

Effects of Fermentation and Extrusion on The Microbiological and Proximate Composition of Ripe Plantain and Groundnut Blend

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Abstract- This study was designed to monitor the effect of fermentation and extrusion on ripe plantain and groundnut blends. The blended samples were prepared in five combinations (A=100% ripe plantain; B= 80% ripe plantain: 20% groundnut; C= 60% ripe plantain: 40% groundnut; D= 50% ripe plantain: 50% groundnut and E= 100% groundnut) and separated into four batches (i.e. first batch = preconditioned and extruded; second batch = fermented; third batch = fermented and extruded; and fourth batch = unfermented/unextruded. The blended samples were fermented for 96 hours in submerged state fermentation. The pH, temperature and total titratable acidity (TTA) of the fermented samples were determined. A total of fourteen microorganisms comprising 9 bacteria, 3 molds and one yeast were isolated and identified as; *Bacillus subtilis*, *B. cereus*, *B. polymyxa*, *Proteus mirabilis*, *Staphylococcus aureus*, *S. epidemidis*, *Lactobacillus plantarum*, *L. fermentum*, *Pseudomonas aeruginosa*, *P. fluorescens*, *Aspergillus niger*, *A. flavus*, *Fusarium oxysporum* and *Saccharomyces cerevisiae*. The pH and TTA values varied significantly with fermentation time. The temperature reduced significantly as the fermentation day increases. The fermented sample showed increase in moisture and crude fibre contents (32.6 and 17.5) in samples E and B while raw blend B and D had lowest values (2.19 and 0.66) when compared to the extruded samples. The carbohydrate and protein contents recorded the highest value (80.8 and 16.6) in Extruded fermented plantain 100% and extruded unfermented groundnut 100% respectively. Findings from this study demonstrated that ripe plantain and groundnut blend can be fermented and extruded to produce food of enhanced nutritional value.

Index Terms- Fermentation, Extrusion, Microorganism, Blend.

I. INTRODUCTION

Ingestion and assimilation of food substance by an organism provide energy, maintain life, or stimulate their growth (FAOSTAT, 2008). Food crops have occupied an important place in human nutrition as they remain the major source of calories and proteins for a large proportion of the world population particularly in the developing countries. The development of nutritionally balanced protein foods to feed the growing population in the world is receiving increasing attention (Edema *et al.*, 2005). Amongst the legumes widely cultivated in

Nigeria, groundnut is among the underutilized. It is a rich source of protein, carbohydrate and phosphorus and it is grown mainly for its oil protein, plant residue and seed cake (Asibuo *et al.*, 2008).

Defatted groundnut flour is listed as being very nutritional and is very low in saturated fat and cholesterol. It is also a good source of dietary fibre, thiamine, folate, potassium and zinc and a very good source of protein, niacin, magnesium, phosphorus, copper and manganese. Groundnut flour produced from cake blends easily enhances or enriches the nutritive value of wheat and other flour (Purohit and Rajyalakshme, 2011).

The demand for plantain fruit within the country is high, with supply struggling to meet demand. This has hampered the status of this crop as a foreign exchange earner. It remains an important staple food, source of revenue, as well as the raw material for industries producing value added products in many parts of Nigeria (FAO, 2006). Plantain occupies a strategic role in rapid food production, being a perennial ratoon crop with a short gestation period (Ayoola, 2011). Food processing is the transformation of raw ingredients, by physical or chemical means into food, or food into other forms. Food processing combines food ingredients to produce marketable food products that can be easily prepared and served by the consumer (Levenstein, 2003).

Food processing dates back to the prehistoric ages when crude processing incorporated fermenting, sun drying, preserving with salts, and various types of cooking (such as roasting, smoking, steaming and oven baking), such basic food processing involves enzymatic changes to the basic structures of food in its natural form, as well serve to build a barrier against surface microbial activity that cause rapid decay (Levenstein, 2003).

Fermentation is one of the oldest methods of food preservation, and embedded in traditional cultures and village life. Fermentation enhances the nutrient of food through biosynthesis and bioavailability of vitamins (Ijarotimi, 2012). Fermented foods are described as palatable and wholesome and are generally appreciated for attributes, their pleasant flavours, aromas, textures, and improved cooking and processing properties (Holzapfel, 2002).

Extrusion cooking technology has been described as a process in which raw materials are heated and worked upon mechanically while passing through compression screws and is forced through a die (Anuonye, 2012). Extrusion cooking has been used as an important technique for modification and manufacture of a wide variety of traditional and novel foods and

food blends (Jisha *et al.*, 2010). Blended foods are usually precooked by extrusion so that less cooking time is required and to increase shelf life.

II. MATERIALS AND METHODS

1 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.

2 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.

3 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 dehusked groundnut seeds were milled to give a paste after which the oil was removed to give a 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.

4 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.

5 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.

6 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

7 Microbiological Analysis

Microbiological analyses were carried out on all the samples including the raw flour blends, during fermentation, on the extrudate as well as during storage. Samples were collected at 24hour interval during fermentation of the flour blends in triplicates. Serial dilution of the samples was carried out in testtubes by aseptically dissolving 1g of each sample (Plantain and groundnut) of five different concentrations at ratios (100: 0, 80:20, 60:40, 50:50 and 0:100) into 9ml of sterile distilled water and serially diluted into 10⁻⁵ dilution factor. 1ml of aliquot of dilution factor 10⁻³ and 10⁻⁵ of each sample was aseptically dispensed into different sterile Petri dishes containing Nutrient agar (NA), DeMan Rogosa and Sharpe agar (MRS) and potato dextrose agar (PDA), allowed to solidify and incubated at 37°C for 24 hours for bacterial growth and 28°C for 3 to 5 days for fungal growth.

8 Determination of pH

One gram of each sample (A-100% of Ripe Plantain; B- 80% Ripe Plantain and 20% Groundnut, C- 60%Ripe Plantain and 40%; D- 50% Ripe Plantain 50% Groundnut and E- 100% Groundnut) was dispensed into beaker containing 10ml of sterile distilled water then pH of the sample was taken using a glass electrode pH-meter (Hanna- pH 210) (Ojokoh *et al.*, 2014).

9 Determination of Temperature

Determination of temperature was done using a thermometer. The thermometer was inserted into the substrate every 24 hour to monitor the temperature (Ojokoh *et al.*, 2014).

10 Determination of Total Titrable Acidity (Tta)

Determination of total titratable acidity (TTA): The total titratable acidity of the fermenting extrudates was determined every twenty-four hour as described by AOAC (2012). Two (2) grams of the sample was weighed, 20ml of distilled water was added and then filtered. 10ml of the filtrate was measured and few drops of phenolphthalein indicator added. This was titrated with 0.1m sodium hydroxide (NAOH) solution and the titre values in milliliter were added from the burette (Ojokoh *et al.*, 2014). The acidity was calculated as follows:

$$TTA = \text{Titre Value} \times \text{Volume of Sample} \times 9\text{mg}/100.$$

11 Proximate Analysis

The proximate composition (moisture, ash, crude fibre, fat, protein and carbohydrate) of the fermented blends, fermented extruded blend, unfermented extruded blends and raw flour blends was determined according to the method of AOAC (2012).

12 Statistical Analysis

Data are represented as mean standard error ± SD. Significance of difference between different treatment groups was tested using one-way analysis of variance (ANOVA)using Duncan's new Multiple Range test at (P<0.05) Confidence Level using SPSS version 20.

III. RESULTS

1 MICROBIAL GROWTH DURING FERMENTATION OF RIPE PLANTAIN AND GROUNDNUT FLOUR BLENDS

1.1 Changes in Bacteria Population during Fermentation of Plantain and defatted Groundnut Blend.

Figure 1 shows the changes in the bacteria population of plantain and defatted groundnut. The bacteria population of the entire blend increased with increase in fermentation time. For sample A (Plantain 100%) at 24 hours, 48 hours and 72 hours the bacteria population increased with values 6.33cfu/g, 13.3cfu/g and 16.6cfu/g while at 96 hours of the fermentation it decreased to 11.0cfu/g. There was increase in bacteria population for sample B (Plantain 80%, Groundnut 20%) at 24 hours and 48 hours with values 10.0cfu/g and 12.6cfu/g, a sharp decrease was recorded at 72 hours with a value of 9.00cfu/g and increased to 16.6cfu/g at 96 hours. An increase in bacteria population for sample C was recorded throughout the fermentation period (24, 48, 72 and 96) with values 7.33cfu/g, 10.0cfu/g, 10.6cfu/g and 14.6cfu/g. There was increase in the bacteria population for sample D (Plantain 50%, Groundnut 50%) at 24 hours and 48 hours with values 8.33cfu/g and 8.00cfu/g. Decrease was recorded at 72 hours with a value of 3.00cfu/g while increase was observed at 96 hours with value 9.00cfu/g. Increase in bacteria population for sample E

was recorded throughout the fermentation period (24, 48, 72 and 96) with values 12.6cfu/g, 16.3cfu/g, 17.3cfu/g and 19.3cfu/g. The highest aerobic bacteria count was observed in flour blend E at 96 hours while the lowest count was observed in the flour blend A at 24 hours.

1.2 Changes in Fungi Population during Fermentation of Ripe Plantain and defatted Groundnut Blend.

Figure 2 shows the changes in the fungal population of the flour blends during fermentation. There was no fungal growth at 0 hour for all the samples. Sample A had an initial fungal count of 8.66 ± 0.67 CFU/g at 24 hours, decreased to 6.67 ± 0.67 at 48 hours, 5.33 ± 0.33 CFU/g at 72 hours and 4.67 ± 0.67 CFU/g at 96 hours. Sample B had an initial growth of 9.33 ± 0.88 CFU/g at 24 hours, 9.33 ± 0.33 CFU/g at 48 hours, decreased to 6.33 ± 0.33 CFU/g at 72 hours and 3.66 ± 0.33 CFU/g at 96 hours. Sample C had an initial growth of 7.00 ± 0.58 CFU/g at 24 hours, decreased to 5.66 ± 0.67 CFU/g at 48 hours, 3.33 ± 0.33 CFU/g at 72 hours and 4.66 ± 0.67 CFU/g at 96 hours. Sample D had an initial growth of 1.66 ± 0.33 CFU/g at 24 hours, increased to 3.00 ± 0.58 CFU/g at 48 hours, decreased to 2.00 ± 0.00 at 72 hours and increased to 4.67 ± 0.67 CFU/g at 96 hours. Sample E had an initial growth of 6.00 ± 0.58 CFU/g at 24 hours, decreased to 4.67 ± 0.67 CFU/g at 48 hours, 2.33 ± 0.33 CFU/g at 72 hours and 3.00 ± 0.00 CFU/g at 96 hours.

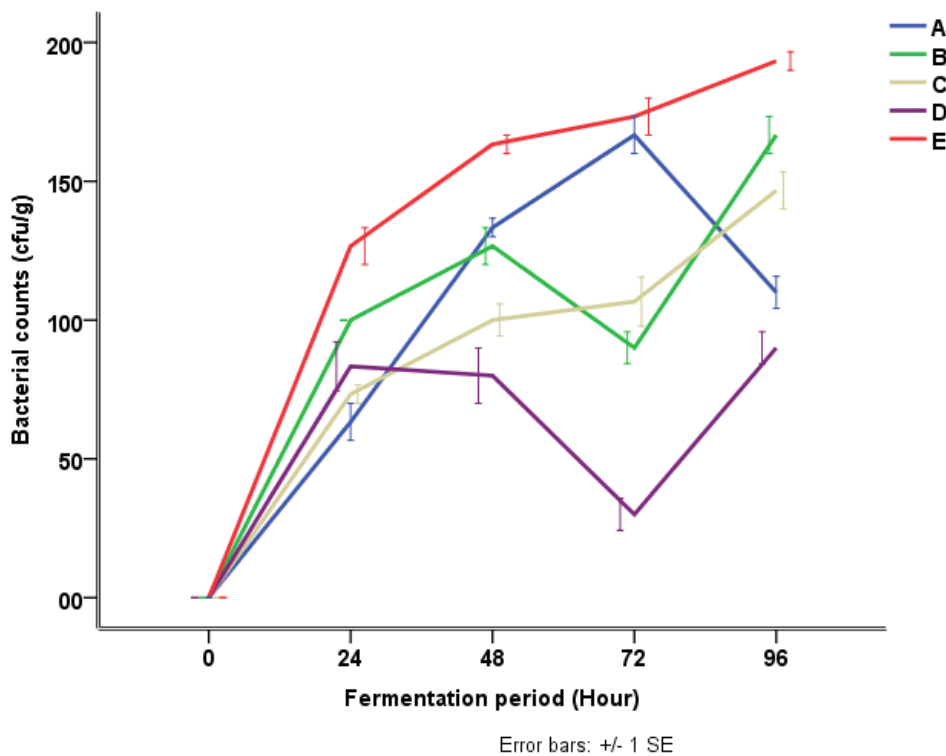


Figure 1: Changes in Bacteria Count during the Fermentation of Ripe Plantain and Groundnut blends ($\times 10^5$)

KEY: A= Plantain 100, B = Plantain 80%, Groundnut 20%, C= Plantain 60%, Groundnut 40%, D= Plantain 50%, Groundnut 50%, E=Groundnut 100%

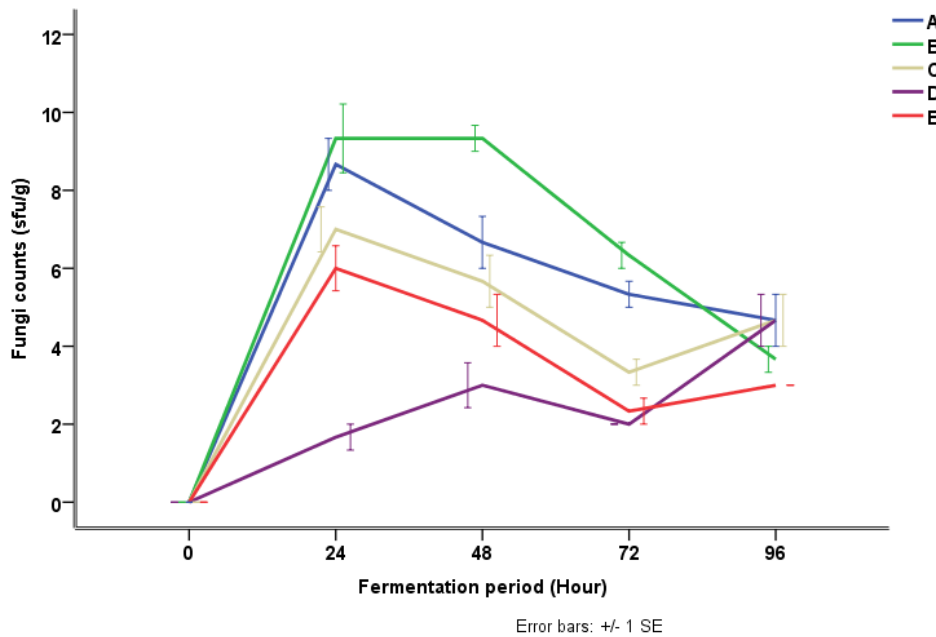


Figure 2: Changes in Fungi Count during the Fermentation of Ripe Plantain and Groundnut blends ($\times 10^5$)

KEY: A= Plantain 100, B = Plantain 80%, Groundnut 20%, C= Plantain 60%, Groundnut 40%, D= Plantain 50%, Groundnut 50%, E=Groundnut 100%.

1.3 Microorganisms isolated during the fermentation of ripe plantain and groundnut flour blends

A total of fourteen (14) microorganisms were isolated during the fermentation of ripe plantain and groundnut flour blends. These comprise of ten (10) bacteria three (3) moulds and one (1) yeast. These are *Bacillus subtilis*, *Bacillus cereus*, *Bacillus polymyxa*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Proteus mirabilis*, *Pseudomonas aeruginosa*, *Pseudomonas fluorescens*, *Lactobacillus fermentum*, *Aspergillus niger*, *Aspergillus flavus*, *Fusarium oxysporum*, *Lactobacillus plantarum* and *Saccharomyces cerevisiae*.

2 Changes in pH during Fermentation of Ripe Plantain and defatted Groundnut Flour Blend.

The pH variations during the fermentation of ripe plantain-groundnut extrudates are shown in Figure 3. Sample A gradually decreased from 5.20 ± 0.00 to 3.76 ± 0.03 , Sample B decreased from 5.30 ± 0.00 to 3.80 ± 0.00 . Sample C, decreased from 5.50 ± 0.00 to 3.80 ± 0.00 . Sample D decreased from 5.60 ± 0.00 to 3.90 ± 0.00 . Sample E at 0 h decreased from 6.00 ± 0.05 to 5.83 ± 0.03 at 24 hours and 48 hours increased to 6.50 ± 0.0 at 72 hours and finally increased to 6.90 ± 0.00 at 96 hours.

3 Changes in Temperature during Fermentation of Ripe Plantain and Groundnut Flour Blends.

Variation in temperature during the fermentation of Ripe Plantain and groundnut flour extrudates are represented in Figure

4. The temperature ranges from 33.0°C to 25.6°C at 0 hour. The temperature value ranges from 31.0°C to 31.0°C at 24 hours. The temperature value ranges from 29.6°C to 31.0°C at 48 hours. The temperature value ranges from 28.0°C to 27.0°C at 72 hours and the temperature range at 96 hours were from 25.6°C to 27.0°C .

4 Changes in Total Titratable Acidity during Fermentation of Ripe Plantain and groundnut

Variations in titratable acidity (TTA) during fermentation of ripe plantain-groundnut extrudates are represented in Figure 5. Sample A had TTA of 0.010 ± 0.00 at 0 hour; this increased to 0.015 ± 0.00 and 0.027 ± 0.00 at 48 hours and 72 hours and decreased slightly to 0.012 ± 0.00 at 96 hours. Sample B increased from 0.026 ± 0.00 at 0 hour and decreased slightly to 0.018 ± 0.00 at 24 hours, increased slightly to 0.024 ± 0.00 at 48 hours and then decreased to 0.009 ± 0.00 at 72 hours and finally increased to 0.033 ± 0.00 at 96 hours. Sample C at 0 hour decreased from 0.030 ± 0.00 to 0.018 ± 0.00 at 24 hours and slightly increased to 0.027 ± 0.00 at 48 hours, decreased to 0.012 ± 0.00 at 72 hours and finally increased to 0.033 ± 0.00 at 96 hours. Sample D at 0 hour decreased from 0.020 ± 0.00 to 0.018 ± 0.00 at 24 hours at 48 hours decreased from 0.030 ± 0.00 to 0.015 ± 0.00 at 72 hours and finally increased to 0.042 ± 0.00 at 96 hours. Sample E (Groundnut 100%) at 0 hour decreased from 0.033 ± 0.00 to 0.027 ± 0.00 at 24 hours and 48 hours, decreased to 0.015 ± 0.00 at 72 hours and finally increased to 0.042 ± 0.00 at 96 hours.

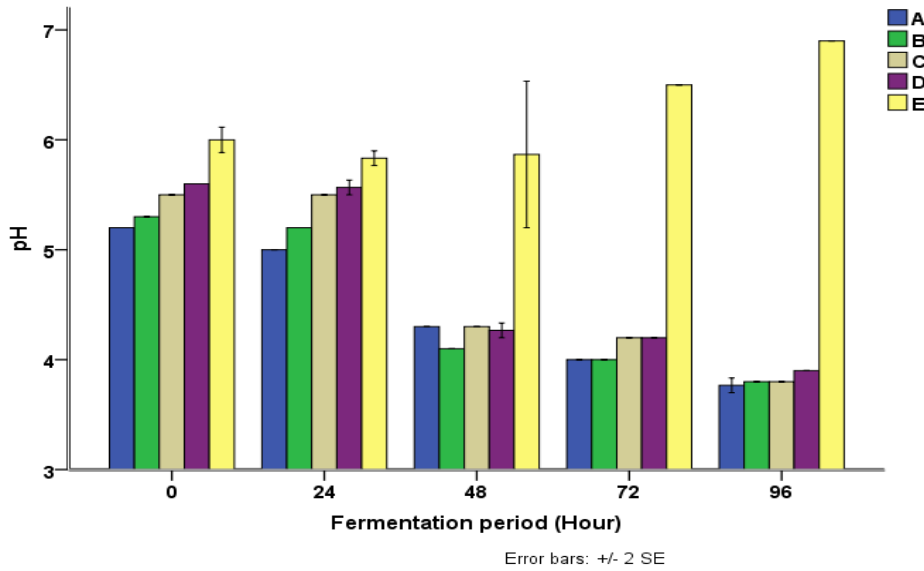


Figure 3: pH Value during Fermentation of Ripe Plantain and Defatted Groundnut Blend.

KEY:

A= Plantain 100%, B= Plantain 80%, Groundnut 20%, C= Plantain 60%, Groundnut 40%, D= Plantain 50%, Groundnut 50%, E=Groundnut100%

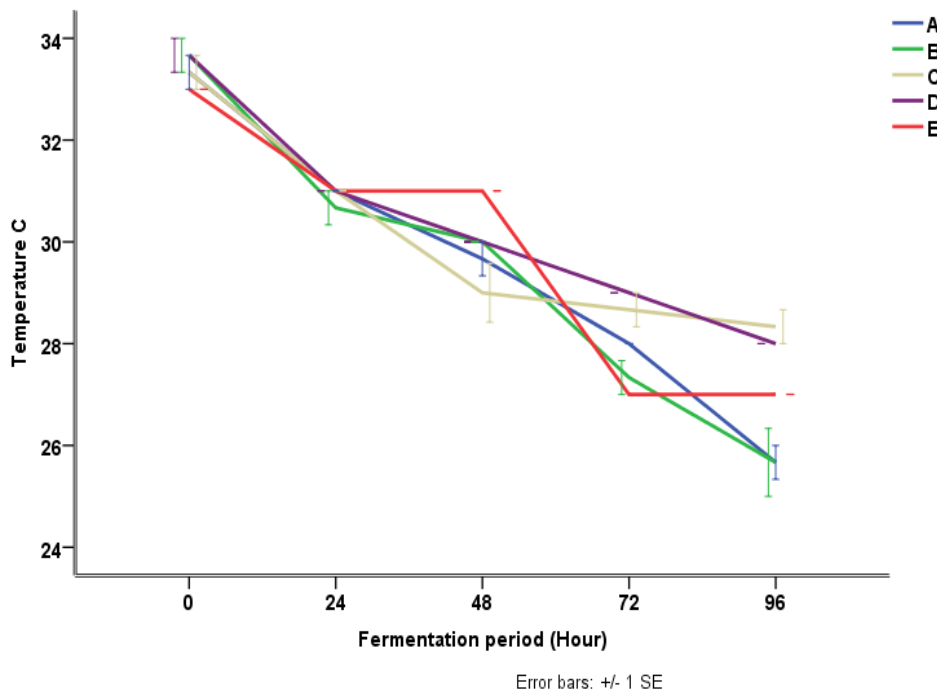


Figure 4: Temperature (°C) during Fermentation of Ripe Plantain and defatted Groundnut flour Blends.

KEY:

A= Plantain 100%, B= Plantain 80%, Groundnut 20%, C= Plantain 60%, Groundnut 40%, D= Plantain 50%, Groundnut 50%, E= Groundnut 100%

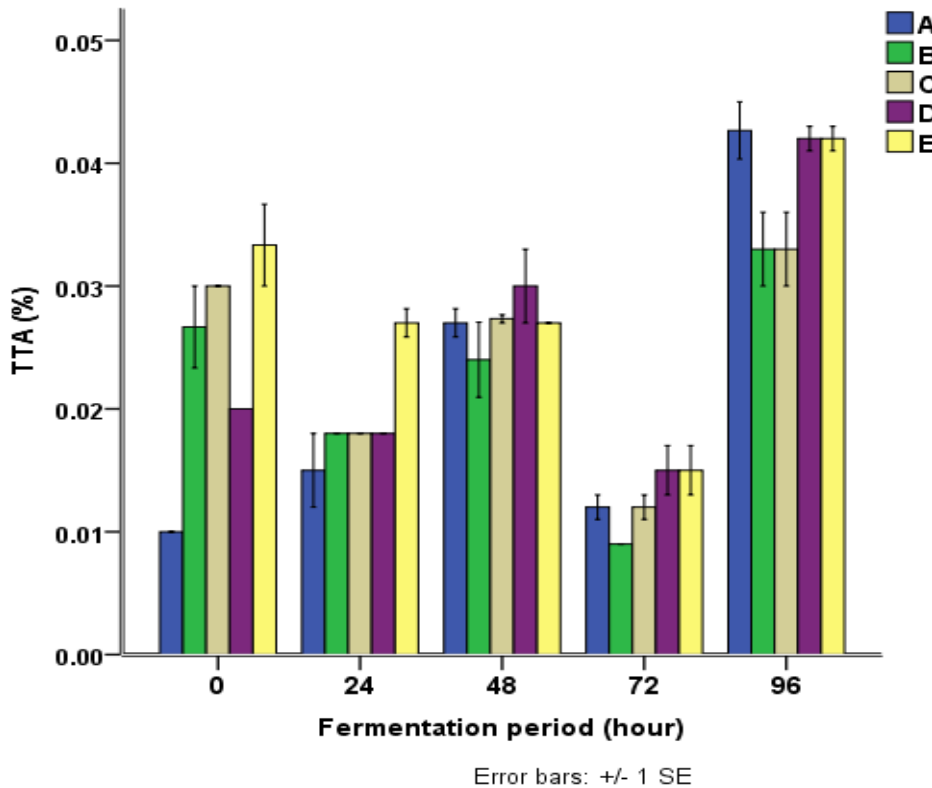


Figure 5: Total Titratable Acidity Variation during the fermentation of Groundnut and Ripe Plantain Blend

KEY: A= Plantain 100g, B= Plantain 80g, Groundnut 20g, C= Plantain 60g, Groundnut 40g. D= Plantain 50g, Groundnut 50g E= Groundnut 100g

5 Changes in Proximate Composition of Ripe Plantain and Groundnut Flour Blend.

5.1 The ash content of ripe plantain-groundnut flour blend

The changes in the ash content of the ripe plantain-groundnut blends are represented in Table 1. The ash content of the raw blends range from 3.03 ± 0.00 to 3.38 ± 0.05 . There was no significant difference between samples B and C. Fermented samples had values ranging from 1.35 ± 0.01 to 1.55 ± 0.01 . Extruded unfermented samples had values ranging from 2.52 ± 0.01 to 3.56 ± 0.01 . Extruded fermented blends had ash content ranging from 1.39 ± 0.04 to 1.77 ± 0.00 .

5.2 The moisture content of ripe plantain-groundnut blend

The moisture content of ripe plantain-groundnut flour blends are represented in Table 1. Raw flour blend had the lowest moisture content with values ranging from 2.19 ± 0.01 to 6.08 ± 0.00 . There was no significant difference ($p \leq 0.05$) in raw flour A and B. Fermented blend had the highest moisture content with fermented blend ranging from 26.0 ± 0.01 to 32.6 ± 0.05 in samples A-E. The extruded unfermented blends ranged from 2.76 ± 0.02 to 5.24 ± 0.03 in samples A-E. Extruded fermented sample exhibited moisture content ranging from 9.80 ± 0.00 to 15.9 ± 0.00 .

5.3 The fat content of ripe plantain-groundnut flour blends

The fat content of ripe plantain groundnut blends are shown in Table 1. There was significant ($p \leq 0.05$) difference in the fat content of the raw flour blends A to E with values ranging from 0.40 ± 0.00 to 28.4 ± 0.11 . There were significant ($p \leq 0.05$) changes in the fermented blends A to E with values 1.00 ± 0.01 to 15.0 ± 0.05 . The extruded unfermented (EU) had the highest fat content with values ranging from 1.36 ± 0.00 to 21.8 ± 0.05 . Fat content of extruded fermented samples ranged from 1.36 ± 0.00 to 18.2 ± 0.11 .

5.4 The crude fibre content of ripe plantain-groundnut flour blends

The crude fibre content of the ripe plantain-groundnut blends are shown in Table 1. There was significant difference ($p \leq 0.05$) in the crude fibre content of the blends. The crude fibre of the raw blends range from 0.66 ± 0.01 to 8.15 ± 0.02 . Fermented blends had the highest crude fibre content ranging from 9.65 ± 0.04 to 17.5 ± 0.02 . Extruded unfermented blends had crude fibre content ranging from 0.73 ± 0.06 to 9.26 ± 0.00 . Extruded fermented blends ranged from 5.09 ± 0.00 to 15.0 ± 0.01 .

5.5 The protein content of ripe plantain-groundnut flour blends

The variations in protein content of ripe plantain-groundnut blends are shown in Table 1. There was significant ($p \leq 0.05$) difference in the raw flour blends with values ranging from 2.45 ± 0.00 to 8.06 ± 0.00 . Fermented samples recorded significant difference ($p \leq 0.05$) for all the blends with values ranging from 2.49 ± 0.00 to 9.77 ± 0.00 . The extruded unfermented sample has protein content ranged from 6.33 ± 0.00 to 16.6 ± 0.05 . Extruded fermented samples exhibited significant difference ($p \leq 0.05$) among all the blends with values ranging from 4.97 ± 0.00 to 9.77 ± 0.01 .

5.6 The carbohydrate content of ripe plantain-groundnut flour blends

The carbohydrate content of ripe plantain-defatted groundnut blends is shown in Table 1. Carbohydrate content of raw flour blends ranged from 58.4 ± 0.00 to 75.7 ± 0.01 . The fermented blends had carbohydrate content ranging from 35.6 ± 0.01 to 62.9 ± 0.03 . Extruded unfermented blends had carbohydrate content ranging from 45.7 ± 0.01 to 80.3 ± 0.00 . The extruded fermented blends had values ranging from 10.2 ± 0.05 to 80.8 ± 0.05 .

Table 1: Proximate composition Ripe Plantain and Groundnut flour blend.

Samples	Ash (%)	Moisture (%)	Fat (%)	Crude (%)	Protein (%)	Carbohydrate (%)
RA	3.03 ± 0.00^j	6.08 ± 0.00^g	0.40 ± 0.00^a	2.06 ± 0.02^b	2.45 ± 0.00^a	75.7 ± 0.01^e
RB	3.38 ± 0.05^l	2.19 ± 0.01^a	4.13 ± 0.00^b	7.13 ± 0.01^c	6.07 ± 0.19^b	75.2 ± 0.07^c
RC	3.33 ± 0.00^l	4.17 ± 0.01^d	14.8 ± 0.11^c	8.15 ± 0.02^j	6.78 ± 0.00^c	64.8 ± 0.00^b
RD	3.04 ± 0.01^j	3.37 ± 0.01^c	22.4 ± 0.11^d	0.66 ± 0.01^f	6.07 ± 0.00^b	58.4 ± 0.11^a
RE	3.13 ± 0.04^k	2.61 ± 0.00^b	28.4 ± 0.11^e	5.91 ± 0.06^d	8.06 ± 0.00^e	58.4 ± 0.00^a
FA	1.35 ± 0.01^{bc}	26.2 ± 0.06^{lm}	1.00 ± 0.00^a	9.65 ± 0.04^j	2.49 ± 0.00^a	62.9 ± 0.05^e
FB	1.38 ± 0.00^{bcd}	28.2 ± 0.01^n	8.85 ± 0.00^b	17.5 ± 0.02^q	7.46 ± 0.00^d	39.6 ± 0.05^c
FC	1.55 ± 0.01^e	26.5 ± 0.04^{mn}	9.10 ± 0.00^c	11.9 ± 0.00^o	4.96 ± 0.00^b	55.8 ± 0.01^d
FD	1.31 ± 0.01^b	26.0 ± 0.01^l	14.1 ± 0.05^d	15.6 ± 0.05^n	7.22 ± 0.00^c	35.6 ± 0.01^a
FE	1.21 ± 0.05^o	32.6 ± 0.05^j	15.0 ± 0.05^e	10.4 ± 0.00^i	9.77 ± 0.00^e	38.1 ± 0.01^b
EUA	3.45 ± 0.01^m	5.24 ± 0.03^f	1.36 ± 0.00^a	0.73 ± 0.06^a	9.88 ± 0.01^c	80.3 ± 0.00^e
EUB	2.52 ± 0.01^h	4.73 ± 0.01^e	3.36 ± 0.00^b	6.33 ± 0.00^a	6.33 ± 0.00^a	74.3 ± 0.05^d
EUC	2.92 ± 0.06^i	4.35 ± 0.01^c	5.51 ± 0.00^c	9.26 ± 0.00^e	8.67 ± 0.00^b	68.0 ± 0.57^c
EUD	3.56 ± 0.01^n	4.35 ± 0.02^d	19.3 ± 0.05^d	8.58 ± 0.00^h	14.0 ± 0.07^d	51.4 ± 0.01^b
EUE	2.49 ± 0.00^h	2.76 ± 0.02^h	21.8 ± 0.05^e	7.25 ± 0.32^g	16.6 ± 0.05^e	45.7 ± 0.01^a
EFA	1.68 ± 0.00^f	9.80 ± 0.00^h	1.36 ± 0.00^a	6.92 ± 0.03^i	6.66 ± 0.00^c	80.8 ± 0.05^e
EFB	1.77 ± 0.00^g	10.7 ± 0.12^i	3.05 ± 0.00^b	5.09 ± 0.00^p	6.55 ± 0.01^b	77.0 ± 0.05^d
EFC	1.52 ± 0.04^e	11.0 ± 0.57^i	3.36 ± 0.14^c	10.2 ± 0.04^l	8.36 ± 0.00^d	70.5 ± 0.00^c
efd	1.39 ± 0.04^{cd}	15.9 ± 0.00^k	12.6 ± 0.05^d	15.0 ± 0.01^m	4.97 ± 0.00^a	35.6 ± 0.05^b
efe	1.43 ± 0.02^d	12.6 ± 0.03^j	18.2 ± 0.11^e	8.99 ± 0.00^n	9.77 ± 0.01^e	10.2 ± 0.05^a

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

KEY: 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 50g Groundnut 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.

IV. DISCUSSION

Different types of microorganisms were isolated during the fermentation of ripe plantain and defatted Groundnut. Fourteen microorganisms were isolated which include (eight bacteria, three moulds and one yeasts). The microorganisms were *Bacillus cereus*, *Bacillus subtilis*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Lactobacillus fermentum*, *Proteus mirabilis*, *Bacillus polymyxa*, *Lactobacillus plantarum*, *Pseudomonas aeruginosa*, *Pseudomonas fluorescens*, *Aspergillus flavus*,

Aspergillus niger, *Fusarium oxysporium* and *Saccharomyces cerevisiae*. The microbiological changes observed during the fermentation was as a result of increase in total bacteria count. The result showed that diverse group of microorganisms were present during the fermentation process (Ojokoh and Olatubi 2015).

The presence of organisms like *Staphylococcus* sp., *Pseudomonas* sp., and *Proteus* spp. could have been as a result of contamination during handling and processing. Some of these bacteria are dangerous as can produce toxic metabolite which can affect the consumer. *Aspergillus* spp. and *Bacillus* are known to

be associated with grains. The eventual disappearance of other microorganisms may not be unconnected with the increase in the acidity of the medium as a result of the fermentative activity of the lactobacillus Daramola and Agbi (2014).

The decrease in pH may be as a result of the activities of microorganisms on the fermentable substrate which led to the hydrolysis of complex organic compounds of the substrate thereby producing acid and ethanol. This is similar to the findings of Ojokoh and daramola, (2012). The acids produced led to decrease in pH and increase in total titratable acidity which consequently resulted in decreasing microbial load. The pH of each blend decreased with increase in fermentation time. This is similar to a result reported by Ojokoh and Udeh (2014).

During the process of fermentation, the temperature of each batch was observed to decrease as fermentation time progresses. The fluctuation in temperature may be due to the presence of different microorganisms during fermentation process. This supports the fact that fermentation is an exothermic process and that the heat generated was due to metabolic activities of the microorganisms such as the Bacillus species converting ethanol previously produced by yeast to acetic acid thereby releasing heat.

Total Titratable Acidity (TTA) of the fermented ripe plantain and groundnut increased, this is similar to a report by Ojokoh (2014). However, the result of this fermentation research suggests that it is a lactic type where pH of fermenting media decreases with increase in total titratable acidity (TTA).

Moisture content of all the samples was significantly different from each other. The moisture content of the fermented flour blends was significantly higher than the raw flour, fermented extruded and extruded unfermented samples. This could be due to the absorption of water during fermentation process (Onasanya and Akinbile, 2015). Low moisture content of food sample gives product a long shelf life since microbial activity is reduced and increased storage periods of the food product reported by Aremu *et al.*, (2006) and Alozie *et al.*, (2009) while high moisture content in food encourages microbial growth.

The ash content is an inorganic residue remaining after the removal of the water and organic matter which provides a measure of total amount of minerals in the food component. Fermentation caused a significant reduction in the ash content of the samples, this corresponds with the report of Omafuvbe *et al.* (2004). The lower ash content recorded in the extruded fermented (EF) samples as compared with that of raw flour blends (RF) and extruded unfermented (EU) could be as a result of the retting of the extrudates there by encouraging the leaching of water soluble mineral content of the extrudates during the fermentation process and this loss of minerals could have served as the mineral source for the fermenting microorganisms (Abu, 2005). The low ash content in fortified meals does satisfy the recommended minimum composition in accordance to Agunbiade and Ojezele (2010) report.

Fat content are one of the major components of food that provides energy and essential lipids. Fat content was highest in raw flour blends. Reduction in the fat content of extruded unfermented and extruded fermented blends could be due to lipid oxidation. Lipid oxidation can reduce the nutritive quality of food by decreasing the content of essential fatty acids, such as

linoleic and linolenic acid, which are essential fatty acids. These long chained fatty acids are highly susceptible to oxidation which results from application of temperature during extrusion. (Ranjit and Subha, 2014).

The result from this study confirmed the observation that groundnut is rich in protein content. As the groundnut proportions were increased the protein content of the sample increased significantly ($p>0.05$). The decrease in protein content in some of the unfermented extrudates compared with the fermented extrudates could as well be attributed to interaction of amino acid in maillard reactions. The increase in protein content is probably due to increase in microbial cell mass during fermentation. Increase in protein content of food resulting from increase in microbial cell mass has been reported by other investigators during fermentation of various foods including jack beans (Onyango, et al., 2004) and soya products (Ojokoh and Wei, 2011). Another reason for increase in protein content may be due to the structural proteins that are integral part of the microbial cells (Tortora *et al.*, 2002).

Crude fibre gives bulk to food and aids in regulating physiological functions in the body. Fibre is an indigestible component of food material that helps in improving roughage and bulk as well as contributes to a healthy condition of the intestine (Potter and Hotchkiss, 2004). The values of crude fibre in unfermented extrudates was low compared to the raw blends. Fermentation caused reduction in the crude fibre content of the extruded fermented samples. The reduction in fibre could be as a result of the activities of microorganisms involved in the fermentation process, secretion of cellulose enzymes which aid in the breakdown of the crude fibre (Olatubi and Ojokoh, 2015).

The carbohydrate content of the raw blends decreased with increase in groundnut. Abiodun and Ogugua (2012) also reported decrease in the carbohydrate content of raw blends of acha and cowpea flour. Reduction in the carbohydrate content of fermented unextruded blends could be as a result of utilization of carbohydrate by microorganisms during fermentation. Decrease in carbohydrate content of fermented samples may be because it was used up as the main source of energy during fermentation. This may be because fermentation improved carbohydrate content of the blend (Anuonye *et al.*, 2009).

V. CONCLUSION

This study has revealed that groundnut and plantain blend can be fermented to produce food of enhanced and better nutritional value with low anti-nutrient content. The processing techniques employed in this research offer the possibility of better storage stability of food, added value and creation of new markets in the food industries.

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