31^{l}	150.0±0.00^{l}	220.0±0.57^{q}	2.90±0.01^{a}
EFB	9.70±0.01^{b}	81.00±0.11^{j}	77.10±0.00^{j}	130.00±0.00^{n}	1.59±0.00^{a}
EFC	6.20±0.00^{a}	74.33±0.08^{g}	50.00±0.00^{h}	120.03±0.31^{m}	1.82±0.01^{a}
EFD	19.09±0.01^{d}	84.30±0.65^{k}	18.00±0.57^{d}	90.03±0.31^{l}	0.87±0.03^{a}
EFE	11.50±0.00^{c}	76.54±0.08^{h}	27.00±0.57^{f}	50.01±0.24^{k}	1.76±0.00^{a}

Values are means of triplicate determinations ± SD. Means in the same column with different superscripts are significantly different (p≤0.05)

Keys:

RA= Plantain 100g, RB= Plantain 80g Groundnut 20g, RC= Plantain 60g Groundnut 40g, RD= Plantain 50g Groundnut 50g, RE= Groundnut 100g.FA=Fermented Plantain 100g, FB= Fermented Plantain 80g Groundnut 20g, FC= Fermented Plantain 60g Groundnut 40g, FD= Fermented Plantain 50g Groundnut 50g, FE= Fermented Groundnut 100%. EUA=Extruded Unfermented Plantain 100g, EUB=Extruded Unfermented Plantain 80g Groundnut 20g, EUC=Extruded Unfermented Plantain 60g Groundnut 40g, EUD= Extruded Unfermented Plantain 50gGroundnut 50g, EUE= Extruded unfermented Groundnut 100g, EFA-Extruded Fermented Plantain 100g, EFB-Extruded Fermented Plantain 80g Groundnut 20g, EFC-Extruded Fermented Plantain 60g Groundnut 40g, EFD-Extruded Fermented Plantain 50g Groundnut 50g EFE- Extruded Fermented 100g.

Organoleptic Analysis (Sensory Evaluation) of Plantain-Groundnut Blends

The result obtained in the evaluation demonstrated that there was no significant difference in the blends for colour, texture, aroma, taste and overall acceptability. Fermented blends and extruded unfermented blend recorded low values for colour. Raw blends, fermented blends and extruded fermented blends recorded highest values for texture. Fermented blends had the highest value for taste. Fermented blends recorded highest value for aroma. Raw blends, fermented blends and extruded fermented for overall acceptability. This result is represented in Table 2.

Table 2: Sensory evaluation of ripe plantain- groundnut blends.

Samples	Colour	Texture	Taste	Aroma	Overall acceptability
RA	8.00±0.19^{fghi}	8.06±0.15^{efgh}	8.00±0.16^{fgh}	8.33±0.12^{ab}	8.53±0.13^{fgh}
RB	7.06±0.22^{bcd}	7.00±0.19^{bc}	7.20±0.22^{cde}	7.40±0.13^{ab}	7.66±0.15^{cd}
RC	8.13±0.23^{ghi}	7.66±0.21^{def}	7.60±0.19^{efg}	7.93±0.22^{ab}	8.26±0.18^{efg}
RD	8.40±0.16^{hi}	8.46±0.13^{h}	8.20±0.20^{ghi}	8.60±0.13^{ab}	8.86±0.09^{h}
RE	7.20±0.20^{bcde}	6.86±0.23^{bc}	6.80±0.22^{bc}	7.06±0.20^{a}	7.20±0.20^{abc}
FA	7.93±0.20^{efghi}	8.00±0.19^{efgh}	8.53±0.16^{hi}	8.80±0.10^{ab}	8.93±0.66^{h}
FB	7.80±0.20^{defgh}	7.73±0.15^{defg}	8.06±0.18^{fghi}	8.06±0.11^{ab}	8.46±0.13^{fgh}
FC	7.00±0.25^{bc}	7.13±0.27^{cd}	7.66±0.21^{efg}	8.80±0.22^{ab}	8.20±0.17^{def}
FD	8.33±0.12^{hi}	8.26±0.15^{fgh}	8.66±0.12^{i}	8.80±0.10^{ab}	8.86±0.09^{h}
FE	6.00±0.23^{a}	6.00±0.19^{d}	6.13±0.19^{a}	7.40±0.19^{a}	6.80±0.20^{a}
EUA	7.33±0.42^{bcdef}	7.46±0.30^{cde}	7.06±0.33^{cde}	8.06±0.30^{ab}	7.66±0.31^{cd}
EUB	6.66±0.34^{ab}	6.86±0.27^{bc}	6.93±0.22^{cd}	6.60±0.19^{a}	7.53±0.21^{bc}
EUC	6.93±0.40^{bc}	6.26±0.22^{a}	6.26±0.28^{ab}	10.9±4.79^{b}	7.21±0.35^{abc}
EUD	8.40±0.21^{hi}	8.20±0.17^{fgh}	8.40±0.23^{hi}	8.26±0.24^{hi}	8.53±0.16^{fgh}
EUE	6.66±0.27^{ab}	6.20±0.17^{a}	6.26±0.18^{ab}	6.26±0.18^{a}	6.80±0.14^{a}
EFA	8.60±0.13^{i}	8.33±0.15^{hi}	8.33±0.18^{hi}	8.26±0.15^{ab}	8.60±0.13^{fgh}
EFB	7.53±0.19^{cdefg}	7.66±0.15^{def}	7.53±0.13^{def}	7.46±0.16^{def}	7.73±0.18^{cde}

EFC	7.20±0.20^{bcde}	7.13±0.19^{cd}	7.13±0.21^{cde}	7.20±0.20^{cde}	7.73±0.15^{cde}
EFD	8.26±0.11^{ghi}	8.26±0.11^{fgh}	8.60±0.13^{hi}	8.73±0.11^{ab}	8.80±0.10^{gh}
EFE	6.85±0.17^{bc}	6.50±0.13^{ab}	6.64±0.13^{abc}	6.78±0.15^{a}	7.07±0.16^{ab}

Values are means of triplicate determinations ± SD. Means in the same column with different superscripts are significantly different ($p \leq 0.05$)

Keys: RA= Plantain 100g, RB= Plantain 80g Groundnut 20g, RC= Plantain 60g Groundnut 40g, RD= Plantain 50g Groundnut 50g, RE= Groundnut 100g.FA=Fermented Plantain 100g, FB= Fermented Plantain 80g Groundnut 20g, FC= Fermented Plantain 60g Groundnut 40g, FD= Fermented Plantain 50g Groundnut 50g, FE= Fermented Groundnut 100%. EUA=Extruded Unfermented Plantain 100g, EUB=Extruded Unfermented Plantain 80g Groundnut 20g, EUC=Extruded Unfermented Plantain 60g Groundnut 40g, EUD= Extruded Unfermented Plantain 50gGroundnut 50g, EUE= Extruded unfermented Groundnut 100g, EFA-Extruded Fermented Plantain 100g, EFB-Extruded Fermented Plantain 80g Groundnut 20g, EFC-Extruded Fermented Plantain 60g Groundnut 40g, EFD-Extruded Fermented Plantain 50g Groundnut 50g EFE-Extruded Fermented 100g.

DISCUSSION

Mineral such as sodium (Na) and potassium (K) are essential in food. Fermentation improved the Na content of the blends. Calcium (Ca) is good for strong bones, teeth and muscle. It has been reported that magnesium is a component of chlorophyll and it is an important content in connection with ischemic heart disease and calcium metabolism in bones (Bergman *et al.,* 2009).Zinc (Zn) and Iron (Fe) are also essential for growth. Baiyeri *et al*., (2011) found significantly high levels of Nitrogen, Phosphorus, Potassium, Magnesium, and Calcium in fully ripe plantain pulp, but low levels of Fe, Cu, Zn, Na. Plantains are also reported to be a great source of vitamins A, B1, B2, B3, B6 and C (Shodehinde *et al*., 2013). Studies have reported processing methods for ripe plantain before consumption.

Sensory evaluation indicated that there was no significant difference in the colour, texture. Aroma, taste and overall acceptability of the raw flour blends, unfermented extruded blends, Fermented unextruded blends and fermented extruded blends. Extruded unfermented blends had the most pleasant aroma, raw flour blend had the best colour and texture while Fermented unextruded blends recorded the best taste. It was observed that fermentation enhanced the aroma of the blends. The judges had preference for fermented extruded blends; this may be because it had the best taste, aroma and overall acceptability. The fermented blends had better flavour than other test blends while raw blends had the best colour. Based on these they were much more acceptable. This is not surprising because it is known that appearance of food evokes the initial response and flavour determines the final acceptance or rejection of the product by the consumer (Onoja and Obizoba 2009). Colour changes of the fermented blends may be as a result of browning which occurred during fermentation.

CONCLUSION

The investigation so far revealed that the blending of ripe plantain and groundnut has the potential of producing enriched complementary food for teeming malnourished children of developing countries. From the results of this research work, it is evident that fermentation and extrusion will produce acceptable products and will go a long way to increase the nutritional and sensory attributes of blends.

REFERENCES

Achi, O. K. (2005). “Traditional Fermented Protein Condiments in Nigeria”. *African Journal of Biotechnology* **4** (13): 1612-1621.

Anyasor, G. N., Ogunwenmo, K. O., Oyelana, O. A., Ajayi, D. and Dangana, J. (2009). Chemical Analyses of Groundnut (Arachi hypogaea) Oil. *Pakistan Journal of Nutrition,* (3):269-272.

AOAC, (2012). Official methods of analysis of the Association of Official Analytical Chemists international. 19th edition. Gathersburg, Maryland, U.S.A.

Baiyeri, K. P., Aba S. C., Otitoju, G. T. and Mbah, O. B. (2011). The effects of ripening and cooking methods on mineral and proximate composition of plantain (Musa sp. AAB cv. ‘Agbagba’) fruit pulp. *African Journal of Biotechnol*ogy, **10**(36):6979-6984

Bergman, B. C., Tsvetkova, T., Lowes, B. and Wolfel, E. E. (2009). Myocardial FFA metabolism during rest and atrial pacing in humans. *American Journal of Physiological Endocrinology Metab*olism, **296**:E358–E366.

Cronauer, S. S. and Krikorian, A. D. (2012). Banana (Musa spp.); In Y.P.S. *Journal of Biotechnology in Agriculture and Forestry*. 233.

Egbebi, A. O, Bademosi T. A, (2011). Chemical composition of ripe and unripe banana and plantain. *International Journal of Tropical Medicine and Public Health*, **1**(1):1-5.

Fagbemi, T. N., Oshodi, A. A., Ipinmoroti, K. O. (2005). Processing effects on some antinutritional factors and in vitro multienzyme protein digestibility (IVPD) of three tropical seeds: breadnut (Artocarpusaltilis), cashewnut (Anacardiumoccidentale) and fluted pumpkin (Telfairiaoccidentalis). *Pakistan Journal of Nutrition*, **4**:250- 256.

FAOSTAT, (2014) "Peanut production" *Food and Agricultural Organization of the United Nations, Statistics Division. 2014. Retrieved 23 November 2016.*

Heuzé, V., Thiollet, H., Tran, G. and Lebas, F., (2017). Peanut forage. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO.

Karwe, Mukund, V. (2008). "Food extrusion". *Food Engineering*. **3**. Oxford Eolss Publishers Co Ltd. ISBN 978-1-84826-946-0.

Kris-etherton, P. M., Hu, F. B., Ros, E. and Sabate, J. (2008). The role of tree nuts and peanuts in the prevention of coronary heart disease: multiple potential mechanisms. *The journal of nutrition*. 138(9), 1746S-1751.

Lokko, P., Armar-klemesu, A. and Mattes, R. D. (2007). Regular peanut consumption improves plasma lipid levels in healthy Ghanaians. *International Journal of food Sciences and Nutrition*, **58**(3), 190-200.

McGovern, P. E., Zhang, J., Tang, J., Zhang, Z., Hall, G. R., Moreau, R. A., Nunez, A., Butrym, E. D., Richards, M. P. and Wang, C.(2004). Fermented beverages of pre- and proto-historic China. *Proceedings of the National Academy of Sciences*, **101**(51):17593–17598.

Odenigbo, M. A., Asumugha, V. U, Ubbor, S., Nwauzor, C., Otuonye, A. C., Offia-Olua, B. I. (2013). Proximate composition and consumption pattern of plantain and cooking banana. *British Journal of Applied Science and Technology*, **3**(4):1035-1043

Ojokoh, A. O. (2014). Proximate composition and antinutrient content of pumpkin *(Cucurbita pepo)* and sorghum *(Sorghum bicolor)* flour blends fermented with *Lactobacillus plantarum, Aspergillus niger* and *Bacillus subtilis. Ife Journal of Science* **16**(3): 1-11.

Onoja, U. S. and Obizoba, I. C. (2009). Nutrient composition and organoleptic attributes of gruel based on fermented cereal, legume, tuber and root flour. *Agro-science Journal of Tropical Agricultural and Food Environmental Extension*. **8**(3):162-168.

Opeke, L. K. (2006). Essential of crop farming. Spectrum Book Limited. Spectrum house Ring Road, Ibadan, 81-84.

Osundahunsi, O. F. (2006). Functional properties of extruded soybean with plantain flour blends. *Jounal of Food and Agricultural Environ*ment, **4**(1): 75-60.

Perez-Navarrete, C., Gonzalez, R., ChelGuerrero, L. and Betancur-Ancona, D. (2006). Effect of extrusion on nutritional quality of maize and lima bean flours blends. *Journal of Science, Food and Agriculture*, **86** (14): 2477-2484.

Riaz Mian, N. (2000). *Extruders in Food Applications*. CRC Press. 193.

Seijo, G., Lavia, G. I., Fernández, A., Krapovickas, A., Ducasse, D. A., Bertioli, D. J., Moscone, E. A. (2007). Genomic relationships between the cultivated peanut (Arachis hypogaea, Leguminosae) and its close relatives revealed by double GISH. *American Journal of Botany*, **94**:1963-1971.

Shodehinde, S. A., Oboh, G. (2013). Antioxidant properties of aqueous extract of unripe Musa paradisiaca on sodium nitroprusside induced lipid peroxidation in rat pancreas in vitro. Asian Pacific. *Journal of Tropical Biomedicine*. **3**(6): 449-457.

Skinner, P. (2005). Plantain and Banana. London: Macmillan Publishers Ltd.

USDA, (2013). United State Department of Agriculture (USDA).

Valmayor, R. V. Jamaluddin, S. H., Silayoi, B., Kusumo, S., Danh, L. D., Pascua, O. C. and Espino, R. R. C. (2000). 'Banana Cultivar Names and Synonyms in Southeast Asia'. *Bioversity international*. 55.

Yu, J., Ahmedna, M. and Goktepe, I. (2007). Peanut protein concentrates: production and functional properties as affected by processing, *Food Chemistry*, **103**:121-129.

Zakpaa, H. D., Al-Hassan, A., Adubofour, J. (2010). An investigation into the feasibility of production and characterization of starch from "Apantu" plantain (giant horn) grown in Ghana. *African Journal of Food Science*, **4**(9):571-577. 5.