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Nutritional and Sensory Properties of Cake-Like Snacks Produced from Plantain, Sweet-Potato, Cocoyam and Wheat Flours

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ABSTRACT

Cake-like snacks were produced from Plantain, Sweet potato and Cocoyam flours varied with wheat and the nutritional and sensory evaluations were determined. The experimental designs were T1, T2 and T3 for Plantain, Sweet potato and Cocoyam flour respectively. They were compared with 100% Wheat flour as Sample T4.They were subjected to proximate and functional analysis, and used to produce the cake-like snacks. The proximate, microbial, and mineral analyses were also evaluated on the products. The protein content of the flours ranged from 2.84 – 3.31 %, moisture; 4.88 – 11.12 %, ash; 2.44 – 4.75 %, fat; 4.42 – 12.00 16 %, fiber; 0.39 – 1.18 % and carbohydrate; 74.33 – 82.45 %. The bulk density, swelling capacity, water and oil absorption capacity had a range of 0.77–0.92 g/ml, 0.13–0.60 %, 0.95 –1.54 g water/g flour and 1.37–1.62 g oil/g flour respectively. The proximate composition of the cake-like snacks varied significantly with cake produced from plantain flour and the control having the highest protein content (1.70 %) and cake-like snack from cocoyam flour having the lowest (1.56 %). The control had low amount of microbial load, next was cocoyam cake-like snack which might be due to the anti-nutritional factors present. Plantain cake-like snack had considerably higher mineral content and better ratings than the others. From all the parameters measured above, plantain cake-like snack compared favorably well with the control.

Keywords: *Cake-like Snack, Nutritional, Sensory properties, Plantain, Sweet-Potato, Cocoyam, Wheat*

INTRODUCTION

Snacks are small portions of food eaten between meals; they are made generally from 30 soft wheat, a cereal, cultivated in many parts of the world, but imported by countries with 31 unfavorable climatic conditions. Cakes made from plantain, cocoyam and sweet potato flour 32 are examples of snack. Therefore, Cakes are convenient food products (Atef et al., 2011) which are snacks. They are usually sweet and often baked, prepared from flour, sugar, shortening, baking powder, egg, and essence as principal ingredients (Clerk and Herbert, 2000; Atef et al., 2011).

In Nigeria, reliance on wheat flour in the pastry and bakery industries has over the years restricted the use of other cereals and tuber crops available to domestic use. The adoption of these locally produced flours such as plantain, cocoyam and sweet potato flours in the bakery industry will increase the utilization of indigenous crops cultivated in Nigeria and also lower the cost of bakery products (Ayo and Gaffa, 2002).Plantain(Musa spp), is a staple food in the tropical regions of the world, treated in the same way as potato and yam with a similar texture and neutral flavor when the unripe fruit is 43 cooked by steaming, boiling or frying (Aderounmu, 2006). Plantain contains carbohydrates (32%), protein (1.0 %), fat (0.02%), water (60%) and some vitamins and mineral elements. The food is extremely low in fat and protein, high in fibre and starch. It is a good source of itamin A, B6 and C which helps maintain vision, good skin and builds immunity against diseases. It is also rich in potassium, magnesium and phosphate when cooked green (Ogaziet 48al., 1996). FAO (2009) has reported that more than 2.5 million metric tons of plantains are produced in Nigeria annually, but about 40 to 60% post-harvest losses had been reported which is attributed to lack of storage facilities and inadequate technologies for food processing. Traditionally, unripe plantain can be processed into flour (Ukhum and Ukpebor, 52

1991). Sweet potato (Ipomoea Batatas Lam) is the seventh most important food crop in the world. It is grown in many tropical and subtropical regions. Among the world's major food crops, sweet potato produces the highest amount of edible energy per hectare per day. Among the root and tuber crops, sweet potato is the only one that has a positive per capita annual rate of increase in production in sub-Saharan Africa. Because of its distinct properties, the use of 58 sweet potato flour is restricted in the production of various snacks (Okorie and Onyeneke, 2012).

Cocoyam (Xanthosomasagittifolium), a member of the Araceae family is an ancient crop and is one of the minor staple root crops commonly grown in the forest zone of Nigeria and Ghana (Ekanem and Osuji, 2006). Cocoyam contributes a significant amount of carbohydrate content of the diet in many regions of developing countries and provides edible starchy storage corms and cormels. The world's leading producer of cocoyam is Nigeria producing an estimate of 3.7 million metric tons annually (Baruwa and Oke, 2012).

This study is therefore aimed at comparing the nutritional and sensory properties of cake like snacks produced from wheat, plantain and some roots crops such as sweet potato and cocoyam flours in 100 % ratio, each as a strategy to supplement and reduce our overdependence of wheat.

MATERIALS AND METHODS

Collection of Food Material

Plantain (Musa spp), Sweet potato (Ipomoea batatas), Cocoyam (Xanthosomasagittifolium), and other ingredients were purchased at Erekesan market in Akure, Ondo State, Nigeria.

Production of Plantain Flour

Unripe plantains were washed under running water, peeled and were sliced uniformly using a slicing machine. The slices were soaked in 2 % sodium metabisulphite for 10min, dried in an oven dryer at 60 oC for 48 h, milled and sieved to get the instant plantain flour. The milled flour was packaged in an airtight polyethylene bag until when needed for analysis (Adegunwa et al., 2014).

Production of Sweet Potato Flour

Sweet potato flour was prepared according to the method of Singh et al, (2008). They were sorted, peeled, washed and cut into slices using a machine slicer. The slices were directly immersed in solution containing 1 % potassium meta bisulphate for 30 min. Drying of sweet potato slices was done by spreading on a tray covered with aluminum foil in a cabinet dryer at 60 °C for 24 h to moisture content 7-8 %. The dried slices were milled after cooling using a hammer mill and sieved to a particle size of 80 mm to obtain sweet potato flour and packaged in an airtight polyethylene bag until it was needed for analysis.

Production of Cocoyam Flour

The cocoyam was washed, peeled, rewashed and cut into 3-4 cm thick discs. They were arranged randomly on the drying trays in single layers and placed in the drying machine (Oven Dryer) at the temperature of 65 oC for 9 h. After that it was milled using attrition milling machine into flour and then sieved. This was done with modification according to Sanfull and Darko, 2010.

Production of Cake-Like Snacks Made from Plantain, Cocoyam and Sweet Potato and Wheat Flour

Cake-like Snacks was produced by the method of Atef et al., 2011 with slight modifications.300 g flour, 200 g sugar, 400 g margarine, 4 g baking powder and 6 eggs were used. The dry materials were mixed in a separate bowl while sugar, margarine and egg albumen were thoroughly mixed in another bowl and the mixture was added together. The mixture was whipped for 30 min and other ingredients added and mixed. The mixture was poured into baking pans, and baked at 170 o C for 15 min.

Chemical Analysis

Proximate Composition of flour and cake-like snack samples

Moisture, crude protein, fat, ash and fiber contents were determined by the Official Methods of AOAC (2000). Moisture was determined by difference in weight after heating in a vacuum oven at 105^{o}C for 4 h or until constant weight was obtained. Crude protein was calculated from the formula, percentage Nitrogen x 6.25, after determining nitrogen content by digestion and titration analysis. Crude fat was determined by the ether extract techniques, using Soxhlet apparatus. Crude fiber content was obtained as the resulting dry residue after treating the defatted sample (2 g) with 200 ml of 0.225 N H2SO4, and with 100 111 ml of 2.5 % of NaOH solution. Ash was determined by calculating the net weight of a known sample after heating in a muffle furnace at 550°C for about 6 h, and the percentage of ash in the samples was calculated. The carbohydrate content was calculated by difference

Functional properties of the flours

The bulk density and swelling capacity were determined using the modified method of Zakpaa et al., 2010, while the water and oil absorption capacities were determined by modifying Oyeyinka et al., 2014). For packed bulk density 50 g was weighed into 100 ml measuring cylinder. The samples were packed by gently tapping the cylinder on the bench top. The volume of the sample was recorded and calculated as

$$\text{Bulk density (g/ml or g/cm}^3\text{)} = \frac{weight\ of\ the\ sample}{volume\ of\ sample\ after\ tapping} \qquad \text{Eqn. 1}$$

The swelling capacity was determined by weighing 10 g of the sample and adding 60 122 ml of water to it and mixed gently. The slurry was kept at room temperature for 4 h, after which the bulk volume was recorded and the swelling capacity expressed as volume occupied by sample per gramme of original sample dry weight.

$$\text{SC \%} = \frac{change\ in\ volume\ of\ sample}{original\ weight\ of\ sample} \qquad \text{Eqn. 2}$$

The water and oil absorption capacities were determined by weighing 1 g of the flour 127 sample mixed with 10 ml distilled water / oil. The mixture was allowed to stand at room temperature for 30 min and then centrifuged at 2000 g for 30 min. Water absorption capacity was expressed as gram of water bound per gram flour.

$$\text{WAC} = \frac{Weight\ of\ water - weight\ of\ decanted\ water}{weight\ of\ sample} \qquad \text{Eqn. 3}$$

The Oil absorption capacity was expressed as gramme of oil bound per gramme flour.

$$\text{OAC} = \frac{Weight\ of\ oil - weight\ of\ decanted\ oil}{weight\ of\ sample} \qquad \text{Eqn.4}$$

Mineral Analyses

Mineral analyseswas performed using the procedure described by the AOAC (1990). The analytical procedures used for sample treatment for Atomic Absorption Spectroscopy analysis were as follows: 1 g of the sample weighed into a Pyrex glass conical flask¸10 ml concentrated nitric acid was introduced into the flask with a straight pipette¸5 ml of perchloric acid was also added. The mixture was then heated on an electro-thermal heater for a period of 20 min until a clear digest was obtained. The digest was cooled to room temperature and diluted to 50 ml with distilled water. The diluents were filtered into a plastic vial for AAS analysis of calcium, magnesium, iron and zinc. While sodium and potassium were determined using flame photometer.

Microbial Analyses

Total mesophilic (total viable bacterial counts) and fungi counts (yeast and mould counts) were carried out on the snack to determine the microbial load of the samples as described by Ijah et al., 2014. Samples were prepared by mashing the snack and mixing in saline water. Subsamples were diluted decimally and 1 ml aliquots were spread plated on nutrient agar (NA), Mac Conkey agar (MCA), Deoxycholate citrate Agar (DCA) and potato dextrose agar (PDA) for the enumeration of aerobic viable bacteria, coli forms, salmonella and shighella and fungi, respectively. The NA, DCA and MCA plates were incubated at 37 151 °C for 24–48 h while PDA plates were incubated at room temperature (25 °C) for 3–5 days. The colonies were then counted and expressed as colony forming units per gram (cfu/g) of samples. All counts were done in duplicate using the Stuart scientific colony counter.

Evaluation of Sensory Attributes

After baking, cakes were allowed to cool for about 30 min and organoleptically estimated for the quality attributes by untrained panelists drawn from the Department of Food Science and technology, Federal University of Technology, Akure, Ondo State. Each sample was rated on perceived intensities of standard sensory attributes (Taste, Color, flavor, Texture and General acceptability) using a 9-point hedonic scale (Larmond, 1977).

Statistical Analysis

Experiments were conducted in triplicate. Mean scores of the results and their standard mean of error were reported. Data were subjected to analysis of variances (ANOVA), and Duncan multiple range (Duncan, 1955) test (DMRT) was used to separate the means. Tests were carried out to ascertain significant effects at $P < 0.05$ level of significance among treatments.

RESULTS AND DISCUSSION

Proximate Composition of Flours

Table 1 shows the proximate composition of plantain, sweet potato, cocoyam and 169 wheat flour. The carbohydrate content of cocoyam flour (82.30 %) is not unusual as it has long been known as a carbohydrate-giving food (Sanful and Darko, 2010). Plantain flour had higher fat content (12.00 %) which was comparable to Adegunwa et al., 2014. There was no significant difference in the fiber content of the flours ($p < 0.05$). Cocoyam flour had high moisture (17.37 %) and carbohydrate content (82.3 %) but low in ash content (2.94 174%) which may due to its anti nutrient present. Sweet potato flour and wheat flour had significant differences in its proximate composition except in fat and fiber ($p < 0.05$) but had higher values than the values reported by Okorie and Onyeneke, 2012; Ugwoan et al., 2012, which might be due difference in cultivar and possibly the processing methods used. The moisture and crude fiber contents of sweet potato were 7.27 % and 0.86 % respectively which are within the values of 8.3 % and 1.0 % respectively as reported by Adeyeye and Akingbola, 2014; but with low fat content (4.42 %) due to an occurrence of oxidative rancidity which might be reduced in non-wheat flours.

Table1. *Proximate composition of plantain, sweet potato, cocoyam and wheat flours*

Samples	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)
T_1	5.69 ± 0.08^c	4.75 ± 0.10^a	2.84 ± 0.00^b	12.00 ± 1.00^a	0.39 ± 0.00^a	74.33 ± 0.94^b
T_2	7.27 ± 0.05^b	2.44 ± 0.29^b	2.56 ± 0.00^b	4.42 ± 0.84^b	0.86 ± 0.07^a	82.45 ± 1.18^a
T_3	4.88 ± 0.29^d	2.94 ± 0.00^b	3.31 ± 0.09^a	5.39 ± 0.31^b	1.18 ± 0.00^a	82.30 ± 0.07^a
T_4	11.12 ± 0.06^a	4.20 ± 0.65^a	3.21 ± 0.19^a	4.90 ± 0.57^b	0.79 ± 0.60^a	75.77 ± 0.98^b

Datas are mean ± Standard error of mean with triplicate readings. Values with same superscript along the same columns are not significantly different ($P < 0.05$).

Keys: *T_1 = Plantain flour*
T_2 = Sweet potato flour
T_3 = Cocoyam flour
T_4 = Control (Wheat flour)

Functional Properties of the Flours

The functional properties of the flours used for the cake-like snack is presented in Table 2, the bulk density of the flours were significantly different with values ranging from 0.77 – 0.92 g/ml. Generally, higher bulk density is desirable for its great ease of dispersibility and reduction of paste thickness which is an important factor in convalescent child feeding (Adegunwa et al., 2014). The values of plantain (0.77 %) and sweet potato flours (0.78 %) is comparable to that obtained by other researchers (Zakpaa et al., 2010; Fagbemi, 1999; USDA, 2009), but the value of cocoyam flour (0.92 %) was higher than the rest because of its smaller particle size due to its smaller starch grains (Oladeji et al., 2010).The bulk density is affected by the particle size and the density of the flour which is very important in determining the packaging requirements, material hand-ling and the application in wet processing in food industry (Adegunwa et al., 2014). There was significant difference between the flours and the control (wheat flour) in the water and oil absorption capacity which both ranged from 0.95 - 1.54 g water/g flour and 1.37 - 1.62 g oil/g flour respectively which might be due to the difference in the granule size thereby enhancing the ability of the flours to absorb water and oil. Oil absorption in starch relies predominantly on the physical entrapment of oil within the starch structure as starch does not possess nonpolar sites compared to those found in proteins (Oyeyinka et al., 2014). Oil absorption capacity of flours is also important for the development of new food products and influences to a great extent their storage stability (Falade and Kolawole, 2011). The swelling capacity of the flours (T1 - 0.50 %, T2 - 0.60 %, and T3 - 0.50 %) was significantly different from the control (wheat flour – 0.13 %) as it follows the same trend with bulk densities (Table 2). This suggests that particle size of the starch granules and damages done to starch by milling operation had great effect on the swelling capacity of the flour.

Table 2. *Functional properties of plantain, sweet potato, cocoyam and wheat flours*

Samples	WAC(g/ml)	OAC(g/ml)	Bulk density g/ ml	Swelling capacity(%)
T_1	1.41 ± 0.06^a	1.37 ± 0.00^b	0.77 ± 0.02^c	0.50 ± 0.06^a
T_2	1.48 ± 0.06^a	1.47 ± 0.06^{ab}	0.78 ± 0.02^c	0.60 ± 0.03^a
T_3	1.54 ± 0.11^a	1.47 ± 0.06^{ab}	0.92 ± 0.01^a	0.50 ± 0.00^a
T_4	0.95 ± 0.00^b	1.62 ± 0.05^a	0.85 ± 0.00^b	0.13 ± 0.03^b

Datas are mean ± Standard error of mean with triplicate readings. Values with same superscript along the same column are not significantly different (P < 0.05). Data was analyzed using SPSS 17 Version.

Keys: *T_1 = Plantain flour*
T_2 = Sweet potato flour
T_3 = Cocoyam flour
T_4 = Control (Wheat flour)
WAC = Water absorption Capacity
OAC = Oil Absorption capacity

Proximate composition of cake-like snacks

Cake-like snacks made from both wheat and plantain flour had high protein content (1.70 %) as shown in Table 3, which may be due to the high amount of gluten as compare to the rest. The proximate composition of sweet potato was higher than wheat except for protein (1.56 %) and ash (1.09 %) which indicates a low amount of gluten and minerals as compared to wheat (1.70 % and 1.48 % for protein and ash respectively), as reported in Okorie and Onyeneke, 2012, only that sweet potato was substituted with wheat in 10 – 50ratio. Cocoyam had high amount of moisture (17.37 %) and carbohydrate (46.23 %) which was expected but low in protein and fat as compared to the control. There was no significant difference in the ash content of the cakes as it was also observed by Kabari and Ejiofor, 2013.

Mineral analysis of cake-like snacks

Cake-like snack made from plantain flour had relatively higher mineral than those produced from the rest as shown in Figure 1. The calcium, sodium, magnesium, zinc, iron and potassium contents of the cake-like snacks ranged from (0.99 - 2.27 mg/100g, 0.06 –0.24 mg/100g, 0.53 - 1.51 mg/100g, 0.03 - 0.05 mg/100g, 0.18 - 0.24 mg/100g and 0.02 –0.06 mg/100g respectively). Calcium and magnesium help reduce the risk to osteoporosis in adults and rickets in children. The increased value of Iron suggests that the cake-like snacks may be used in prevention and control of anemia. Minerals are required for normal growth; cellular activity and oxygen transport (Fe), fluid balance and nerve transmission (K) as well as the regulation of blood pressure and strengthening of bones (Ca and K). Due to the low sodium and protein content, plantain is used in special diets for kidney disease sufferers (Zakpaa et al., 2010).

Table 3. *Proximate analysis of plantain, sweet potato, cocoyam and wheat cakes*

Samples	Moisture (%)	Protein (%)	Ash (%)	Fat (%)	Fibre (%)	Carbohydrate (%)
T_1	15.67 ± 0.12^c	1.70 ± 0.16^a	2.49 ± 0.28^a	41.00 ± 0.58^a	0.80 ± 0.00^b	38.35 ± 0.04^d
T_2	17.13 ± 0.09^a	1.56 ± 0.08^a	1.09 ± 0.00^{ab}	33.50 ± 0.29^c	0.60 ± 0.00^c	45.25 ± 0.32^b
T_3	17.37 ± 0.12^a	1.56 ± 0.08^a	1.94 ± 0.01^{ab}	31.00 ± 0.58^d	1.30 ± 0.06^a	46.83 ± 0.46^a
T_4	16.27 ± 0.15^b	1.70 ± 0.00^a	1.48 ± 0.20^b	38.00 ± 0.58^b	0.30 ± 0.06^d	42.25 ± 0.23^c

Datas are mean ± Standard error of mean with triplicate readings. Values with same superscript along the same column are not significantly different (P < 0.05).

Keys: *T_1 = Plantain cake-like snack*
T_2 = Sweet potato cake-like snack
T_3 = Cocoyam cake-like snack
T_4 = Control (Wheat cake-like snack)

Microbial Analysis of Cake-Like Snacks

No microbial growth was observed on the first day till the eight day, but on the ninth day there was significant growth of bacteria and fungi, but coli form and salmonella and shighella growth was not detected as shown on Table 4. These are within the limit set by the Standard Organization of Nigeria (SON), which states that the counts of aerobic bacteria must not exceed 100cfu/g and coli form growth must not be detected in cake-like snacks samples. This shows that the cake-like snacks are safe for consumption as there was no fecal contamination. Bacteria have the potential to contaminate baked products which could have evolved during baking or from the raw ingredients. The bacteria and fungi counts were higher in Plantain cake-like snack on the ninth day, 7.6 × 105cfu/g and 0.6 × 105 cfu/g than the control, 0.3 × 105cfu/g and no fungal count, which is similar to Ijah et al., 2014. High amount of microorganisms present in Plantain cake-like snack might be due to abundance of moisture and nutrient and also probably due to raw materials, processing, handling, and storage.

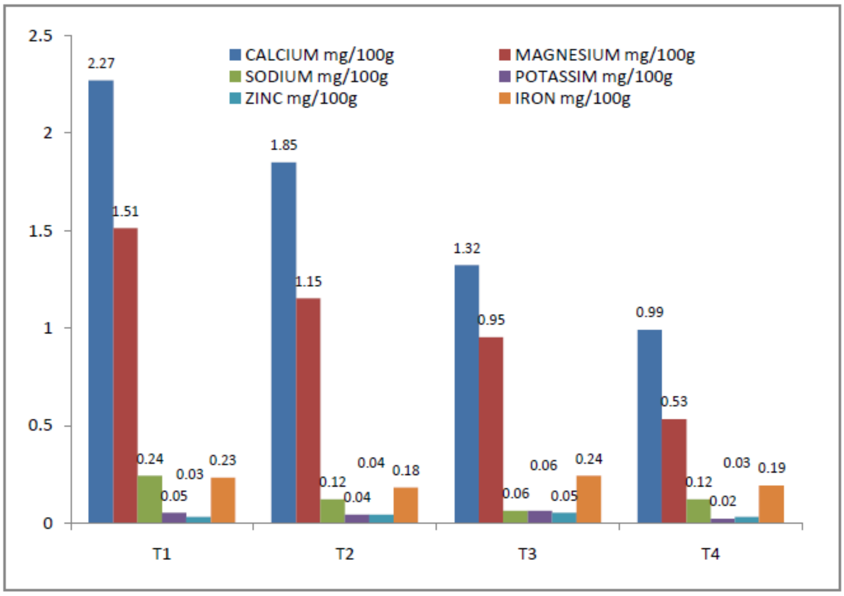

Figure1.*Mineral analysis of cake-like snack Calcium and Magnesium are highest in T1 and least in T4, while Sodium is highest in T1 and least in T3; Iron is high in T3 and low in T2.*

Keys: *T_1 = Plantain cake-like snack*
T_2 = Sweet potato cake-like snack
T_3 = Cocoyam cake-like snack
T_4 = Control (Wheat cake-like snack)

Table 4.*Microbial analysis of cake-like snacks*

Samples	TVCCount(cfu/g)		Fungi count(cfu/g)		Coliform count(cfu/g)		Salmonella and Shighella count (cfu/g)	
	DAY1	DAY 9	DAY 1	DAY 9	DAY1	DAY 9	DAY1	DAY9
T1	NIL	7.6×10^5	NIL	0.6×10^5	NIL	NIL	NIL	NIL
T2	NIL	4.1×10^5	NIL	0.5×10^5	NIL	NIL	NIL	NIL
T3	NIL	1.9×10^5	NIL	0.4×10^5	NIL	NIL	NIL	NIL
T4	NIL	0.3×10^5	NIL	NIL	NIL	NIL	NIL	NIL

Keys: *T_1 = Plantain cake-like snack*
T_2 = Sweet potato cake-like snack
T_3 = Cocoyam cake-like snack
T_4 = Control (Wheat cake-like snack)
TVC – Total viable count

Sensory Attributes of Cake-Like Snacks

There was a significant difference ($P < 0.05$) in texture and taste of the cake-like snacks as showed in Table 5. The cake-like snack made from plantain had comparable values with the control in texture, color, and taste. Cake-like snacks made from sweet potato had the highest preference in flavor while cake-like snacks from cocoyam had the least. On the whole cake-like snacks produced from cocoyam flour had the least ratings which were due to their inferior taste and poor general acceptability. Generally, cake-like snacks produced from plantain and wheat flour had similar and the highest ratings for general acceptability. This result indicates the highest possibility of utilizing plantain in cake production.

Table5. *Sensory attributes of cake-like snacks*

Samples	Texture	Flavour	Colour	Taste	General Acceptability
T_1	6.90 ± 0.48^{ab}	6.60 ± 0.40^{b}	6.80 ± 0.36^{b}	7.30 ± 0.34^{ab}	7.00 ± 0.33^{b}
T_2	6.30 ± 0.56^{bc}	6.90 ± 0.23^{b}	6.40 ± 0.31^{b}	6.10 ± 0.43^{bc}	6.60 ± 0.27^{bc}
T_3	5.40 ± 0.62^{c}	6.60 ± 0.40^{b}	6.10 ± 0.38^{b}	4.80 ± 0.66^{c}	5.90 ± 0.35^{c}
T_4	8.30 ± 0.21^{a}	8.00 ± 0.39^{a}	8.30 ± 0.21^{a}	8.10 ± 0.31^{a}	8.10 ± 0.31^{a}

Datas are mean ± Standard error of mean with triplicate readings. Values with same superscript along the same column are not significantly different (P < 0.05). Data was analyzed using SPSS 17 Version.

Keys: *T_1 = Plantain cake-like snack*
T_2 = Sweet potato cake-like snack
T_3 = Cocoyam cake-like snack
T_4 = Control (Wheat cake-like snack)

CONCLUSION

This study has revealed that plantain flour which is available locally can also be used in developing pastry products over the overall dependence on wheat flour. The results showed that cake-like snack produced from plantain was comparable in terms of quality and acceptability to that produced from wheat flour as it has equal amount of protein (1.17 ± 2580.16), and high amount of minerals compared to the others, which is needed for the normal 259growth and development of the body. Its high protein content shows that it can be used as an ingredient in functional foods production and also as a food thickener for people of all ages. Plantain cake-like snack is therefore recommended due to its high Calcium content which helps prevent the risk to Osteoporosis in adults and rickets in children and its protein content which is comparable to that of wheat indicates its high leavening ability in contrast to others.

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