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Investigating the effect of drying factors on the quality assessment of plantain flour and wheat- plantain bread

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Abstract

The objective of this research was to know the effect of drying factors on the quality attributes of plantain flour when used for composite bread. In this study, the drying parameters (temperatures and loading density) were employed to produce plantain flour. It was subjected to proximate (moisture content, protein, ash, fibre, fat and carbohydrate) and functional (bulk density, swelling capacity and water absorption capacity) analyses. The plantain flour was mixed with wheat flour to produce composite breads. The bread was subjected to sensory (crumb smoothness, aroma, taste, flavor and overall acceptability) and minerals (Zn, Mg, Fe, Ca, P, Na and K) analyses. The results of the proximate composition were as follows: moisture (12.20-14.20)%, protein (0.92-1.93)%, fat (0.28- 0.42)%, ash (1.73-2.24)%, crude fibre (1.29-3.00)% and carbohydrate content (80.19-81.99)%. The results of functional properties were as stated: bulk density (0.63-0.78) g/cm3, swelling capacity (1.05-1.37) g water/ g sample and water absorption capacity (1.35-1.85) cm^3/g. The result of sensory analysis of the breads were: colour (6.23-8.17), crumb smoothness (6.56 -8.00) aroma (6.05-7.99), taste (5.67-7.84), flavor (6.05-7.84) and overall acceptability (6.05-8.00). The results of mineral content of the breads ranges were: 1.65-1.77, 50.23- 74.69, 7.92-7.97, 57.10- 61.90, 130.14- 140.21, 452.33- 475.54 and 188.91- 214.77 mg/100g for Zn, Mg, Fe, Ca, P, Na and K respectively. Results obtained showed that as the drying temperatures increased, the value of some parameters such as moisture content, ash, fat and bulk density decreased. In contrast, swelling capacity and water absorption capacity increased with increasing temperature. The sensory and mineral analyses conducted showed that composite bread with 30% plantain flour yielded the same result when compared to 100% wheat bread and inclusion of plantain flour increased the mineral contents of the bread. Therefore, this study concludes that, effective drying temperatures and loading density could produce quality plantain flour for production of composite bread.

Introduction

Plantain (*Musa* spp.) is an important staple crop that contributes to the calories and subsistence economies globally (Adeniji and Tenkouano, 2008). They are produced abundantly in Africa with more than twelve million metric tonnes annually in which Nigeria is the lead producer (Ajala and Ajala, 2015). Plantain could be consumed when it is ripe, could be cut into chips or fried. Moreover, due to its enormous benefits, it has been found useful as a substitute for yam flour which serves as a staple food when made into gelatinized paste called 'amala' in South West Nigeria. More so, because of its high nutritious value as a source of dietary carbohydrates, minerals and vitamin A as reported by Kainga and Seiyabo (2012) and Ajala and Ajala (2015), it is being used in other food formulation development. Recently, there has been innovation on the use of other flours to supplement wheat in bread baking; this is majorly due to increase in price of wheat flour which adversely the cost of bread; therefore there is an increasing demand to develop indigenous flour aside from wheat so as to increase their utilization in the bakery likewise complimenting wheat flour with a view to reducing the price of bread.

Various attempts have been made to develop composite breads. Olaoye *et al.* (2006) used wheat, plantain and soy bean flour to produce composite bread, Yetunde *et al*. (2009) used Bambara flour to produce composite bread, Maria *et al.* (2013) used wheat, maize and cassava in ratio 5:3:2 to produce composite bread and Trejo-González *et al.* (2014) used potato at a maximum level of 20% for composite bread. However, the use of plantain flour exclusively to produce composite bread is barely reported in the literature.

Although, plantain flour has recently been

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eulogized in Nigeria for supplementing wheat flour due to its good proportion of vitamins and minerals; however, most of the flour produ ced locally cannot meet up with the set standard due to unhygienic processing method employed especially during the drying process. In Nigeria, the method adopted for plantain flour production is still primitive because it entails spreading the plantain under the sun. This drying method often produces brown colour flour which makes it useless for production of products such as in cookies, bread and biscuits. Apart from this, essential minerals and vitamins are also lost during the traditional production of such flour. This work tends to fill this gap by employing alternative mechanical drying method with a view to preserving the necessary drying factors that would produce good flour.

Materials and Methods

Materials

Plantain used for this research work was purchased from Ladoke Akintola University Teaching and Research Farm, Ogbomoso, Oyo State, Nigeria. Matured plantains that were free from all form of mechanical injury which might be a possible source of contamination were used. Other reagents used in the course of analysis were of analytical grade

Preparation of plantain flour

Mature and unripe plantains used were properly washed to remove sands and contaminant. They were subsequently peeled and made into chips into flat sizes. The fresh chips were loaded into trays at loading densities of 300 g, 400 g, 500 g/tray afterwards they were transferred into the tunnel dryer for drying at temperatures of 50^{0}C, 60^{0}C and 70^{0}C respectively. The dried chips were then milled and sieved to flour for proximate and functional analyses.

Preparation of composite flour and bread making

Wheat flour was purchased from Sabo market in Ogbomoso, Oyo State. The acquired flour was mixed with plantain flour by varying the proportion of wheat to plantain flour in each mix to make a composite flour of 400 g. The following were the formulation of the composite flour: Sample R (100% of wheat flour), sample A (90% of wheat and 10% of plantain flour), sample B (70% of wheat and 30% of plantain flour) and sample C (50% of wheat and 50% plantain flour). Each sample was then mixed with 20 g butter, 5 g yeast, 15 g sugar, and 5 g of salt; water was added to form dough. After the dough has been formed, it was cut and moulded into baking pan and allowed to proof. The proofed dough were loaded into the oven and then baked to form breads. Sensory and minerals analyses were carried out on the breads.

Determination of proximate composition on the plantain flour and breads

Moisture, crude fat, protein, ash, carbohydrate and crude fibre were determined using the Official Methods of Analysis of the Association of Official Analytical Chemists, (AOAC) (2000).

Determination of physico-chemical properties of the flour

Determination of water absorption, bulk density and swelling capacity were carried out using the AOAC (2000) methods

Sensory evaluation of breads

Sensory evaluation based on the sensory attributes was conducted with the aid of standard 9 points hedonic scales method (where 1 = dislike very much and 9 = like very much) [Larmond, 2007]. A total of 40 semi-trained panelists of age 19 years and above were involved in the evaluation for crust and crumb colour, aroma, taste, texture and overall acceptability. Among these panelists, 18 were males and 22 were females. The bread samples were sliced into uniform pieces of 2 cm thickness, coded with 3-digit random number using statistical random tables. These were then served to the panelists at around 11.15 a.m with distilled water for rinsing the mouth after every sample taste in a randomized order. The panelists were instructed to rate the attributes indicating their degree of liking or disliking by putting a number as illustrated in the hedonic scale.

Determination of mineral components of the breads

Mineral components (Zn, Mg, Fe, Ca, P, Na and K) of the bread samples were determined using Atomic Absorption Spectrophotometer (AAS) using the official method of AOAC, (2000).

Statistical analysis

All values were carried out in triplicates and subjected to statistical analysis. In each case, a mean value was calculated and analysis of variance (ANOVA) was also performed. Separation of the mean values was done by Duncan's multiple range tests at $p \leq 0.05$ using Statistical Analysis System (SAS) software, version 10.0.

Results and Discussion

Proximate composition of plantain flour

The proximate composition of plantain flour as shown in Table 1 consists of moisture content, protein, ash, fibre, crude fat and carbohydrates. The moisture content of the plantain flour ranged from 12.20±0.36 to 14.20±2.27% at different degree of temperatures and significantly differed. However, samples with loading density of 300, 400 and 500g/tray at the same temperature were not significantly different. At a loading density of 300g/tray and 70°C of temperature, the moisture content recorded was 12.20% while at a loading density of 500g/tray and 70°C of temperature the moisture content recorded was 12.34±0.36%. This shows that higher loading density conferred increased moisture content on the sample which was due to the occurrence of longer moisture diffusion path. This may be as a result of the clumsiness of the samples in which all the surface area of the food product were not exposed to equal amount of drying air. Samples with lower moisture content have tendency of longer shelf life because low moisture content confers higher shelf life to flours where both microbial and enzymatic activities are minimal. This observation is consistent with findings earlier reported by Ajala *et al.* (2012). Also, the moisture content recorded in this study is similar to those obtained by Emperatríz *et al.* (2008) and USDA (2009).

The protein content of plantain flour ranged between 0.92±0.04% to 1.93±0.13 % and were significantly different from one another at P<0.05. The lowest value of protein was obtained at a temperature of 50°C and a loading density of 400g/tray while the highest value was recorded at temperature of 70°C and 500g loading density. The recorded protein content was similar to that reported by USDA (2009) but was lower when compared to tubers, fruits and other widely eaten stable roots as studied by Arisa *et al.* (2013). The results show that protein increased as the drying temperature increased. This was because, as the moisture content decreased at elevated temperature, other proximate compositions became more concentrated in the samples leading to an apparent increase in the protein content. However, no specific pattern of influence was observed from the loading density.

The ash content in foodstuffs is the inorganic content residue remaining after the organic matter has been burnt away, it can provide an estimate of the type and quantity of the minerals in the burnt product. With plantain flour as a case study, the ash content ranged from 1.73±0.02 to 2.24 ±0.13% and was significantly different at P<0.05. This implies that the samples could be good sources of nutritionally essential minerals and trace elements (Ajala and Idowu, 2016). The lowest and highest values were achieved at a loading density of 500g/tray but no regular pattern of observation was recorded. These values were consistent with those reported by Ketiku (1973); Arisa *et al.* (2013) and Zakpaa *et al.* (2010).

The fibre content of plantain flour ranged from 1.29±0.05% to 3.00±0.23% and were significantly different at p<0.05. The lowest value of 1.29±0.05% corresponds to temperature of 50°C at loading density of 300g/tray while the highest value of 3.00±0.23% corresponds to temperature of 70°C at loading density of 500 g/tray. Influence of both temperature and loading density on the fibre content did not

Table 1a. Proximate analysis of plantain flour

Temperature °C	Loading density (g/tray)		
	300	400	500
	Moisture content (%)		
50	14.03 ± 2.67^{b}	14.17±2.75^{b}	14.20±0.91^{b}
60	13.46 ±0.74^{a}	13.04±0.00^{a}	13.96 ± 1.46^{a}
70	12.20 ±0.62^{a}	12.25±1.83^{a}	12.34±0.36^{a}
	Protein (%)		
50	1.12 ±0.14^{ab}	0.92±0.05^{a}	1.02±0.00^{a}
60	1.28±0.00^{c}	0.92±0.04^{a}	1.10±0.28^{a}
70	1.30±0.19^{c}	0.97±0.08^{a}	1.93 ±0.13^{b}
	Ash (%)		
50	1.97 ± 0.2^{ab}	1.88±0.48^{a}	1.73±0.02^{a}
60	1.98 ±0.25^{cd}	1.92±0.00^{cd}	1.91±0.05^{cd}
70	2.09±0.28^{d}	1.95±0.25^{bc}	2.24 ±0.13^{e}

Table 1b. Proximate analysis of plantain flour continued

Temperature °C	Loading density (g/tray)		
	300	400	500
	Fibre (%)		
50	1.29 ±0.05^{a}	1.60±0.10^{ab}	2.08±0.12^{c}
60	2.18±0.02^{c}	1.83±0.00^{b}	2.10±0.31^{c}
70	1.92±0.13^{b}	2.08±0.11^{bc}	3.00 ±0.23^{c}
	Fat (%)		
50	0.30±0.00^{a}	0.28±0.00^{a}	0.29±0.00^{a}
60	0.40±0.00^{bc}	0.31±0.00^{a}	0.38±0.00^{b}
70	0.42±0.02^{c}	0.32±0.00^{a}	0.39±0.00^{b}
	Carbohydrate (%)		
50	80.59±2.67^{a}	81.15±3.18^{ab}	80.87±1.24^{bc}
60	80.60±0.99^{abc}	81.69±3.08^{c}	80.73±3.20^{abc}
70	80.79±1.39^{abc}	81.99±3.82^{c}	80.19 ±1.27^{abc}

follow any pattern. The values obtained in this work were greater than the value reported by Izonfou and Omuaru (1988) which was 0.9%. Furthermore, the values also were greater than the value reported by Zakpaa *et al.* (2010) which was 0.978%. This shows that plantain flour is a poor source of crude fibre which helps to promote gastric digestion.

The crude fat content of the plantain flour obtained ranged from 0.28±0.00% to 0.42±0.02% and significantly different at $p<0.05$. At a temperature of 50oC and a loading density of 400 g/tray, a low value of 0.28±0.00% was obtained while the highest value obtained (0.42±0.02%) was achieved at a temperature of 70^{o}C and a loading density of 300g/ tray. This shows that samples dried at lower temperature had lower fat content. This could be attributed to oxidation of the fat during the long duration of drying at lower temperature than high temperature. Though, Fagbemi (1999) reported a value of 3.00%, however, the values reported by Ketiku (1973); USDA, (2009) and Zakpaa *et al*. (2010) ranged between 0.2 to 2.5% which is in agreement with the present study

The carbohydrate content of plantain flour ranged from 80.19 ±1.27 to 81.99±3.82% and was significantly different from one another ($p<0.05$). The lowest value of 80.19 ±1.27% was achieved at a temperature of 70^{0}C and a loading density of 500 g/tray while the highest value of 81.99±3.82% was achieved at a temperature of 70^{o}C and a loading density of 400g/tray. Though the values reported in this study was consistent to that reported by Carolina *et al*. (2013), a higher value of 91.16% was reported by Zakpaa *et al*. (2010).

Functional properties of the flour

The bulk density was measured at different temperatures and loading densities as shown in Table 2. The results showed that the bulk densities obtained ranged from 0.63±0.02 to 0.78±0.02 g/cm^3. The lowest value was obtained at a temperature of 70^{o}C and a loading density of 300 g/tray while the highest value was obtained at a temperature of 50^{o}C and a loading density of 500 g/tray. Bulk density has inverse relationship with temperature but direct relationship with loading density as shown in Table 2. This is because moisture content which affects the bulk density of the flour was greatly reduced at higher temperature and lower loading density. This observation was earlier reported by Ajala *et al.* (2012). Significant difference at $P<0.05$ was observed in bulk density of the entire sample. The values obtained were similar to that obtained for sweet potato powder by USDA, (2009) with value of 0.7453 g/cm^3. As reported by USDA, (2009), apart from bread baking,

Table 2. Functional properties of plantain flour

Temperature ^{0}C	Loading density (g/tray)		
	300	400	500
	Bulk density (g/cm^3)		
50	0.75±0.01^{c}	0.76±0.00^{c}	0.78±0.02^{c}
60	0.70±0.00^{b}	0.72±0.01^{b}	0.74±0.01^{b}
70	0.63±0.02^{a}	0.64±0.03^{a}	0.66 ±0.04^{a}
	Swelling capacity (g water/g sample)		
50	1.05±0.02^{a}	1.17±0.02^{a}	1.13±0.02^{a}
60	1.22±0.01^{a}	1.29±0.03^{a}	1.25±0.00^{a}
70	1.37±0.04^{c}	1.33±0.08^{b}	1.31 ±0.04^{b}
	Water absorption capacity (cm^3/g)		
50	1.45±0.07^{a}	1.60±0.00^{bc}	1.35±0.07^{a}
60	1.54±0.05^{b}	1.69±0.02^{c}	1.50±0.03^{b}
70	1.85±0.07^{d}	1.75±0.07^{d}	1.62 ±0.14^{bc}

plantain flour can be used as a thickener in the food industries.

The swelling capacity of plantain flour obtained ranges from 1.05±0.02 to 1.37±0.04 g water/g sample and exhibited significant difference ($p<0.05$). The lowest value of 1.05±0.02 g water/g sample was achieved at a temperature of 50^{o}C and a loading density of 300 g/tray while the highest value of 1.37±0.04 g water/g was obtained at a temperature of 70^{o}C and a loading density of 300 g/tray. Samples dried at higher temperature resulted in higher swelling capacity; however, sample dried at higher loading density resulted in lower swelling capacity. The results obtained were lesser than the values reported by Agunbiade *et al.* (2006) and Zakpaa *et al.* (2010) which were 1.89 and 5.00 g water/g sample respectively. The differences in values could be as a result of the variety of plantain used.

The water absorption capacity (WAC) ranged from 1.35±0.07 to 1.85±0.07 cm^3/g and showed a significant difference among the samples. The lowest value at 1.35±0.07 cm^3/g was recorded at a temperature of 50^{0}C and loading density of 500 g/ tray while the highest value at 1.85±0.07 cm^3/g was achieved at a temperature of 70^{oC} and loading density of 300 g/tray. The WAC of plantain flour obtained in this study were lower than the value reported by Fagbemi (1999) which ranged from 3.52 to 10.5 cm^3/g. WAC increased as the temperature of drying increased as shown in Table 2. This is because at higher drying temperatures, the sample moisture content reduced which allowed more water absorption during rehydration of the samples. Water absorption capacity and swelling capacity are directly related because swelling of flour comes as a result of water absorption by the samples. Swelling capacity could

Table 3. Sensory evaluation of plantain wheat bread

Properties	R	A	B	C
Colour	8.17±0.08a	7.95±0.54a	7.72±0.06a	6.23±0.47ab
CS	8.00±0.00a	7.71±0.06a	7.05±0.23a	6.56±0.00a
Aroma	7.99±0.33a	7.67±0.32a	7.05±0.23a	6.05±0.23ab
Taste	7.84±0.39a	7.67±0.32a	7.22±0.47a	5.67±0.32a
Flavor	7.84±0.23a	7.67±0.32a	7.22±0.47a	6.05±0.39ab
OA	8.00±0.24a	7.71±0.32a	7.05±0.47a	6.05±0.39ab

Key:
R- 100% wheat flour; A- 90% wheat flour, 10% plantain flour; B- 70% wheat flour, 30% plantain flour; C- 50% wheat flour, 50% plantain flour, CS- Crumb smoothness and OA- Overall acceptability.

be inhibited by the lipid content of the flour (Wang and Seib, 1996; Hathaichanock and Masubon, 2007). However in baking of bread, swelling can also come as a result of leavening agents such as yeast cells.

Sensory evaluation of the plantain-wheat bread

The result for sensory analysis is as shown in Table 3 which evaluated the composite bread in terms of colour, crumb smoothness (CS), aroma, taste, flavor and overall acceptability (OA). The colour of sample R (100% wheat bread), sample A (90%wheat, 10% plantain flour) and sample B (70%wheat, 30% plantain flour) had no significant difference ($p< 0.05$) except sample C (50% wheat, 50% plantain flour). Sample R was preferred most followed by sample A and the least was sample C. Also, the colour of the breads' crumb became brownish as the level of plantain flour substitution increased. Therefore, sample C was exceptionally brown than other samples and it exhibited significant difference. There was no significant difference ($p< 0.05$) between the crumb smoothness of wheat bread and the composite bread but sample C was rated least by the panelists. There was no significant difference ($p< 0.05$) between the aroma of wheat bread and other composite bread except sample C which was significantly different ($p<0.05$) from all other samples. The results also showed that there was no significant difference($p< 0.05$) in the taste of wheat bread and composite bread but sample C was shown to be least liked by the panelists. Besides, there were no significant difference ($p< 0.05$) between the flavor of wheat bread and the composite bread except in sample C. Furthermore, the overall acceptability of this study shows that there was no significant difference ($p< 0.05$) between the wheat bread and other composite breads except sample C which was significantly different. Finally, sample R was rated highest in overall acceptability as shown in Table 3. Among the composite bread, sample A was rated the highest while sample C was the least. This means that substitution of plantain flour up to 30% level was comparable to 100% wheat flour in sensory quality. This observation on production of composite bread using different materials has been reported by Eddy *et al*. (2007); Chinma *et al.* (2012); Maria *et al.* (2013).

Proximate evaluation of the plantain-wheat bread

Moisture content of the bread samples ranged from 29.65 to 34.93% as shown in Table 4 and increased as the samples of plantain flour increased in the composite bread. There were statistical differences among the samples at $p<0.05$. Due to the increased moisture content of the composite bread, the shelf life of sample would be in this order: C< B< A < R. The value of moisture content of the bread was comparable with the values of bread based on blends of *Vigna* Sp and wheat flour (Onoja *et al*., 2014). The protein content of the bread samples slightly increased from 7.67 to 7.69% as the portion of plantain flour increased in the composite bread but no significant differences were observed between them at $p<0.05$ as shown in Table 4. This was because plantain flour is not a good source of protein and cannot be a good source of protein enhancement for bread (Zakpaa *et al.*, 2010). The value of protein was in close range with the values reported by Malomo *et al.* (2011). Ash content increased from 2.00 to 2.53% as the values of plantain increased with sample C differed significantly from others at $p<0.05$. The increase in ash content of composite bread suggested plantain flour increased the ash levels. The value was comparable with the values reported by Mongi *et al.* (2011). From Table 4, fibre content of the composite bread increased from 0.45 to 1.90% as the values of plantain flour increased in the bread samples. Samples R and C were significantly different but samples A and B were not at $p<0.05$. The values were comparable with the values of

Table 4. Proximate evaluation of wheat- plantain bread

Nutrients	R (%)	A (%)	B (%)	C (%)
Moisture	29.65±1.34^{a}	31.72±1.32^{ab}	33.76±1.32^{c}	34.93±1.44^{d}
Protein	7.67 ±1.20^{a}	7.71±0.99^{a}	7.73±1.32^{a}	7.69±1.05^{a}
Ash	2.00±0.01^{a}	2.14±0.05^{ab}	2.18±0.09^{ab}	2.53±0.03^{c}
Fibre	0.45±0.04^{a}	1.56±0.32^{b}	1.57±0.54^{b}	1.90±0.47^{c}
Fat	2.50±0.63^{d}	2.05±0.72^{c}	1.87±0.43^{b}	1.21±0.66^{a}
Carbohydrate	58 73±3.03^{c}	54.82±2.92^{b}	52.89±2.02^{a}	51.74±2.71^{a}

Key:
R- 100% wheat flour; A- 90% wheat flour, 10% plantain flour; B- 70% wheat flour, 30% plantain flour; C- 50% wheat flour, 50% plantain flour,

Table 5. Minerals evaluation of wheat- plantain bread

Minerals	R (mg/100g)	A (mg/100g)	B (mg/100g)	C (mg/100g)
Zn	1.65±0.04^{a}	1.66±0.32^{a}	1.76±0.22^{a}	1.77±0.44^{a}
Mg	50.23 ±5.20^{a}	55.71±5.99^{b}	67.73±7.32^{c}	74.69±7.05^{d}
Fe	7.92±1.01^{a}	7.94±0.05^{a}	7.91±0.99^{a}	7.97±1.03^{a}
Ca	57.10±7.24^{a}	57.96±6.32^{a}	58.77±7.54^{ab}	61.90±5.47^{b}
P	130.14±11.63^{a}	133.05±7.72^{b}	137.87±6.43^{c}	140.21±6.66^{d}
Na	452.33±10.52^{a}	458.54±9.33^{b}	467.44±8.52^{c}	475.54±7.52^{d}
K	188.91±8.12^{a}	194.52±6.42^{b}	199.34±7.66^{c}	214.77±6.33^{d}

Key:
R- 100% wheat flour; A- 90% wheat flour, 10% plantain flour; B- 70% wheat flour, 30% plantain flour; C- 50% wheat flour, 50% plantain flour,

composite bread reported by Mongi *et al.* (2011). The value of fat content took a different trend in the composite bread in Table 4, because the level of fat content decreased as the content of plantain increased in the composite sample with significant difference at $p<0.05$. The values ranged from 1.21% (sample C) to 2.50% (sample R). It could be deduced from this that more fat droplets were being absorbed in the starch granule of plantain flour which caused fat decrease in the composite bread. The values were comparable with those reported by Onoja *et al.* (2014). The value of carbohydrate in Table 4 also followed decrease trend as the plantain flour increased in the composite bread. There was no significant difference between sample B and C but there was between sample A and R at $p<0.05$. The values were comparable with those reported by Michael *et al.* (2013).

Minerals evaluation of the plantain-wheat bread

The value of Zn in Table 5 ranged from 1.66 to 1.77 mg/100g. The least value was found in sample R while sample C had the highest value. However, there was no corresponding significant increase at $p<0.05$ in the Zn content despite increase in plantain flour in the composite bread. This shows that plantain flour is a poor source of Zn (Adepoju *et al*., 2012). The values of Mg in the composite bread in Table 5 shows that the values increased significantly as the plantain flour increased in the bread. This suggests an appreciable amount of Mg in plantain-wheat bread. The values ranged from 50.23 to 74.69 mg/100g and comparable to the values of bread fortified with rice bran (Michael *et al*., 2013). The value of Fe in the bread ranged from 7.92 to 7.97 mg/100 g without any significant difference at $p<0.05$ despite increase in plantain flour from 10 to 50% in the composite bread. This was because plantain is not a rich source of Fe and hence cannot significantly improve the Fe content of the bread samples (Zakpaa *et al*., 2010). The value of Ca is as shown in Table 5 which ranged from 57.10 to 61.90 mg/100 g and this shows that an appreciable amount of Ca was available in the bread. There were no significant differences among sample R, A and B except sample C. This connotes that to get an appreciable amount of Ca, much plantain proportion greater than 50% would have to be added to the composite bread. The value were lesser than the value of bread produced from wheat, breadfruits and bread nut blends as reported by Malomo *et al.* (2011) but comparable with the values of composite bread reported by Michael *et al.* (2013). On another trend, P, Na and K varied significantly at $p<0.05$ as shown in Table 5 and increased in value as the content of plantain increased in the composite bread. P ranged from 130.14 to 140.21 mg/100g and greater than the value of French bread earlier reported by

Gusmão *et al*. (2015). Na ranged from 452.33 to 475.54 mg/ 100 g and the values were also greater than the value of wheat-soybean bread reported by Anna and Małgorzata (2011) while K ranged from 214.77 mg/100 g and these values were greater than the values of honey fortified bread reported by Juhaimi *et al.* (2016). These values suggest that plantain flour is a rich source of these minerals and bread minerals can easily be enhanced using this substitution at a convenient range from 10 to 50%.

Conclusion

The observation drawn from the various analyses conducted in this research revealed that higher drying temperatures confer lower moisture content on the flour. Also, the higher the temperature, the lower the bulk density of the flour. Furthermore, the higher the loading density, the less the moisture removal due to the clumsiness of the samples in the tray. The amount of minerals present in composite breads were higher than that of 100% wheat bread and up to 30% substitution of plantain flour compared favourably well with 100% wheat bread in the overall acceptability.

References

Adepoju, O.T., Sunday, B. E. and Folaranmi, O. A. 2012. Nutrient composition and contribution of plantain *(Musa paradisiacea)* products to dietary diversity of Nigerian consumers, African Journal of Biotechnology 11(71): 13601-13605.

Adeniji, T.A. and Tenkouano, A. 2008. Effect of processing on the proximate, mineral, and pasting properties of whole flour made from some new plantain and banana hybrids pulp and peel mixture. Journal of Tropical Agriculture, Food, Environment and Extension 7(2): 99-105.

Agunbiade, S.O., Olanlokun, J.O. and Olaofe, O.A. 2006. Quality of chips produced from rehydrated dehydrated plantain and banana. Pakistan Journal of Nutrition 5 (5): 471-473.

Ajala, A. S., Babarinde, G. O. and Olatunde, S. J. 2012. Effect of temperatures, air velocity and flow rate on quality attributes of dried cassava chips. Asian Journal of Agriculture and Rural Development 2 (4): 527–535.

Ajala, A.S. and Ajala, F.A. 2015. Water absorption characteristics and modelling of unripe plantain chips. International Journal of Scientific and Engineering Research 6(5):29-38.

Ajala, A.S. and Idowu, T.O. 2016. Investigation on the quality of fermented white yam flour (elubo) at different drying temperatures. Canadian Journal of Agriculture and Crops 1(1): 1-10.

Anna, W.M. and Małgorzata, K. 2011. Evaluation of the mineral composition of breadstuff and frequency its consumption. Acta Science Polonorum Technologia Alimentaria 10(4): 487-495.

AOAC 2000. Official Methods of Analysis, 16th edn. Association of Official Chemists International. Richmond Virginia.

Arisa, N.U., Adelekan, A. O., Alamu, A.E. and Ogunfowora, E.J. 2013. Effect of pretreatment of plantain *(Musa Parasidiaca)* flour on the pasting and sensory characteristics of Biscuit Product. Pakistan Journal of Food Sciences 23(1): 43-51

Carolina, V. B., Antonio, M.R., Edna, R. A. and Luiza, H. M. 2013. Nutritional potential of green banana flour obtained by drying in spouted bed. Revista Brasileira de Fruticultura (35) 4: 1140-1146.

Chinma, C.E., Igbabul, D.E. and Omotayo, O.O. 2012. Quality characteristics of cookies prepared from unripe plantain and defatted sesame flour blends. American Journal of Food Technology (7) 7: 398-408.

Eddy, N.O., Udofia, P.G. and Eyo, D. 2007. Sensory evaluation of wheat/cassava composite bread and effect of label information on acceptance and preference. African Journal of Biotechnology 6 (20): 2415-2418.

Emperatríz, P.D., Ronald, M.E.P. and Mily, S.E. 2008. Production and characterization of unripe plantain. Interciential 33(4):290-294.

Fagbemi, T.N. 1999. Effect of blanching and ripening on the functional properties of plantain (*Musa* aab) flour. Plant Foods Human Nutrition 54: 261-269.

Gusmão, T.A.S., De Gusmão, R.P., De Sousa, S., Mário, E.R., Mata, M.C., Duarte, M.E.M., De Figuereido. R.M.F. and Moreira, R.T. 2015. Mineral content in French type bread with sodium replacement using fluorescence spectrometry X-rays by energy dispersive. African Journal of Biotechnology 14(51): 3333-3339.

Hathaichanock, C. and Masubon. T. 2007. The chemical and physico-chemical properties of sorghum starch and flour. Kasetsart Journal of Natural Science 41: 342-349.

Izonfuo, W.A.L. and Omuaru, V.O.T. 1988. Effect of ripening on the chemical composition of plantain peels and pulps *(Musa paradisiaca)*. Journal of the Science of Food and Agriculture 45: 333-336.

Juhaimi, F.A., Ghafoor, K., Babiker, E.E., Ozkan, M.M. and Harmankaya, M. 2016. Mineral content of traditional bread enriched with flora honey. India Journal of Traditional Knowledge 15 (2): 223-226.

Kainga, P. E. and Seiyabo, I. T. 2012. Economics of plantain production in Yenagoa Local Government Area of Bayelsa State. Journal of Agriculture and Social Research 12 (1):5-7.

Ketiku, A.O. 1973. Chemical composition of unripe (green) and ripe plantains *(Musa paradisiaca)*. Journal of the Science of Food and Agriculture 24: 703-707.

Larmond, E. 2007. Texture measurement in meat by sensory evaluation. Journal of Texture Studies 7 (1):1-10.

Malomo, S. A., Eleyinmi, A. F. and Fashakin, J. B. 2011.

Chemical composition, rheological properties and bread making potentials of composite flours from breadfruit, breadnut and wheat. African Journal of Food Science 5(7): 400 – 410.

Maria, E., Ulf, S., Jorge, O. and Lilia, A. 2013. Effect of cassava flour characteristics on properties of cassava-wheat-maize composite bread types. International Journal of Food Science 1(1): 1-11.

Michael, O.A., Dick, I.G. and Bibiana, D.I. 2013. Physico-chemical and sensory evaluation of wheat bread supplemented with stabilized un-defatted rice bran. Food and Nutrition Sciences 4: 43-48.

Mongi, R.G., Ndabikunze, B.K., Chove, B.E., Mamiro, P., Ruhembe, C.C. and Ntwenya, J.G. 2011. Proximate composition, bread characteristics and sensory evaluation of cocoyam-wheat composite breads. African Journal of Food, Agriculture and Development, 11(7):5586-5598.

Olaoye O. A., Onilude, A. A. and Idowu, O. A. 2006. Quality characteristics of bread produced from composite flours of wheat, plantain and soybeans. African Journal of Biotechnology 5 (11): 1102-1106.

Onoja, U.S., Akubor, P.I., Njoku, I., Atama, C.I., Onyishi, G.C., Eken, F.N., Eyo, J.E. and Ejere, V.C. 2014. Nutritional composition, functional properties and sensory evaluation of breads based on blends of 'orarudi' (*Vigna* sp) and wheat flour. Scientific Research and Essay 9(24): 1019-1026.

Trejo-González, A. S., Loyo-González, A. G. and Munguía-Mazariegos, M. R. 2014. Evaluation of bread made from composite wheat-sweet potato flours. International Food Research Journal 21(4): 1683-1688

United States Department of Agriculture (USDA) National Nutrient Database for Standard Reference (NNDSR) (August 2009). Plantain nutritional facts. Retrieved on May 25, 2015 from NNDSR Website: *http://www.nal.usda.gov /fnic/foodcomp/plantain*

Wang, L. and Seib, P.A. 1996. Australian salt-noodle flours and their starches compared to US wheat flours and their starches. Cereal Chemistry 73: 167-175.

Yetunde, E.A., Mary, A.I., Olajumoke, L., Ukpong, U. and Ime, F. 2009. Utilization of bambara groundnut flour blends in bread production. Journal of Food Technology 7(4): 111-114

Zakpaa, H. D., Mak-Mensah, E. E. and Adubofour, J. 2010. Production and characterization of flour produced from ripe "apem" plantain (*Musa sapientum* L. var. paradisiacal; French horn) grown in Ghana, Journal of Agricultural Biotechnology and Sustainable Development 2(6): 92-99.