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MICROBIOLOGICAL, PHYSICOCHEMICAL, AND NUTRITIONAL COMPOSITION OF PLANTAIN FLOUR FORTIFIED WITH WHEAT FLOUR

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Microbiological, physiochemical, and proximate analysis of wheat (W) and plantain (P) flour blends in varying ratios [W:P (25:75, 50:50 and 75:25)] stored at room temperature for a period of nine weeks were analyzed. At the end of storage, the total viable count of fungi and bacteria in wheat and plantain flour blends of varying ratios increased. Bacterial genera isolated from the blend of wheat and plantain samples include; *Proteus*, *Klebsiella*, *Bacillus*, *Pseudomonas*, *Micrococcus* and *Staphylococcus*. Fungal species isolated from the samples of wheat and plantain flour blends include *Aspergillus niger*, *Aspergillus flavus*, *Rhizopus sp.*, *Pennicillium sp.*, and *Fusarium sp*. Changes in physiochemical properties revealed that the pH was inversely proportional to the titratable acidity. Analysis of proximate and mineral compositions respectively showed that the nutrients and micronutrients decreased minimally with storage period. The blend 25:75 had the highest protein content and was least contaminated. It had the best nutrient quality when compared with other ratios.

Keywords: pH, Plantain, Storage, Food fortification, Plantain flour, Wheat flour, Flour blends

INTRODUCTION

Food fortification refers to the practice of deliberately increasing the contents of an essential micronutrient such as vitamins, minerals (including trace elements) in a food irrespective of whether the nutrients were originally in the food or not before processing, so as to improve the nutritional quality of the food and to provide public health benefits with minimal risk to health (WHO, 2008).

Food fortification has been carried out in several ways and includes the use of vitamins and minerals premixes, addition of milk solids to combination of cereals, legumes and other foods (Bloem *et al.*, 2005).

Wheat and plantain are staple foods in Nigeria and are very good sources of carbohydrate. The utilizable protein of plantain is higher than that of cassava but it is much lower than other staples such as yam, maize and wheat (Omole *et al.*, 1978).

Wheat and plantain flour are susceptible to contamination by food handlers during or after processing, thereby creating a suitable environment for microorganisms to degrade nutrients present in the product which eventually results in spoilage.

Appropriate packaging materials can be used to control microbial proliferation and shelf life. Shelf life can be influenced by several factors such as water activity, redox

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potential, nutrients, natural microflora, as well as time, temperature, relative humidity and exposure to light during processing and storage (Darton-Hill, 1998).

However, not much work has been carried out on these samples in relation to microbiological, physico-chemical and nutritional determination, hence the objective of this study has been designed to evaluate the microbiological, physico-chemical and proximate qualities of wheat (*Triticum aestivum)*enhanced with plantain (M*usaaccuminata),* at different proportions.

MATERIALS AND METHODS

Collection of Samples: The samples used in this study include plantain (*Musa accuminata*) and wheat (*Triticumaestivum*) which were purchased from Royal Market, Ekpoma, Edo State, Nigeria.

Preparation of the Sample: The already peeled, sliced and dried plantain as well as the dried wheat were separately processed aseptically into their respective flours with the aid of a milling machine. After the processing of the samples, each flour of wheat and plantain were weighed and mixed in different ratios; wheat and plantain (w:p) 25:75, 50:50 and 75:25. These samples were packaged (100 grams per pack) in high density polythene bag (packaging material) and sealed using an electric sealant. The packaged blends of flour were labeled accordingly, and stored on a shelf at ambient temperature of (28 ±2 ^{0}C) for nine (9) weeks.

Sterilization of Materials: Glassware's such as test tubes and beakers were wrapped in foil paper and sterilized in a hot air oven at a temperature of 160 ^{0}C for 1 hour. Also growth media which include; nutrient agar, potato dextrose agar and peptone water were prepared according to the manufacturers specifications and were sterilized by autoclaving at 121 ^{0}C for 15 minutes.

Microbiological Analysis: Ten (10) gram of each sample blend (W and P 75:25, 50:50 and 25:75) was weighed aseptically and homogenized in 90 ml of sterile distilled water. 1 ml of the supernatant which formed the stock solution was used for microbiological analysis. Using pour plate method, nutrient agar and Potato Dextrose Agar (PDA) supplemented with chloramphenicol (to inhibit bacterial growth) was used for the enumeration of bacterial and fungal counts respectively. Nutrient agar plates were incubated at 37 ^{o}C for 24-48 hours, while potato dextrose agar plates were placed at room temperature (28 ± 2 ^{0}C) for 3-5 days. After the appropriate timing, counts of visible colonies were made and expressed as cfu/g (Colony forming unit per gram). Purification and maintenance of bacterial isolates were carried out by repeated sub-culturing. Colonies of bacteria were maintained on a slope of nutrient agar (by preparing nutrient agar slants in bijou bottles) and stored in a refrigerator at 4 ^{o}C until when needed.

Identification of Bacterial Isolates: Standard cultural and biochemical tests were used for the putative identification of isolated microorganisms. Gram staining, motility test and sugar fermentation test, biochemical test such as catalase, coagulase, oxidase and indole were employed.

Identification of Fungal Isolates: This was performed using a wet mount technique. A drop of lacto-phenol cotton blue was placed on a clean grease-free slide and a portion of the mould growth of the test organism was picked up with a straight wire loop and teased out on the slide containing lacto-phenol cotton blue. The smear was covered with a cover slide, care was taken to exclude the presence of bubbles, and then it was viewed under a microscope and examined for the presence of cross-walls or septa. Standard fungal atlas was used for identification.

PHYSICOCHEMICAL ANALYSIS

Determination of Hydrogen ion Concentration (pH): To determine the pH of the sample, 10 g of the sample was dissolved in 90 ml of distilled water. Thereafter, 10 ml of the supernatant was taken using a sterile pipette and transferred into a beaker. The pH was determined by immersing the electrode of the pH meter (with model H196107) into the supernatant to allow for reading with the most repeated value record.

Determination of Percentage Moisture Content (%M.C.): The weight of the watch glass was measured and recorded. 10 g of wheat and plantain flour blends was placed on a watch glass and weighed to obtain the initial reading. The watch glass containing the sample was placed in the hot air oven at a temperature of 105±5 ^{o}C for 30 to 50 minutes. The watch glass containing the sample was brought out at various intervals of time to weigh so as to ensure the sample doesn't get burnt. This procedure was performed until 3 consecutive readings were recorded. The final readings were recorded and the percentage (%) moisture content was calculated thus;

$$\%M.C. = \frac{Initial\ \ weight - Final\ \ weight}{Weight\ \ of\ \ sample} \times 100$$

Determination of Titratable Acidity as Percentage Lactic Acid: This was carried out using the supernatant of wheat

and plantain flour blends, 0.1 M solution of sodium hydroxide (NaOH) and phenolphthalein as indicator. 10 g of processed samples of wheat and plantain flour was weighed and dissolved in 90 ml distilled water. 10ml of the supernatant was measured using a sterile pipette into a conical flask and 2-3 drops of phenolphthalein indicator was added. The burette attached firmly to the clamp was filled with 0.1 M of NaOH to the zero mark. 0.1 M solution of NaOH was titrated against 10 ml of the supernatant until a color change was observed and the final readings recorded. Readings were taken from the point of meniscus, 3 consecutive readings for each sample were taken and recorded.

Titratable acidity is calculated using the formula;

Titratable Acidity (TA) = VMK/S. Where V = Volume of acid used, M= Molar concentration of the base, K= Constant, i.e., 0.09, S = Weight of the sample.

PROXIMATE (NUTRITIONAL) ANALYSIS

Determination of Fat and Oil: In carrying out this analysis, 2-3 g of the dried sample was used to load each thimble and plunged with cotton wool. The thimbles were dried and inserted into the soxtec HT. 25-50 ml of the solvent was added into each extraction cups and inserted into the soxtec HT. This was thereafter subjected to extraction for 15 minutes in boiling position and 30-45 minutes in rinsing positions. The solvent was evaporated, while the cups were rinsed, dried at 100 ^{o}C for 30 minutes, cooled in a desiccator and weighed. The percentage (%) fat content was calculated using the formula; % fat and oil = W_2-W_1 X 100/W_1. Where; Weight of cup with extracted oil = W_g, Weight of empty cup = W_2, Weight of sample = W_1

Determination of Ash Content: The crucible used was washed and dried in the oven after which it was allowed to cool in a desiccator and weighed. 2-3 g of dried sample was weighed into an empty porcelain crucible which had been previously ignited and weighed. The material was ignited either over a low flame or a hot plate in the fume cupboard to char the organic matter. The crucible was placed in a muffle furnace maintained at a temperature of 600 ^{o}C for 6 hours. The crucible was then transferred directly to a desiccator, cooled, and weighed immediately (Association of Official Analytical Chemists (AOAC), 1970). The percentage (%) ash content was calculated using the formula;

% Ash = (Weight of crucible + ash) – (Weight of empty crucible) x 100/sample weight.

Determination of Crude Fibre (Trichloroacetic Acid Method): The sample was defatted with petroleum ether/ hexane and 1 g of the defatted sample was weighed into 600 ml beaker. 100 ml of trichloroacetic acid (TCA) reagent was added, brought to boil and refluxed for 40 minutes beginning from the time boiling starts. The flask was removed, cooled slightly, filtered, and the residue was washed six (6) times with hot distilled water and once with methylated spirit. The filter paper with sample was transferred into a porcelain crucible, dried in the oven at 100 ^{o}C overnight and subsequently cooled in a desiccator and weighed (weight A). Thereafter, it was converted to ash in a muffle furnace at 600 ^{o}C for 6 hours, cooled in a desiccator and weighed (weight B) (Whitehouse *et al.*, 1945).

Loss in weight during incineration is equivalent to the amount of crude fibre. % crude fibre = (weight A) – (weight B) X 100/sample weight

Protein Content: The protein content of the samples was determined by the methods of (Hach, 1990). 0.25 g sample was weighed into Hach digestion flask and 4ml of concentrated sulphuric acid was added. The sample was transferred to a fume hood and heated for 5 minutes at 440 ^{o}C. To the charred sample was added 16 ml of hydrogen peroxide (H_2O_2) to clear off the brown fumes and make the digest colorless. The flask was taken off the heater, allowed to cool and the contents made up to 100 ml mark with deionized water and mixed. To 1 ml of the digest, was added 3 drops of mineral stabilizer and 3 drops of polyvinyl alcohol dispersing agent. It was mixed, made up to 25 ml and 1ml of Nessler's reagent was added. The colour was read within 5 minutes at 460 nm on the Hach spectrometer against deionized water blank. The absorbance gave apparent nitrogen in mg/l. The true Kjeldahl nitrogen was calculated as follows;

% nitrogen (N) = 0.005625 x A/B x C. Where A = mg/l (reading displayed), B = ml or g sample digested, C = ml digest analyzed (Hach, 1990).

Determination of Carbohydrate: Carbohydrate content was simply determined by difference. This was calculated by subtracting the whole nutrient contents (protein, fat, ash and fibre content from hundred).

Micronutrient Analysis: Micronutrients of the sample blends were determined by methods of International Institute of Tropical Agriculture (IITA, 2002). 0.48-0.52 g of the sample was weighed into a clean ceramic crucible

(to the nearest 0.001 g) while an empty crucible was included as a blank. This was placed in a cool muffle furnace, while the temperature was raised to 500 °C over a period of 2 hours and for an additional two hours at the same temperature. After coolling down, it was removed from the oven (care was taken to ensure that the environment was free from breeze). The ash sample was poured into an already labeled 50 ml centrifuge tubes, while the crucible was rinsed with 5 ml of distill water into the tubes. The crucible was again rinsed repeatedly with 5 ml of aqua regia, into the tubes until 20 ml of total volume was made. The sample was vortexed for proper mixing, centrifuged at 3,000 rpm (revolutions per minute) for 10 minutes and the supernatant decanted into clean vials for determination of the nutrients using the atomic absorption spectrophotometer.

RESULTS

The results for the Total Viable Count (TVC) in cfu/g on packaged wheat and plantain flour at different ratio's during storage at room temperature (29.0 ± 2 °C) for a period of nine (9) weeks for both bacterial and fungal counts are presented on Tables 1 and 2 respectively. The results indicated that as the period of storage increased, there was a progressive increase in both bacterial and fungal counts, irrespective of their individual proportions.

Table 1: Total Viable Count (TVC) of Bacteria in cfu/g on Packaged Wheat and Plantain Flour at Different Ratios During Storage at Room Temperature (29.0±2 °C) for a Period of Nine (9) Weeks

Period of Storage (Weeks)	Total Viable Count (Bacteria) cfu/g				
	% Ratios of the Samples (W&P)				
	25:75	50:50:00	75:25:00	100 W	100 P
0	7.0×10^5	5.0×10^3	2.0×10^2	5.0×10^1	2.0×10^3
1	9.0×10^5	7.0×10^3	4.0×10^2		
2	1.5×10^6	1.0×10^4	3.5×10^3		
3	8.5×10^6	4.0×10^5	3.0×10^4		
4	2.5×10^7	9.0×10^5	2.5×10^5		
5	8.5×10^7	2.9×10^6	9.5×10^5		
8	1.0×10^9	1.2×10^8	2.0×10^7		
9	1.2×10^9	3.0×10^8	8.5×10^7		

Note: cfu/g = Colony Forming Unit per gram, W = wheat only, P = Plantain only, W$P = Wheat and Plantain.

Table 2: Total Viable Count (TVC) of Fungi in cfu/g of Packaged Wheat and Plantain Flour at Different Ratio's During Storage at Room Temperature (28±2 °C) for a Period of Nine (9) Weeks

Period of Storage (Weeks)	Total Viable Count (Fungi) cfu/g				
	% Ratios of the Samples (W&P)				
	25:75	50:50:00	75:25:00	100 W	100 P
0	2.0×10^4	2.3×10^2	1.5×10^2	2.0×10^1	2.0×10^2
1	2.4×10^4	2.5×10^2	2.0×10^2		
2	3.5×10^5	4.5×10^3	2.0×10^3		
3	6.5×10^5	2.6×10^4	8.5×10^3		
4	1.7×10^6	3.5×10^5	1.5×10^4		
5	2.6×10^6	1.2×10^6	3.0×10^4		
8	1.5×10^8	1.0×10^8	1.5×10^6		
9	2.0×10^8	1.6×10^8	2.1×10^6		

Note: W = Wheat only, P = Plantain only, W&P = Wheat and Plantain, cfu/g = Colony Forming Unit Per gram.

Table 3 shows the changes in physico-chemical qualities of wheat and plantain flour at different ratio's during storage at ambient temperature for a period of nine weeks. Changes in physiochemical properties revealed that the pH was inversely proportional to the Titratable Acidity (TA).

Table 3a: Changes in Physico-Chemical Quality of W&P at Different Ratio's During Storage at Room Temperature (29.0±2 °C) for a Period of Nine (9) Weeks

Period of Storage (Weeks)	% Ratios of the Samples (W&P)					
	25:75			50:50:00		
	pH	TA	MC	pH	TA	MC
0	6.3	0.0006	15	6.45	0.00054	14
1	5.7	0.00045	15	5.65	0.00039	17
2	5.1	0.000403	17	5	0.00032	19
3	5	0.00045	20	5	0.00033	23
4	4.95	0.000477	24	5.1	0.0003	23
5	4.8	0.000582	25	4.9	0.0005	24
8	4.5	0.000742	30	4.65	0.00064	28
9	4.35	0.000842	33	4.43	0.00078	30

Note: pH = Hydrogen ion concentration, TA = Titratble acidity, MC = Moisture Content.

Table 3b: Changes in Physico-Chemical Quality of W&P at Different Ratio's During Storage at Room Temperature (29.0±2 °C) for a Period of Nine (9) Weeks

Period of Storage (Weeks)	% Ratios of the Samples (W&P)								
	75:25:00			100 W			100 P		
	pH	TA	MC	pH	TA	MC	pH	TA	MC
0	6.5	0.00036	12	5.12	0.00032	7	6	0.000436	10
1	6.05	0.00024	15						
2	5.95	0.00021	17						
3	5.4	0.00024	21						
4	5.2	0.00036	22						
5	5.1	0.000462	23						
8	5	0.00062	25						
9	4.95	0.000638	28						

Note: pH = Hydrogen ion concentration, TA = Titratble acidity, MC = Moisture Content.

Table 4: Microorganisms Isolated from Wheat and Plantain (W$P) at Different Ratio's During Storage at Room Temperature (29 ± 2 °C) for Nine (9) Weeks

Different Ratios	Bacterial Isolates	Fungal Isolates
W&P 25:75	B1, B2, B5 and B6	F1, F2 and F3
W&P 50:50	B1, B3, B4, B5 and B6	F1, F2, F3 and F5
W&P 75:25	B1, B2, B3 andB4	F1, F2 and F4
W only	B1 and B3	F1 and F2
P only	B1, B2, B4, B5 and B6	F1, F3, F4 and F5

Note: B1 = *Proteus sp.*, B2 = *Klebsiella sp.*, B3 = *Bacillus subtilis*, B4 = *Pseudomonas aeruginosa*, B5 = *Micrococcus sp*, B6 = *Staphylococcus aureus*, F1 = *Aspergillus niger*, F2 = *Aspergillus flavus*, F3 = *Rhizopus sp.*, F4 = *Penicillium sp.*, F5 = *Fusarium sp*.

Table 5: Proximate Composition of Sample Blends Based on Wheat and Plantain (W:P) Flours

Nutrient (%)	% Ratios of Sample Blends						
	W:P		W:P		W:P		100 W
	25:75		50:50:00		75:25:00		
	A	B	A	B	A	B	A
Protein	8.91	8.3	7.42	7.03	10.63	10.05	12.29
Fat	3.9	3.87	3.3	3.27	3.82	3.79	3.26
Ash	2.36	2.26	2.09	2.05	2.6	2.54	2.48
Fibre	2.13	2	1.92	1.8	1.4	1.32	1.85
Carbohydrate	83.78	81.35	74.62	72.80	80.79	78.28	73.45

Note: A = 0 hour, B = 9th week, W = Wheat, P = Plantain

Table 6: Mineral Composition of Sample Blends Based on Wheat and Plantain (W:P) Flours

Mineral (mg/100 g)	Proximate Composition in mg/100 g							
	% Ratios of Sample Blends							
	W:P		W:P		W:P		100 W	100 P
	25:75		50:50:00		75:25:00			
	A	B	A	B	A	B	A	A
Calcium	12.38	12.11	10.59	10.13	14.75	14.03	17.42	6.39
Sodium	1.54	1.38	1.25	1.1	2.73	2.43	1.86	0.85
Phosphorous	124.3	123.1	120.5	119.3	123.2	122.5	121.05	122.06
Iron	1.24	1.2	1.16	1.13	1.39	1.25	1.16	1.12
Iodine	2.15	2.09	1.25	1.22	1.80	1.75	1.26	2.07

Note: A = 0 hour, B = 9th week, W = Wheat, P = Plantain.

Table 4 presents the microbial isolates of wheat and plantain at different combinations during storage for nine weeks at 29.0±2 °C. The results indicated that the most while the most frequent fungus was *Aspergillus niger*.

Finally, Tables 5 and 6 respectively show the proximate and micronutrient compositions of the sample blends for the zero hour and the ninth week only. These tables show a progressive decrease in the nutrient and mineral content with increase in storage period from zero hour to the 9th week.

DISCUSSION

The total viable count (cfu/g) of all blends increased with increasing levels of plantain flour during the period of storage for nine weeks with values ranging from 7.0 x 10^5 - 1.0 x 10^9 (25:75), 5.0 x 10^3 - 3.0 x 10^8 (50:50) and 2.0 x 10^2 - 8.5 x 10^7 (75:25). The total viable fungal counts (cfu/g) of all the blends increased as well, with increasing levels of plantain flour during the period of storage for nine weeks with values ranging from 2.0 x 10^4 - 2.0 x 10^8 (25:75), 2.3 x 10^2 - 1.6 x 10^8 (50:50) and 1.5 x 10^2 - 2.1 x 10^6 (75:25). Genera of microorganisms isolated include *Proteus, Klebsiella, Bacillus, Pseudomonas, Micrococcus, Staphylococcus, Aspergillus, Rhizopus, Penicillium*and *Fusarium*. Similar organisms were isolated from previous work carried out by Ohenhen *et al.* (2006) in their study on microorganisms associated with preparation of plantain pudding in Western Nigeria. The source of these microbes present in wheat and plantain could be inherent microflora in the tissues of animals, air environment or contamination due unhygienic pre-processing, and handling of the sample. The rapid microbial proliferation may be attributed to nutrient

availability and favorable micro-environment with resultant recovery of homeostatic imbalance (Ogbulie *et al.*, 1993).

The hydrogen ion concentration (pH) decreased with the increase in storage period. The pH decreased with values ranging from 6.30-4.35 (25:75), 6.45-4.43 (50:50) and 6.50-4.95 (75:25). Subsequently, the titratable acidity increased as storage time increased. Titratable acidity increased with values ranging from 0.000540 to 0.000842 (25:75), 0.000600 to 0.000784 (50:50) and 0.000360 to 0.000638 (75:25). The decrease in pH and the subsequent increase in titratable acidity may be attributed to the microbial activities which help to breakdown carbohydrates for the production of organic acids. This may be responsible for the gradual increase recorded in titratable acidity. Similar findings for other food items have been documented (Eka, 1986; and Ogiehor *et al.*, 2003).

An increase in percentage moisture content was recorded in all the flour blends throughout the 9 weeks period of storage. The blend 25:75 had the highest moisture content (15-33%), followed by 50:50 (14-30%) and 75:25 (12-28%). The increase in moisture contents of the blends with subsequent increase in plantain flour may be attributed to the increase in proportion of plantain flour as unripe plantain fruits has been reported by Zakpaa *et al.* (2010) to have high amylose content thereby implying high hydroxyl (OH) groups to form Hydrogen bonding hence, their ability to bind more water. The moisture content in a food affects its packaging, keeping quality, nutrient content, types and rate of microbial spoilage (Rendon-Villalobos *et al.*, 2008).

The decrease in protein content in all blends with increase in storage time, with values ranging from 8.91-8.30% (25:75), 7.42-7.03% (50:50) and 10.63-10.03 (75:25). The decrease in protein content on the other hand, with subsequent increase in plantain flour, may be attributed to dilution effect. A dilution effect is likely responsible for this pattern since plantain flour has low protein content (Rendon-Villalobos *et al.*, 2008). It may also be due to the activities of microorganisms in the product. This pattern of decrease in protein content was similar to previous work done by Onuh and Isah (2009).

The lipid (fat) content of the blends was generally low, with very minimal reduction from zero hour to the ninth week. Values ranging from, 3.90-3.87% (25:75), 3.30-3.27% (50:50) and 3.82-3.79% (75:25) were observed. The observed low percentage values in fat content for all blends may be attributed to the fact that cereals, tubers are generally known to store energy in the form of starch rather than fat. The low fat content may be due to the activities of micro-organisms. However, the fat content is important in diets as it promotes fat soluble vitamin absorption. It is noteworthy to mention that, this minimal fat content could be very significant as fat plays a vital role in the determination of shelf life of foods. A low value indicates that oil can resist lipolytic hydrolysis and oxidative deterioration, while a high amount of fat can accelerate the rate of spoilage by promoting rancidity, leading to off flavors and odor development (Olaoye and Onulide, 2008).

The decrease in values for ash content for all blends from the zero (0) hour to the ninth (9^{th}) week with values ranging from, 2.36-2.26% (25:75), 2.09-2.00% (50:50) and 2.60-2.49% (75:25) was in close agreement with previous work carried out by Rendon-Villalobos *et al.* (2008) on wheat-plantain starch salted noodles preparation. This relatively low ash percentage values suggest relatively low mineral contents of foods (Olaoye and Onulide, 2008).

The crude fiber content for all the blends were observed to decrease with storage time, with values ranging from 2.13-2.00% (25:75), 1.92-1.80% (50:50) and 1.40-1.32% (75:25). Similar observations have been reported by Rendon-Villalobos *et al.* (2008). Crude fiber acts as roughage which aids the digestion process thus, promoting human health. The increase in fiber content with subsequent increase in plantain flour may be attributed to the presence of resistant starch in green fruits of plantains. This may increase the fibre content of the food (Rendon-Villalobos *et al.*, 2008).

The decrease in carbohydrate content with storage time with values ranging from 83.75-81.35% (25:75), 74.62-72.80% (50:50) and 80.79-78.28% (75:25) may be associated with high utilization of carbohydrates as a source of energy and lesser use of protein and fat. This observation was in good agreement with (Obiakor and Nwanekezi, 2009) in their study on nutrient and microbial quality of soup condiment (dadawa) produced from fermented baobab seeds (*Adansoniadigitata*). The high carbohydrate content with corresponding increase in the plantain flour in each composite blend was expected. This could probably be due to higher carbohydrate content in plantain when compared to that of wheat.

A decrease in micronutrient content such as Calcium (Ca), Sodium (Na), Phosphorous (P), Iron (Fe) and Iodine (I) in all blends was observed as storage period increased from

the zero hour to the ninth week. Low values were reportedly low for micronutrients like Na [1.54 -1.38 (25:75); 1.25-1.10 (50:50) and 2.73-2.43 (75:25)], Fe [1.24-1.20 (25:75); 1.16-1.13 (50:50) and 1.39-1.25 (75:25)] and I [2.15-2.09 (25:75); 1.25-1.22 (50:50) and 1.80-1.75 (75:25)] when compared to those in Ca [12.38-12.11 (25:75); 10.59-10.13 (50:50) and 14.75-14.03 (75:25)] and P [124.28-123.11 (25:75); 120.47-119.33 (50:50) and 123.28-122.49 (75:25)]. This pattern of values in mineral contents was in conformities with (Rendon-Villalobos *et al*., 2008), who reported high phosphorus content in their study on composite wheat-plantain starch salted noodles preparation. These differences in the values of the minerals could be attributed to the differences in soil conditions such as soil type, structure and mineral content.

The presence of calcium and phosphorus is a good indication that the products are rich in minerals for bone formation. Calcium is very essential in blood clotting, muscles contraction and in certain enzymes in metabolic processes. Low Ca/P ratio facilitates the calcinations of calcium in the bone, while the Ca/P ratio above two (2) helps to increase absorption of calcium in the small intestine.

CONCLUSION

This study revealed the microbiological, physico-chemical and nutritional qualities of wheat and plantain flour at room temperature under storage for a period of nine (9) weeks. The consumption of processed and unprocessed foods depends on the nutritive quality of the food. The storage and processing of the food are indices to food safety and stability.

This study has revealed that enhancing plantain flour with wheat flour is nutritionally advantageous. Although, minimal reduction in protein and calcium contents of all the blends was observed, protein and calcium quality of wheat has been reported to be higher than that of plantain.

However, nutrients such as carbohydrate, and micronutrients such as phosphorous and iodine, were indeed highly improved with corresponding increase in plantain flour. It is therefore recommended that the flour blends should be used in complementary feeding as it will help to the fight against malnutrition especially in cases of protein and calcium deficiency, thus leading to better nutrition in the country. Also, the use of hygienic techniques should be practiced when handling and processing food as this will help in improving the nutritive quality, shelf life, acceptability and safety of the product.

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