UNDER PEER REVIEW

Original Research Articles

Effects of fermentation and extrusion on the proximate and organoleptic properties of cowpea-plantain flour blends

ABSTRACT

This study was conducted to investigate effects of fermentation and extrusion on the nutritional and sensory properties on blends of unripe plantain flour and cowpea flours. Three ratios (100:0, 80:20 and 60:40) of unripe plantain and cowpea flour were fermented and extruded. A total of 18 organisms were isolated during fermentation of plantain: cowpea blends. They include eleven (11) bacteria, four (4) moulds and three (3) yeasts. These are *Bacillus subtilis, Bacillus licheniformis, Micrococcus luteus, Enterobacter cloacae, Proteus mirabilis, Staphylococcus aureus, Leuconostoc mesenteroides, Lactobacillus bulgaricus, Lactobacillus casei, Lactobacillus fermentum, Lactobacillus lactis, Aspergillus niger, Aspergillus flavus, Rizopus stolonifer, Trichoderma viride, Candida utilis, Geotrichum candidum* and *Saccharomyces cerevisiae.* The pH and total titratable acidity (TTA) varied significantly during fermentation. The proximate composition of the raw blends, fermented, extruded and fermented- extruded samples were assessed. The crude protein and moisture content increased in the fermented, extruded and fermented- extruded samples; whereas fermentation and extrusion reduced the carbohydrate content. Fat, crude fibre and ash contents varied among all the samples. The sensory evaluation of the samples showed a good preference for fermented- extruded samples in terms of texture and aroma.

INTRODUCTION

Food is any substance usually composed of carbohydrates, fats, proteins and water, which can be eaten or drunk by animals including humans for nutrition or pleasure. Items considered food may be sought from plants, animals or other categories such as fungus and fermented products (Jango-Cohen, 2005). The problem of malnutrition is predominant in Nigeria due to deficiency of protein and calories and protein-calories sources of vegetable origin have been proposed as a solution to this problem.

Plantains (*Musa paradisiaca*) are used as an inexpensive source of calories in Nigeria and many African countries (Akubor et al., 2003). It is an important starchy staple and commercial crop in the West and Central Africa where fifty percent of the world's plantain crop is produced (Swennen, 1990). According to FAO (2009), 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. Unripe plantain is traditionally processed into flour in Nigeria and in other west and central African countries (Ukhum and Ukpebor, 1991). The flour produced is mixed with boiling water to prepare an elastic pastry ("amala" in Nigeria).

Cowpea (*Vigna unguiculata*) is a drought tolerant food crop, well adapted in varieties of climates and soils. This crop is widely cultivated throughout the tropics and subtropics, particularly in west and central Africa, with an annual production of 3 millions tones

UNDER PEER REVIEW

(Onyenekwe *et al.*, 2000). Its grains are used to prepare many traditional foods such as moin-moin, akara, and gbegiri (soup). Cowpea grains have been used to fortify cereal-based weaning foods, in which they formed complementary amino acid profiles and improved protein quality (Bresani, 1985).

While many foods can be eaten raw, many also undergo some form of preparation for reasons of safety, palatability, texture, or flavor and digestibility. At the simplest level this may involve washing, cutting, trimming, or adding other foods or ingredients, such as spices. It may also involve mixing, heating or cooling, pressure cooking, fermentation, extrusion or combination with other food. Fermentation is one of the oldest methods of food preservation, and embedded in traditional cultures and village life. 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 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; Nwabueze *et al*., 2007; Oluwole and Olapade, 2011; Sobota and Rzedzicki, 2009).

Materials and method

Collection of samples

Green matured plantain and cowpea seeds used for this study were obtained from a local market in the Southwestern part of Nigeria.

Processing of unripe plantain flour

The unripe plantain was sorted for maturity and cleaned by washing with water. The clean unripe plantains were peeled and sliced thinly into 2mm diameter and sun dried for 72 hours. The dried unripe plantain was then fed into an attrition mill. The milled flour was sieved with 120µm aperture sieve into fine flour and kept in an air tight container.

Processing of cowpea flour

Cowpea seeds were cleaned by sorting out dirt and stones. The cleaned cowpea seeds were coarsely milled to separate the coat from the cotyledon. The husk was separated from the seed by blowing air into it. The dehalled cowpea seeds were milled into fine flour using an attrition mill after which it was sieved through 60µm mesh screen. The cowpea flour was kept in an airtight container to prevent it from absorbing moisture, contamination as well as rodent infestation.

Fermentation and extrusion of flour blends

A batch of the flour blends were fermented using semi- solid state fermentation for 72 hours. 75ml of boiled water was added to 100g of each sample in cleaned containers and properly sealed. The fermentation process was terminated by oven drying at 60^0C for 24 hours. Two batches of samples were subjected to extrusion cooking. The first batch consists of the unfermented 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. The samples were extruded using a Brabender 20DN single screw laboratory extruder (Brabender OHG, Duisburg, Germany). The second batch of the samples consists of the fermented samples. The fermented samples were also extruded using a Brabender 20DN single

UNDER PEER REVIEW

screw laboratory extruder (Brabender OHG, Duisburg, Germany). All the extrudates were air dried for 12 hours after which they were stored at 382^{0}C in sterile polyethylene bags and kept in properly labeled air tight containers.

Microbiological analysis of the samples

Microbial population of total bacteria and fungi were determined using nutrient agar (NA) and potato dextrose agar (PDA) respectively. Organisms were enumerated by using appropriate serial dilution and pour plate techniques. The bacterial culture was incubated at 37^{0}C for 18 to 24 hours while fungal plates were inverted and incubated at 24^{0}C for 48 to 72 hours. The organisms were characterized based on biochemical and morphological observations.

Determination of pH and TTA

The pH of all fermenting samples was determined at 24 hours interval using a pocket size pH meter. The total titratable acidity of the fermenting samples was determined at 24 hours interval as described by AOAC (2005). A 2g of macerated sample was weighed into a beaker. 50ml of distilled water was added to it, it was mixed and filtered. 10ml of the filtrate was measured into a beaker and 2 drops of phenolphthalein indicator was added into it. This was titrated with 0.1M sodium hydroxide (NaOH) solution and the titre value was read. The acidity was calculated as stated below:

$$TTA = \text{Titre value} \times 9mg/100$$

Proximate composition

All the samples were analyzed for moisture, ash, crude fibre, protein (N*6.25), crude fat and the carbohydrate determined by difference according to the method described by AOAC (2012).

Sensory evaluation

The sensory evaluation was done by methods described by Ihekoronye and Ngoddy (1985). A panel of 10 judges (untrained but familiar with extruded products such as pasta, noodles, breakfast cereal quality characteristic) was set up. Coded samples of the raw flour, extruded unfermented flour, fermented unextruded flour and fermented extruded flour were served to the panelists. The panelists were asked to rate the samples based on the colour, aroma, texture and overall acceptability by scroring them on a seven-point hedonic scale.

Statistical analysis

All analyses were performed in triplicates. The data obtained were subjected to one way analysis of variance (ANOVA) while differences in mean were determined using Duncan's New Multiple Range Test (DMRT). All data analyses were done with SPSS 16.0 version.

RESULTS

Microorganisms isolated during fermentation of cowpea-plantain flour blends

A total of eighteen (18) microorganisms were isolated during the fermentation of cowpea and unripe plantain flour blends. These comprise of eleven (11) bacteria, four (4) moulds and three (3) yeasts. These are *Bacillus subtilis, Bacillus licheniformis, Micrococcus luteus, Enterobacter cloacae, Proteus mirabilis, Staphylococcus aureus, Leuconostoc mesenteroides, Lactobacillus bulgaricus, Lactobacillus casei, Lactobacillus fermentum, Lactobacillus lactis, Aspergillus*

UNDER PEER REVIEW

niger, Aspergillus flavus, Rizopus stolonifer, Trichoderma viride, Candida utilis, Geotrichum candidum and *Saccharomyces cerevisiae*

Changes in pH during fermentation of cowpea: plantain flour blends

The pH variations during the fermentation of cowpea- plantain flour blends are shown in figure 3. The pH of sample A slightly increased from 6.84 ± 0.02 to 6.89 ±0.01 at 24 hours but gradually decreased to 6.3 ± 0.00 and 5.18 ± 0.00 at 48 hours and 72 hours respectively. Sample B gradually decreased from pH 6.88 ± 0.01 at 0 hour to 6.23 ± 0.01, 6.01 ± 0.01 and 5.31 ± 0.01 at 24 hours, 48 hours and 72 hours respectively. Sample C also decreased from pH 7.41 ± 0.01 at 0 hour to 6.80 ± 0.01, 5.86 ± 0.01 and 5.36 ± 0.02 at 24 hours, 48 hours and 72 hours respectively.

Changes in total titratable acidity (TTA) during fermentation of cowpea: plantain flour blends

Variations in the total titratable acidity (TTA) during fermentation of cowpea- plantain flour blends are shown in figure 4. Sample A had initial TTA of 0.011 at 0 hour which increased to 0.022± 0.00 at 24 hours to 0.025 ± 0.00 at 48 hours and finally to 0.043 ± 0.00 at 72 hours. Sample B increased from 0.018 ± 0.00 at 0 hour to 0.032 at 24 hours and decreased slightly to 0.018 at 48 hours which later increased to 0.079 at 72 hours. Sample C had initial TTA of 0.014 which increased to 0.065 at 24 hours and decreased to 0.054 at 48, it finally increased to 0.086 at 72 hours.

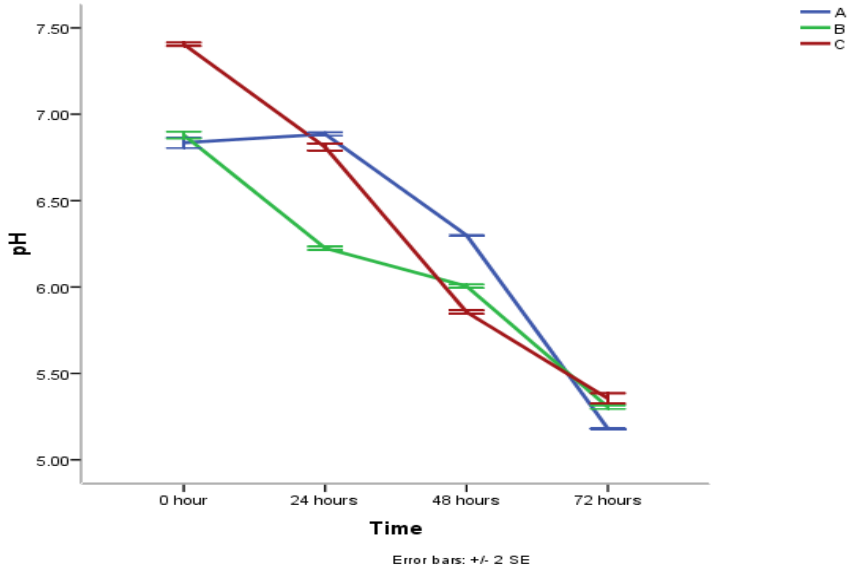


Figure 1: pH variations during fermentation of cowpea-plantain flour blends. A= 100g Plantain flour; B= 80g and 20g plantain: cowpea blend; C= 60g and 40g plantain: cowpea blend

UNDER PEER REVIEW

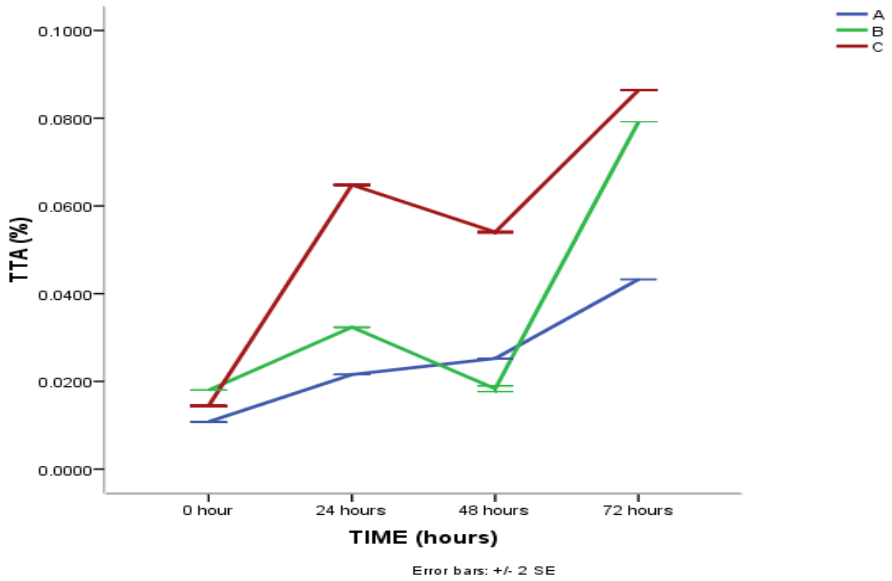


Figure 2: total titratable acidity (TTA). A= 100g Plantain flour; B= 80g and 20g plantain: cowpea blend; C= 60g and 40g plantain: cowpea blend

Changes in proximate composition of cowpea-plantain samples

The protein Composition of cowpea- plantain flour blends

The moisture content of cowpea- plantain flour blends are shown in figure 3. Raw flour (RF) blends had the lowest moisture content ranging from 4.00 ± 0.03 to 6.40 ± 0.02 in sample A – C. There was no significant difference ($P \leq 0.05$) in the moisture content of sample A and C of the raw flour blends but sample B was significantly different ($P \leq 0.05$). The moisture content of unfermented extruded blends ranged from 8.20 ± 0.06 to 12.24 ± 0.10 in samples A- C. The moisture content of fermented unextruded blends ranged from 12.24 ± 0.10 to 13.00 ± 0.03. Fermented extruded blends exhibited moisture content ranging from 6.10 ± 0.11 for sample B to 8.10 ± 0.03 for sample A and C.

The protein Composition of cowpea- plantain flour blends

The changes in protein content of the cowpea- plantain blends are shown in figure 4. There is significant difference ($P \leq 0.05$) in the protein content of all the blends except 100% raw plantain flour (RFA) and unfermented extruded 100% plantain (UEA). Fermented extruded blends recorded the highest protein content with values ranging from 3.06 ± 0.03 to 12.10 ± 0.08. Protein content of fermented unextruded blends ranged from 2.98 ± 0.06 to 11.44 ± 0.08. Unfermented extruded blends exhibited protein contents ranging from 2.62 ± 0.09 to 9.11 ± 0.03. Raw blends had the least protein content with values ranging from 2.62 ± 0.11 to 8.75 ± 0.12.

The carbohydrate Composition of cowpea- plantain flour blends

The carbohydrate content of the blends is represented in figure 5. Carbohydrate content of raw flour blends range from 82.80 ± 0.88 to 88.88 ± 0.09 in sample C to A. Unfermented extruded blends had carbohydrate content ranging from 72.66 ± 0.23 to 82.70 ± 0.18. Fermented unextruded samples had the least moisture content with values ranging from 60.27 ± 0.21 to 72.47 ± 0.07. Fermented extruded blends had carbohydrate content ranging from 75.43 ± 0.05 to 84.25 ± 0.13.

UNDER PEER REVIEW

The fat Composition of cowpea- plantain flour blends

The variations in the ash content of cowpea- plantain blends are shown in figure 6. There was a significant difference (P≤0.05) in the fat content of the blends. Fermented unextruded blends had the highest fat content with values ranging between 4.89 ± 0.10 and 5.80 ± 0.02. Raw blends had the least fat content with values ranging from 1.19 ± 0.03 to 1.99 ± 0.04. Unfermented extruded blends had fat content ranging from 2.19 ± 0.09 to 5.50 ± 0.13. Fat content of fermented extruded blends range from 1.90 ± 0.02 to 3.18 ± 0.05.

The crude fibre Composition of cowpea- plantain flour blends

The crude fibre content of cowpea- plantain blends are shown in figure 7. There was a significant difference (P≤0.05) in the crude fibre content of the blends. The crude fibre contents of the raw blends range from 0.10 ± 0.04 to 0.41 ± 0.01. Unfermented extruded blends had crude fibre content ranging from 0.64 ± 0.02 to 0.82 ± 0.02. Fermented unextruded blends had values ranging from 1.00 ± 0.03 to 1.12 ± 0.02. Fermented extruded blends had crude fibre ranging from 0.11 ± 0.02 to 0.43 ± 0.01.

The ash Composition of cowpea- plantain flour blends

The ash content of the cowpea- plantain blends are shown in figure 8. There is a significant difference in the ash contents of the samples. The ash content of the raw blends range from 1.73 ± 0.03 to 2.85 ± 0.13. Unfermented extruded blends had values ranging from 2.29 ± 0.01 to 3.69 ± 0.05. The ash content of fermented unextruded blends ranged from 2.03 ± 0.02 to 2.69 ± 0.09. Fermented extruded blends had ash content ranging from 1.90 ± 0.08 to 2.60 ± 0.07.

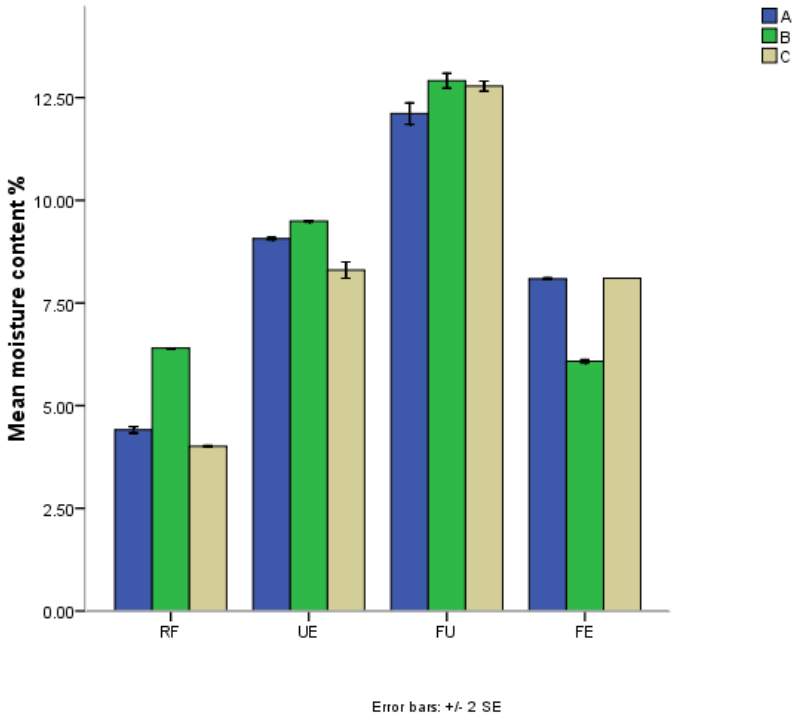
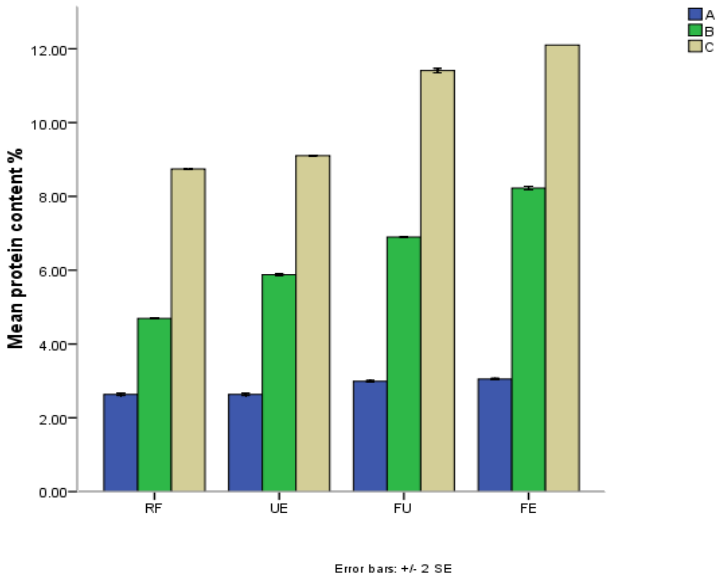
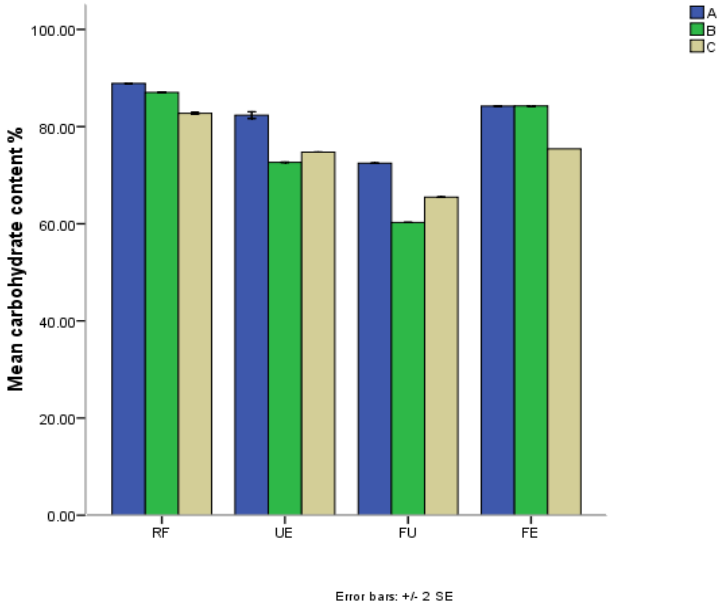


Figure 3: Moisture content of cowpea-plantain blends. A= 100g Plantain flour; B= 80g and 20g plantain: cowpea blend; C= 60g and 40g plantain: cowpea blend; RF= Raw Flour Samples; UE= Unfermented Extruded blend Samples; FU= Fermented Unextruded Samples; FE= Fermented Extruded Samples.

UNDER PEER REVIEW



198
199 **Figure 4:** Protein content of cowpea-plantain blends. A= 100g Plantain flour; B= 80g and 20g
200 plantain: cowpea blend; C= 60g and 40g plantain: cowpea blend; RF= Raw Flour Samples; UE=
201 Unfermented Extruded blend Samples; FU= Fermented Unextruded Samples; FE= Fermented
202 Extruded Samples.



203
204 **Figure 5:** Carbohydrate content of cowpea-plantain blends. A= 100g Plantain flour; B= 80g and
205 20g plantain: cowpea blend; C= 60g and 40g plantain: cowpea blend; RF= Raw Flour Samples;
206 UE= Unfermented Extruded blend Samples; FU= Fermented Unextruded Samples; FE=
207 Fermented Extruded Samples.
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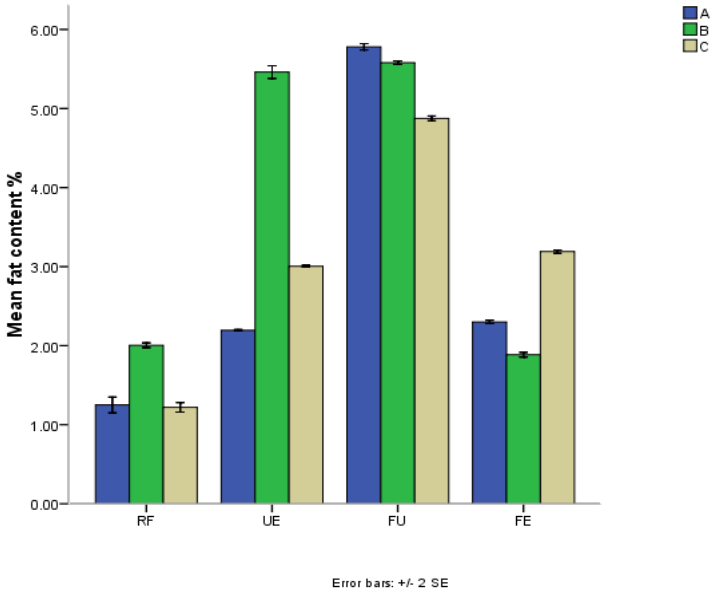
UNDER PEER REVIEW



209
210 **Figure 6:** Fat content of cowpea-plantain blends. A= 100g Plantain flour; B= 80g and 20g
211 plantain: cowpea blend; C= 60g and 40g plantain: cowpea blend; RF= Raw Flour Samples; UE=
212 Unfermented Extruded blend Samples; FU= Fermented Unextruded Samples; FE= Fermented
213 Extruded Samples.
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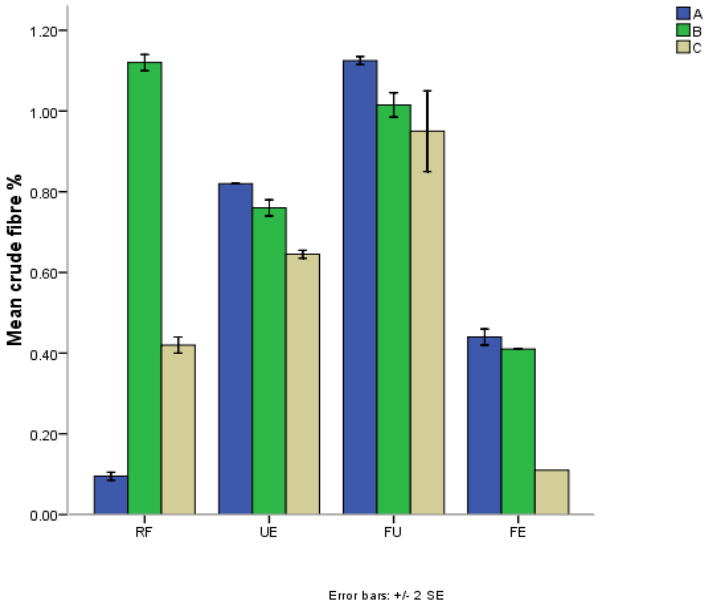

215
216 **Figure 7:** Crude fibre content of cowpea-plantain blends. A= 100g Plantain flour; B= 80g and
217 20g plantain: cowpea blend; C= 60g and 40g plantain: cowpea blend; RF= Raw Flour Samples;
218 UE= Unfermented Extruded blend Samples; FU= Fermented Unextruded Samples; FE=
219 Fermented Extruded Samples.
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UNDER PEER REVIEW

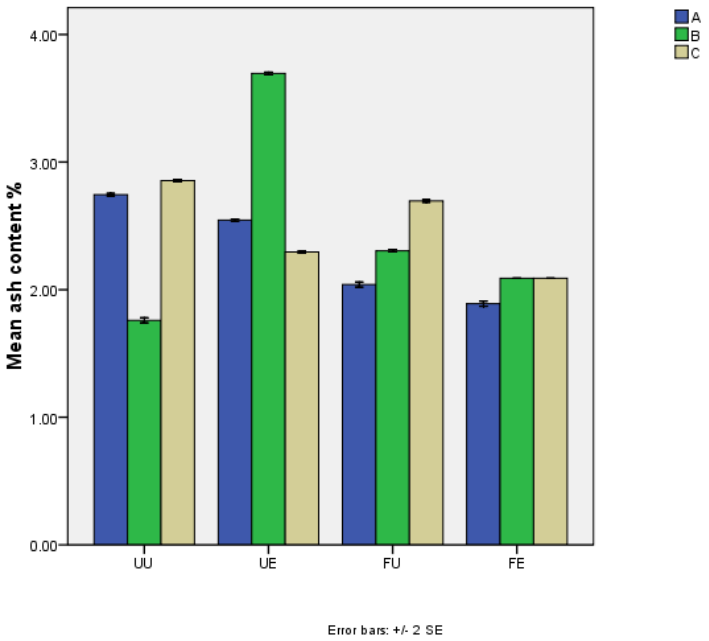

Figure 8: Ash content of cowpea-plantain blends. A= 100g Plantain flour; B= 80g and 20g plantain: cowpea blend; C= 60g and 40g plantain: cowpea blend; RF= Raw Flour Samples; UE= Unfermented Extruded blend Samples; FU= Fermented Unextruded Samples; FE= Fermented Extruded Samples.

Sensory evaluation of the blends

The result obtained in the sensory evaluation indicated that there was no significant difference in the colour of the raw blends and unfermented extruded blends. Fermented unextruded blends and fermented extruded blends recorded significantly low colour. There was no significant difference in the texture of raw blends and unfermented extruded blends. Fermented blends recorded significantly high values in terms of aroma. Raw blends and fermented extruded blends recorded high values for overall acceptability. This result is represented in table 1.

TABLE 1: Sensory evaluation of cowpea-plantain blends

Sample	Colour	Texture	Aroma	Overall acceptability	Total
RFA	6.40±0.70^{e}	6.30±0.48^{d}	5.40±1.26^{cd}	6.00±0.67^{e}	24.10^{e}
RFB	6.20±0.79^{e}	6.20±0.63^{cd}	4.70±0.95^{bc}	6.00±0.82^{e}	23.10^{d}
RFC	5.90±0.88^{e}	5.90±0.74^{bcd}	3.80±0.92^{a}	3.50±0.85^{a}	19.10^{b}
UEA	6.10±0.74^{e}	5.40±0.70^{abcd}	5.00±0.82^{bc}	5.20±0,92^{cde}	21.70^{c}
UEB	5.60±0.70^{e}	5.40±1.07^{abcd}	4.20±1.14^{ab}	5.10±0.74^{cd}	20.30^{bc}
UEC	5.60±0.84^{e}	5.00±0.67^{ab}	4.30±0.95^{ab}	4.10±0.88^{ab}	19.00^{a}
FUA	4.50±1.18^{d}	5.30±0.82^{abc}	6.20±0.63^{d}	4.50±0.53^{bc}	20.50^{bc}
FUB	3.40±1.51^{ab}	4.80±1.03^{a}	5.30±0.82^{cd}	4.80±0.63^{bcd}	18.30^{a}
FUC	2.70±0.95^{a}	5.20±0.79^{ab}	5.90±0.88^{d}	5.20±0.79^{cde}	19.00^{b}

UNDER PEER REVIEW

FEA	4.70±0.67[d]	4.40±1.78[a]	6.20±0.63[d]	5.40±0.97[de]	20.70[bc]
FEB	4.30±0.48[cd]	4.90±1.10[ab]	6.10±0.74[d]	5.20±1.03[cde]	20.50[bc]
FEC	3.60±0.97[bc]	5.40±1.17[abcd]	6.20±0.79[d]	4.70±1.25[bcd]	19.90[b]

A= 100g Plantain flour; B= 80g and 20g plantain: cowpea blend; C= 60g and 40g plantain: cowpea blend; RF= Raw Flour Samples; UE= Unfermented Extruded blend Samples; FU= Fermented Unextruded Samples; FE= Fermented Extruded Samples.

DISCUSSION

The microbial flora of the fermenting media was heterogeneous comprising of eleven (11) bacteria, four (4) and three (3) yeasts. This is similar to the findings of Ojokoh and Udeh (2012) and Efuvwevwere and Akoma (1997) that legume supplemented products had a greater microbial diversity and higher microbial populations. The decrease in pH may be as a result of the activities of microorganisms on the fermentable substrate which lead to the hydrolysis of complex organic compounds of the substrate thereby producing acid and ethanol. The acids produced now leads to decrease in pH and increase in total titratable acidity which consequently resulted in decreasing microbial load (Hassan *et al*., 2015). Similar results were reported by Hassan *et* al., (2015) and Ojokoh and Udeh (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 is one of the most important and commonly measured properties of different food products. It is measured for various reasons including legal and label requirements, economic importance, food quality, better processing operations and storagability. The stable moisture content of the raw blends prior fermentation and extrusion indicates the storagability and shelf life of the samples if properly packaged (Aremu *et al.,* 2006, Alozie *et al.*, 2009 and Odom *et al*., 2013).

The protein increased with increasing level of cowpea flour substitution indicating nutrients enhancement with cowpea flour substitution. This could obviously be due to the significant quantity of protein in cowpea seeds. The high protein content in plantain- cowpea blends will be of nutritional importance in most developing countries, Nigeria inclusive where many people can hardly afford high proteinous foods because of the costs. The increase in protein content is similar to some other research study in which cowpea flour was used in supplementation, such as in ogi supplemented with cowpea (Ashaye et al., 2000) and acha and cowpea blends (Abiodun and Ogugua, 2012). There was a moderate increase in the protein content of unfermented extruded blends. This is contrary to the findings of Oguntunde and Shoola (1999) that extrusion cooking caused reduction in protein and carbohydrate. Increase in protein content of unfermented extruded blends corresponds with the findings of Abiodun and Ogugua (2012) in the evaluation of extruded snacks from blends of acha and cowpea. Protein content of fermented unextruded blends ranged from 2.98 ± 0.06 to 11.44 ± 0.08. Increase in the protein content of fermented unextruded blends could be as a result of protein synthesis by microorganisms during fermentation which contribute to high value in fermented samples. This increase could be attributed to the increase in microbial mass during fermentation, causing extensive hydrolysis of

UNDER PEER REVIEW

the protein molecule to amino acid and other simple peptides (Igbabul *et al*., 2014). Another reason for the increase in protein content may be due to the structural proteins that are integral part of the microbial cells (Tortora *et al.*, 2002). The apparent increase in growth and microbial proliferation of microorganisms in the form of single cell protein of the normal flora may account for the observed trend in crude protein (Oboh, 2006). This trend was also reported by Michodjehoun *et al.,* (2005) and Igbabul *et al*., (2014). Increase in the protein content of fermented extruded blends was also reported by Osundahunsi (2006). Jeff- Agboola and Oguntuase (2006) reported that microorganisms are found to increase the protein content of the samples on which they grow. Fermented extruded blends recorded the highest protein content with values ranging from 3.06 ± 0.03 to 12.10 ± 0.08. This is in agreement with the findings of Ojokoh and Udeh (2014) in which extruded fermented blends had the highest protein contents.

The carbohydrate content of the raw blends decreased with increase in cowpea. 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.

Fat contents are one of the major components of food that provides essential lipids and energy. Lipid constituents are the major determinants of overall physical characteristics of food such as aroma and texture. Fat content was highest in fermented unextruded blends. This could be as a result of the metabolic activities of the fermenting microorganisms. Reduction in the fat content of unfermented extruded and fermented extruded 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 linolenic acid and linoleic acid, which are essential fatty acids. These long-chained fatty acids are highly susceptible to oxidation which results from application of high temperature during extrusion (Ranjit and Subha, 2014).

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 and Odom *et al.,* 2013).Crude fibre gives bulk to food and aids in regulating physiological functions in the body. Fermented unextruded blends had the highest crude fibre content but unfermented extruded and fermented extruded blends had low crude fibre content. This implies that extrusion had negative impact on the crude fibre content of the blends. The result of the fermented unextruded blends compares favourably with the work of Eze and Ibe (2005) on the effect of fermentation on the nutritive value of *B. Eurycoma* "Achi" where an increase in fibre content for the fermented sample was reported. The reason for unexpected increase in fibre content for the fermented samples may be due to the activities of microorganisms. The fermentation process involves the conversion of materials to the perculiar needs of the microorganisms, which include the bacterial cell wall. The bacterial cell wall is made of peptidoglycan or murein, which is a polysaccharide like cellulose. As the microorganisms were not separated from the biomass, the

UNDER PEER REVIEW

increase in fibre could be due to such conversion of materials to peptidoglycan by the microorganisms (Eze and Ibe, 2005).

Ash is an inorganic residue remaining after the removal of water and organic matter which provides a measure of total amount of minerals in the food component. Fermentation caused a significant ($P \leq 0.05$) reduction in the ash content of the samples. Michodjehoun *et al*. (2005) also reported a decrease in ash content during fermentation of ‘‘Gowe’’, a traditional food made from sorghum, millet or maize. This also corresponds with the report of Omafuvbe *et al*. (2004). This may be attributed to leaching of water soluble mineral content of the samples during the fermentation process.

The result obtained in the sensory evaluation indicated that there was no significant difference in the colour of the raw flour blends (RF) and unfermented extruded blends (UE). Fermented unextruded blends and fermented extruded blends recorded significantly low values for colour. There was no significant difference in the texture of raw blends and unfermented extruded blends. Fermented blends recorded significantly high values in terms of aroma. Raw blends and fermented extruded blends recorded high values for overall acceptability. The low values obtained for colour in fermented blends may be as a result of browning which occurred during fermentation. It was observed that fermentation enhanced the aroma of the blends. There is no significant difference ($P \leq 0.05$) in the texture of the flour blends. The higher organoleptic attributes of the raw blends (19.10 - 24.10) when all the attributes were summed up and compared is simple to explain. The judges were familiar with raw plantain and cowpea flour. On the other hand, the similarity in organoleptic attributes between the raw flour blends and unfermented extruded blends indicates that the samples were equally liked. The judges had preference to colour for the raw flour blends blend over the other test samples while fermented unextruded and fermented extruded blends had highest preference for aroma. The fermented blends had better flavour than other test blends while raw blends had the highest 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 (Nnam,2002; Teratanavat and Hooker, 2006). The improved flavor of fermented blends may be as a result of fermentation and mutual supplementation effect of food nutrients.

Conclusion

Plantain supplemented with cowpea had a higher protein content compared with only plantain flour. However, fermentation and extrusion of cowpea-plantain blends improved the nutritional quality of the samples compared with the raw blends.

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UNDER PEER REVIEW

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