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Nutritional Quality And Sensory Properties Of Instant Plantain Flake Enriched With Egg Parts

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Abstract: There is needs to start thinking of producing food products in relation to population census of two decades ago where majority of the populace felt into working class of 25-65 yrs. The study investigated the nutritional quality and sensory properties of instant plantain flakes enriched with different egg parts. Firmly riped plantain pulp was blends with egg-part to give three samples while 100 % whole plantain pulp serves as control. The blends were dried, milled and mixed with other baking ingredients before kneaded, rolled, cut into piece, pressed to 1 mm thick and baked until golden colour was obtained. Proximate composition, minerals and vitamins profile, functional and sensory properties of the instant plantain flakes were determined using standard methods. The result of proximate composition showed that values for moisture content, protein, fat, fibre, ash, carbohydrate and energy ranged from 9.05-18.56, 5.40-12.66, 1.25-5.48, 6.30-6.85, 3.41-4.21, 62.20-66.31 g/100g and 293.17-351.04 kcal/100g respectively. The study revealed improvement in the minerals and vitamins content of the instant plantain flake compare to control sample. Result of functional properties revealed that functional properties of the instant plantain flake improved with different egg-part. Sensory property results showed that Sample D had the highest mean score in terms of taste and overall acceptability than other instant plantain flake samples with a value of 7.63 and 7.52, respectively. It can be deduced based on the study results that acceptable plantain-egg composite flour and its flake can be produced from the blends of plantain and whole egg.
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1. Introduction

There is increased advocacy on the consumption of functional foods by world human nutrition due to different health problems related with food consumption such as diabetes and other food related diseases (WHO/FAO, 2003). Food producers might be faced with challenges of producing food products containing functional ingredients to meet nutritional requirements of individuals with health challenges. Plantain has been shown to be excellent for weight control, slow in the release of energy after consumption with a low glycermic index (Ayodele and Erema, 2011), high in resistant starch, potassium and good for diabetic patients (Akinsola *et al*., 2018; Akubor, 2003). Plantain is also a good source of Iron, and β – Carotene (Pro-Vitamin A) as reported by Ogazi (1988; 1986). It's a very reliable sources of starch and energy; ensuring food security for millions of inhabitants worldwide, Nigeria inclusive. Dietary fibre in human diets lowers serum cholesterol, reduces the risk of heart attack, colon cancer, obesity, blood pressure, appendicitis and many other diseases (Rehinan *et al*., 2004). Resistant starch has interesting functional properties for use in foods including formation of products with high fibre content and low volume with improved sensory properties like texture and appearance (Nugent, 2005).

Over the years there have been different recommendations regarding the best part of the egg to be used. Recent researches have shown that, contrary to initial belief, normal consumption of eggs does not have a negative impact on cholesterol. According to Schmid and Walther (2013), regular consumption of two eggs per day does not affect a person's lipid profile and may, in fact, improve it. Egg is a complete nature given protein source because it contains all the essential amino acids our bodies needed in the right amounts. They're a natural source of key nutrients including omega-3 fatty acids, vitamins A, E and B_{12}, antioxidants and choline (Eshetu and Tola, 2014). Eggs are high in several natural antioxidants including Lutein and Zeaxanthin, which protect eyes and maintain their health (Schmid and Walther, 2013). Egg whites also contain selenium, which protects body immune system. Choline is used by the body for metabolic processes such as liver function, normal brain development, nerve function and muscle movement especially during pregnancy to support foetal brain development (Schmid and Walter, 2013).

Baked products provide a unique opportunity to incorporate food-grade fractions from cereals, legumes or other food materials. Various parts of plantain and banana as reported by Okorie *et al*. (2015) have been studied for various uses: alcohol production from ripe fruit, medicinal use for treatment of gastric ulcer, and the pseudo-stem as a source of fibre. Ripe plantain is rich in minerals like potassium, sodium and phosphorus (Eleazu *et al*., 2013). This could be formulated into instant food products for convalescence and young infant baby as these categories of human being require high levels of minerals for their growth and repairs (Zakpaa *et al*., 2010).

Plantain alone cannot meet adult protein and micronutrient needs, hence there is need to fortify it with protein-micronutrients rich food to make a readily available food product similar but nutrient dense than corn flake for consumption. Considering the health benefits of plantain, its incorporation with egg, a complete nature given food in the production of flake, a close substitute to corn-flake will help in improving health status of its consumers and reduce total dependence on wheat flour which could lead to incidence of certain chronic non-communicable disease such as glycermiasis. The possibility of producing baked products from wheat and enriched plantain composite flour is the focus of this study. It is imperative therefore to investigate a study on nutritional quality and sensory properties of plantain pulp enriched with different egg part to produce instant plantain flake.

2. Materials and methods

2.1 Materials

The fresh plantains (*Musa paradisiaca*) used for this study were bought at a farm in Awe town, Oyo State, Nigeria. The plantain was at stage 5 (firm ripe) of ripeness using the colour index chart as described by Aurore *et al.* (2009) while other ingredients included wheat flour, margarine, eggs, granulated sugar, vanilla and baking powder were also bought from the town local market.

2.2 Preparation of sample flours

2.2.1 Plantain-egg part composite flour preparation

Freshly harvested matured plantains were ripened by covering in jute sack for 4 days with the addition of ripe orange peels to quicken ripening. The ripe plantain fruits were sorted, peeled, manually pulped and mixed with 100 g liquid albumin, yolk, whole egg separately at constant quantity while whole plantain flour was used as control and coded as sample A, B. C and D. All samples were dried in a Gallenkamp over dryer (Model: DC 500; Serial number: 12B154) maintained between 55±5 ^{o}C for 48 hr to obtain dry lumps which were milled with a ball mill to get the dried powder. Sample A that contain 100 % plantain flour served as control, while samples B, C, D consist of plantain-albumin, plantain-yolk and plantain-whole egg flours, respectively.

2.3 Plantain-flake making

Each sample was initially manually blended with other ingredients used before homogenized using Kenwood mixer (HC 750D, Kenwood, United Kingdom) at 450 rpm for 15 min until uniform blends were obtained. Other ingredients added consists of wheat flour (100 g), sugar (100 g), salt (25 g), vanilla (25 g), baking powder (50 g), water (500 ml) and margarine (400g). The paste was further kneaded, rolled and cut into pieces (100 g) with stainless-steel knife. The cut dough was placed on margarine greased baking trays, pressed to 1 mm thick using locally fabricated stainless-steel hydraulic press machine and baked until a brown/golden colour was obtained. The flakes were cooled, broken to pieces, packed in low density polyethene bags and stored at room temperature (28±2 ^{o}C) prior to subsequent analysis.

2.4 Methods

2.4.1 Proximate composition

Proximate analysis of the samples was carried out using AOAC methods (AOAC, 2012), carbohydrate content was determined by difference while energy value of each sample was determined by calculation from fat, carbohydrate and protein content using the Atwater's conversion factor; 4.0 kcal/g protein, 9.0 kcal/g fat and 4.0 kcal/g carbohydrate (Iombor *et al.,* 2009).

2.4.2 Minerals and vitamins profile analyses

Provitamin A was determined using the method adopted from IVACG (1992) while vitamin B_1, B_2, B_3, B_6, and vitamin C were determined using the method of AOAC (2012). The standard method described by Association of Official Analytical Chemists was used for mineral content analysis of the samples (AOAC, 2005). The samples were ashed separately at 550 ^{o}C. The ash was boiled with 10 ml of 20 % hydrochloric acid in a beaker and then filtered into a 100ml standard flask. This was made up to the mark with deionized water. The minerals were determined from the resulting solution using an inductively-coupled plasma atomic emission spectrometer (ICPAES, TL 6000 USA). Minerals profile determined includes calcium, phosphorus, magnesium, sodium, potassium, zinc and iron. All values were expressed in mg/100g.

2.4.3 Functional properties determination

The selected functional properties of the instant plantain flake samples determined included bulk density, water absorption capacity, oil absorption capacity, swelling index by Onwuka (2005) while least gelation capacity was determined using the method of Coffmann and Garciaj (1977) and wettability index of the flakes were determined following the methods described by Okezia and Bello (1988).

2.4.4 Sensory evaluation of the plantain-flake samples

Sensory attributes of the instant plantain flake were determined using preference test as described by Akinsola *et al*. (2018). Twenty un-trained panelists but familiar with corn-flake, a similar product to the study samples were drawn from the College community. The panelists were asked to indicate their preference for the samples in term of chewiness, colour, crispness, flavour, taste and overall acceptability on 9-point Hedonic scale where 9 =like extremely and 1=disliked extremely. Each panellist sat in an enclosed cubicle designed for sensory evaluation and water was provided to rinse mouths before and after tasting each of the samples.

2.5 Statistical analysis

All data were statistically analysed using SPSS version 17.0 for analysis of variance, while Duncan multiple range test (DMRT) at $p<0.05$ was used to separate means where there is a significant difference. For each sample, triplicate determinations were carried out.

3. Results and discussions

3.1 Proximate properties of the instant plantain flake samples

The proximate composition of the instant plantain flake samples was as shown in Table 1. Statistical differences ($p<0.05$) were observed in all the parameters investigated compare to the control (100 % plantain) sample. The moisture content of the samples ranged from 8.83 g/100g in sample C to 18.56 g/100g in sample A. Moisture contents of all the samples fall within reported values (8.80 – 19.33 g/100g) of many authors (Ibeanu *et al*., 2016; Adegunwa *et al*., 2014). The low moisture content obtained in this study is an indication that mould activities and other biochemical reactions will be reduced, hence the product shelf-life is enhanced. This in agreement with Koua *et al*. (2018) and Sriroth *et al*. (2000) who reported that low moisture content lower than 10 % is generally accepted as standard value for dry food products with a long shelf-life. There were significant differences ($p<0.05$) in protein content of the instant plantain flakes with values between 5.40 and 12.66 g/100g. Protein content of the samples ranged from 5.40 g/100g in sample A to 12.66 g/100g in sample D while fat content of the samples ranged from 1.25 g/100g in sample A to 5.48 g/100g g in sample C. Research have shown that protein play a vital role in organoleptic properties of food products, boost immune system and play a key role in cell division and growth (Akinsola *et al*., 2018; Okorie *et al*., 2015).

Sample D had the highest protein and fats value while sample A had the lowest value. The protein and fats content recorded in this study shows that whole plantain is not a good choice to improve protein and fats content of food during product development. Ayodele and Erema (2011) and USDA (2009) in their work also reported that plantain has low protein and fats content. The low-fat content of the samples is an indication that the flake will have a good storage stability and reduces chances of rancid flavour development. However, in order to meet daily protein-fat requirement, plantain-based food products need to be supplement with protein-fat rich food to have beneficial impact on protein-energy-malnutrition (PEM). The increase in protein content as shown in Table 1 indicates nutrients improvement of egg as quality nutritive enhancer.

Crude fiber content of the instant plantain flake samples ranged from 6.30 g/100g in sample A to 6.85 g/100g in sample D. Fibre is important for the removal of waste from the body thereby preventing constipation and many health disorders. The viscose and fibrous structure of dietary fibre controls the release of glucose with time in the blood, which helps in proper control and management of diabetes mellitus and obesity (Animashaun *et al*., 2017; Aleixandre and Miquel, 2008). Dietary fibres as reported by Okeke and Adaku (2009) slow down rate of glucose absorption into bloodstream and reduce risk of hyperglycemia, has numerous medical importance like lowering blood cholesterol, maintain blood sugar level and helps in reducing body weight (Akinsola *et al*., 2018; Soetan and Olaiya, 2013). Dietary fibre according to UICC/WHO (2005) also help in digestion, prevention of colon cancer and protection against cardiovascular disease, colorectal cancer, diabetes and obesity while ash content supplies a rough estimation of the product minerals content.

The study results revealed that ash level of the samples ranged from 3.41 g/100g g in the sample A to 4.21 g/100g g in sample D. The value obtained for fibre and ash in this study fall within the range reported by Akinsola *et al*. (2018) and Ibeanu *et al*. (2016) in their work for plantain enriched with African yam bean (AYB) flour, and composition and sensory properties of plantain cake, respectively. Ash or minerals content of food is a useful tool in maintain acid-base (ionic) balance of the body fluid system. The ash content of the study shows that its consumption will reduce micronutrient malnutrition in their consumers than consuming whole plantain crop/flake. The percentage carbohydrate of the instant plantain flake samples ranged from 62.20 g/100g in sample D to 66.96 g/100g in sample B which is within 65.50

g/100g of the close substitute commercial brands used in the study. The high carbohydrate contents of the samples make it a good source of energy given and protein sparing food product. Omoyeni and Adeyeye (2009) reported that carbohydrate, apart from being a good source of energy, they are needed for metabolism and oxidation of fats in the body. Carbohydrate supplies energy to cells such as brains, muscles, blood, and contributes to fat mechanism, acts as mild natural laxative, and spares proteins as an energy source (Akinsola *et al*., 2018). Energy value of the instant plantain flake samples ranged from 293.17 kcal/100g in sample A to 356.05 kcal/100g in sample B. All the samples energy values were high than 323 g/100g of the same commercial sample used in this study except the control sample.

Table 1: Proximate composition of the plantain flake samples, g/100g

Sample	Moisture	Protein	Crude fat	Crude fibre	Ash	CHO	Energy, Kcal
Sample A	18.56±1.22	5.40 ±0.11	1.25 ±0.01	6.30 ±0.00	3.41 ±0.00	65.08 ±2.28	293.17 ±0.63
Sample B	9.05±0.06	11.92±0.06	1.73±0.08	6.49±0.02	3.85±0.10	66.96±1.69	356.05±0.58
Sample C	8.83±0.23	11.11±0.13	5.48±0.00	6.45±0.00	4.02±0.09	64.11±2.01	336.04±1.44
Sample D	9.12±0.17	12.66±0.42	4.96±0.41	6.85±0.11	4.21±0.71	62.20±1.88	347.92±0.76

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different ($p < 0.05$). Sample A = Control (Whole plantain); sample B = Plantain-albumin; sample C = Plantain-yolk; sample D = Plantain-whole egg; CHO = Carbohydrate

3.2 Mineral profiles of the instant plantain flake samples

Mineral profiles of the instant plantain flakes samples were as shown in Table 2. The mineral profiles of the samples show significant differences at alpha 0.05 in all the instant plantain flake samples. Sodium content of the samples ranged from 2.40 mg/100g for sample C to 16.63 mg/100g for sample D. There were significant differences ($p<0.05$) in sodium content of the samples while potassium content of the samples ranged from 349.23 mg/100g in sample A to 392.62 mg/100g in sample D. Sodium is crucial in fluid and acid-base balance; osmosis, regulates muscle, nerve irritability and glucose absorption while potassium is an essential constituent, apart from osmosis fluid balance, in regular heart rhythm and nerve impulse conduction; cell metabolism (Ihekoronye and Ngoddy, 1985). The potassium values of all the samples were higher than the sodium values which is an indication of good health promoter by inhibit hypertension according to Chen *et al*. (2010) who reported that intake of diets with higher sodium to potassium ratio has been related to the incidence of hypertension.

Calcium content of the instant plantain flake samples ranged from 18.04 mg/100g to 36.08 mg/100g for sample A and D, respectively. Calcium as reported by Weaver and Heaney (2006) is a micronutrient essential to health and wellbeing, which performs diverse biological function in the human body. It serves as a second messenger for nearly every biological process, stabilizes many proteins and in deficient amounts is associated with many diseases. Calcium is an important component of intracellular processes that occur within insulin responsive tissues like skeletal muscle and adipose tissue. Alteration in calcium flux can have adverse effects on insulin secretion which is a calcium-dependent process (O'Connell, 2001). The phosphorus content of the sample ranged from 14.03 mg/100g in sample A to 30.16 mg/100g in sample D while sample C had the least (37.04 mg/100g) value and sample D had the highest (42.19 mg/100g) value for magnesium content. Phosphorus is involved in several biological processes such as bone mineralization, energy production, cell signalling and regulation of acid-base homeostasis.

Phosphorus is an essential element which plays an important role in multiple biological processes such as maintenance of cell membrane integrity and nucleic acids, generation of ATP, maintenance of acid-base homeostasis, among others (Akinsola *et al*., 2018; Penido and Alon, 2012). Calcium and phosphorus as reported by Koua *et al*. (2018) and Turan *et al*. (2003) play an important role in human diets based on their association with growth and maintenance of bones, teeth and muscles. The molar ratio of Ca:P ranged from 1.01 – 1.29. This ratio is an indication that it is a good predictor of calcium availability in diet (Koua *et al*., 2018). According to the authors, Ca/P values which are greater than 1 suggests a good absorption of calcium as reported by Koua *et al.* (2018), while values less than 0.5 indicates a poor calcium uptake. In the present study, the ratios Ca/P in all the samples were higher than1, this constitute a great advantageous and indication of good intestinal absorption of calcium. Magnesium is essential for good health because it is necessary for normal muscle and nerve functions, production of ATP, DNA and protein and vitamin D metabolism (Akinsola *et al*., 2018; Koua *et al*., 2018).

Magnesium is crucial constituent of all cells and necessary for the functioning of enzymes involved in energy utilization and bone formation (ADA, 2002; Ibeanu *et al*., 2016). As far as the content of magnesium is concerned, values are higher than those (18.00-30.40 mg/100 g DM) reported by Ukom *et al*. (2009) who work on nutrient composition of selected sweet potato varieties as influenced by different level of nitrogen fertilizer application. The study results revealed that zinc and iron content of the instant plantain flake samples ranged from 0.14 – 0.51 mg/100g and 0.60 – 0.88 mg/100g for sample A and D, respectively. Zinc is needed for the body's immune system to work properly and plays a role in cell division, cell growth wound healing and breakdown of carbohydrate (Wardlaw and Kessel, 2002). Zinc also plays a key role in regulation of insulin production by pancreatic tissues and glucose utilization by muscles and fat cells (Eleazu *et al*., 2013). Zinc eliminates cholesterol deposits; aids in absorption of vitamin $B_{complex,}$ manufacture of enzymes and insulin, metabolism of carbohydrate; essential for growth; aids healing essential for proper function of prostate gland; prevent prostate cancer and sterility; keeps hair glossy and smooth (Pharmaics, 2019).

Presence of iron in food help to prevent poor pregnancy outcomes, impaired physical and cognitive development, reducing of work productivity and morbidity (Rohner *et al*., 2010; Staubli *et al*., 2001). Iron has several functions in the human body which includes; being a constituent of the haemoglobin molecule – 70 %, myoglobin stored in muscles, an activating molecule of several enzymes and found in storage molecules such as ferritin and hemosiderin while iron deficiency anaemia is characterized by small red cells with low haemoglobin (Pharmics, 2019; Koua *et al*., 2018).

Table 2: Mineral content of the plantain flake samples, mg/100g

Sample	Sodium	Potassium	Na/K	Calcium	Phosphorus	Ca/P	Magnesium	Zinc	Iron
Sample A	4.01±0.01	349.23±3.08	0.01	18.04±0.00	14.03±2.11	1.29	37.16±1.13	0.14±0.01	0.60±0.01
Sample B	11.82±0.17	374.91±2.52	0.03	19.17±0.01	18.32±1.25	1.05	38.76±1.00	0.22±0.00	0.67±0.00
Sample C	2.40±0.01	359.46±2.09	0.01	27.35±0.20	26.97±1.89	1.01	37.04±0.86	0.28±0.01	0.74±0.02
Sample D	16.63±0.28	392.62±3.19	0.04	36.08±0.18	30.16±0.96	1.20	42.19±0.45	0.51±0.02	0.88±0.11

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different ($p < 0.05$). Sample A = Control (Whole plantain); sample B = Plantain-albumin; sample C = Plantain-yolk; sample D = Plantain-whole egg.

3.3 Vitamin profiles of the instant plantain flake samples

Table 3 presented the results of vitamin profiles of the instant plantain flake samples. Statistical differences were observed in all the samples vitamin investigated at alpha 0.05 except vitamin B_3 (niacin). Vitamin A content of the sample ranged from 1127 IU in sample A to 1538 IU in sample D. Plantains are rich source of vitamin A and B_6 (Eshetu and Tola, 2014). Vitamin A, apart from being a powerful antioxidant, it also plays a vital role in the visual cycle, maintaining healthy mucosa, and enhancing skin complexion while pyridoxine is an important B-complex vitamin that has a beneficial role in the treatment of neuritis, anaemia, and to decrease *homocysteine* (one of the causative factors for coronary artery disease (CHD) and stroke episodes) levels in the body (Eshetu and Tola, 2014). It helps in convert food into energy and repair cellular damage (McDowell, 2012). Vitamins are essential nutritive beneficial to human being because of its involvement in biochemical activities especially Kreb's circles pathways that involve maintenance of body temperature and energy required even when sleeping or resting.

There were no significant differences ($p>0.05$) in vitamin B_1 of the plantain flake with values between 0.02 and 0.06 mg/100g. The vitamin B_1 content of the sample ranged from 0.02 mg/100g to 0.06 mg/100g for sample B and D, respectively. The instant plantain flake samples were also significant different in their vitamin B_2 and B_3 content. There values ranged from 0.29 – 0.69 mg/100g and 0.59 – 0.71 mg/100g for vitamin B_2 and B_3 content, respectively. Vitamin B_6 content of the sample ranged from 0.28 – 0.53 mg/100g for sample B and C, respectively. Vitamin B_1 is essential in part of enzymes needed for energy metabolism, helps convert sugar and starches into energy; promotes digestion, strong heart muscle, child growth, prevent, fat deposits in arteries (Price, 2015) while vitamin $B_{2,}$ apart from help in energy metabolism, it is important for normal vision and skin health. Aids in releasing energy to body cells; enables utilization of fats, proteins and sugar (Bender, 2003). Vitamin B_3 aids normal functioning of tissues, particularly skin, gastrointestinal tract and nervous systems; used with other vitamins in converting carbohydrates to energy (Gavrilov, 2003). Vitamin B_6 is essential in providing part of enzymes needed for carbohydrate, protein and fats metabolism, help make red blood cell; control cholesterol level; aids chemical balance between blood and tissues; prevent water retention; builds haemoglobin (Price, 2015).

Vitamin C content of the samples ranged from 19.23 mg/100g in sample A to 25.41 mg/100g in sample D. Vitamin C essential for the formation of collagen; needed for absorption of iron, some proteins and folic acid; prevent oxidation of other vitamins; aids in metabolism of amino acids and calcium; stops internal bleeding; strengthens blood vessels, maintains hard bones and teeth; promotes stamina; holds body cells together, prevent infections, colds, fatigue and stress; reduces allergies; heals wounds and burns (Price, 2015; Gavrilov, 2003).

Table 3: Vitamin profile of the plantain flake samples, mg/100g

Sample	Vit A*, IU (Retinol)	Vit B_1 (Thiamine)	Vit B_2 (Riboflavin)	Vit B_3 (Niacin)	Vit B_6 (Pyridoxine)	Vit C (Ascorbic acid)
Sample A	1127 ±3.47	0.05±0.01	0.69±0.10	0.59±0.01	0.34±0.00	19.23±0.21
Sample B	1264±2.16	0.02±0.00	0.32±0.01	0.67±0.00	0.28±0.01	22.36±0.18
Sample C	1473±3.11	0.04±0.01	0.29±0.00	0.61±0.01	0.53±0.02	20.58±0.64
Sample D	1538 ±5.20	0.06±0.01	0.47±0.02	0.71±0.00	0.41±0.01	25.41±1.01

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different ($p< 0.05$). Sample A = Control (Whole plantain); sample B = Plantain-albumin; sample C = Plantain-yolk; sample D = Plantain-whole egg. * = 6 µg of beta-carotene equal 1 retinol activity equivalent and 1 retinol equivalent of vitamin A activity equivalent to 1 µg of retinol (IVACG, 1992)

3.4 Functional properties of the instant plantain flake samples

Table 4 presents the functional properties of the instant plantain flake samples. There were no significant differences ($p>0.05$) in bulk density of the instant plantain flakes with values ranging from 0.74 g/cm3 in sample A to 0.86 g/cm3 in sample D. There were no statistical differences ($p>0.05$) in all the samples bulk density. Bulk density has been shown to determine unit package ability and material handling of food product. The bulk density is affected by the particle size and shape which also determine its wet-processing application in food industry (Adebowale *et al*., 2008). 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 (Padmashree, *et al*., 1987). Samples were significantly different ($p<0.05$) in their oil absorption capacity (OAC) and swelling index compare to control sample. The values ranged from 2.43 – 3.46 g/100g and 1.82 – 2.63 for OAC and swelling index, respectively. There were significant differences in oil absorption capacity (OAC) of the instant plantain flake samples. OAC decreases with the addition of different part of egg.

Akinsola *et al*. (2018) reported that OAC is the ability of food sample to absorb oil, retain flavour and enhance mouth feel. This result shows that sample B will have low flavour and mouth feel compare to other samples. The water absorption capacity (WAC) and least gelation capacity (LGC) values of the instant plantain flake samples were significantly different at alpha $p<0.05$. There values ranged from 2.68 – 3.85 g/100g and 34.12 – 41.25 ^{o}C for WAC and LGC, respectively. Statistical differences were observed in swelling index (SI) of all the instant plantain flake samples except samples A. Increase in SI were observed with addition of different part of egg compare to the control. SI is an indicator of the extent of associative forces like protein and carbohydrate within the food sample. This explain the amount of water needed to change a given dry sample to its viscoelastic form (Daramola and Osanyinlusi, 2006). Swelling index and water absorption capacityy are important parameters which ultimately determine sample consistency and compositional structure (Akinsola *et al*., 2018; Ayo-Omogie and Ogunsakin, 2013). According to Riaz-Mian and Swanmylingappa (2006) and Adebowale *et al*. (2005), swelling index is largely controlled by the strength and character of the micellar network within the granules.

The water absorption capacity (WAC) observed in this study is probably related to the low viscosity patterns and weak internal organization resulting from starch granules as reported by Singh et al. (2003) who worked on cookie-making properties of corn and potato flours. Least gelation capacity (LGC) is the lowest protein concentration at which gel remains in the inverted tubes. There were significant differences ($p<0.05$) in LGC of the instant plantain flake samples. Decreases in the LGC of the samples might be due to low protein hydrolysis during preparation and processing methods employed. This statement agreed with the work of Mbaeyi and Onweluzo (2013) who work on sorghum and pigeon pea flaked breakfast formulated blends. Variation in the gelling properties of the food sample is attributed to the relative ratio of protein, carbohydrates, lipids that made up the sample and interaction between such components as reported by Sathe *et al*. (1982).

All the instant plantain flake samples were significantly different in their wettability index. Wettability index of the samples ranged from 3.04 sec in sample B to 4.46 sec in sample C. Wettability time in second indicate the time required for all sample particles to be wetted and is the ability of one gramme of the sample dropped from a height of 15 mm on to the surface of 200 ml distilled water contained in a 250 ml beaker at room temperature (30 ± 2 ^{o}C) to wet/sec (Akinsola *et al*., 2018). This shows the hydrophilic nature of the food sample and the ease at which a flour/sample dispersed in water. The sample with least wettability index will dissolve faster in water compare to other samples.

Table 4: Functional properties of the plantain flake samples, g/100g

Sample	Bulk, g/cm3	OAC	Swelling index	WAC	LGC ^{o}C	Wettability, Sec
Sample A	0.74±0.00	3.46±0.01	1.82±0.03	2.68±0.00	34.12±0.21	3.82±0.00
Sample B	0.82±0.02	2.43±0.00	2.46±0.11	3.12±0.01	41.25±0.30	3.04±0.01
Sample C	0.78±0.01	2.85±0.12	2.34±0.00	2.96±0.14	38.79±0.17	4.46±0.00
Sample D	0.86±0.02	2.94±0.08	2.63±0.12	3.85±0.23	39.61±0.26	4.22±0.02

All values are expressed as mean ± standard deviation of triplicate determinations. Mean values in the same column with different superscript are significantly different (p< 0.05). Sample A = Control (Whole plantain); sample B = Plantain-albumin; sample C = Plantain-yolk; sample D = Plantain-whole egg. OAC = Oil absorption capacity; WAC = Water absorption capacity; LGC = Least gelation capacity.

3.5 Sensory properties of the plantain flake samples

Table 5 presents the sensory properties of the instant plantain flake samples. In term of chewiness, sample C had the highest mean score of 7.54 and was significantly preferred to sample A and B. There values ranged from 6.63 in sample A to 7.54 in sample C. Chewiness and crispness are one of the attributes in sensory evaluation that indicates quality desirability of flake as a snack or food. A good chewability and crispness is an indication of desirable mouth and hand feel. The mean score obtained for colour, crispness and flavour ranged from 5.34 – 7.38, 6.10 – 7.22, 4.21 – 7.47 in sample A to sample D, respectively. The results showed that there were differences in terms of colour. Colour is an important sensory property of any food because of its sight influence and product acceptability. The high mean score of sample C in terms of colour is an indication of colour impartation of egg-yolk on it blends or food products. Flavour plays an important factor in consumer's preferences and products; hence sample C would be most preferred than other instant plantain flake samples. All the panelists did not show total dislike for any of the samples in terms of colour and flavour. In term of taste and overall acceptability, the formulated instant plantain flake sample D had the highest mean score (7.63) and was significantly different at alpha 0.05 compared to other samples of 5.92 – 6.75. In terms of taste, there was significant differences (p<0.05) among the instant plantain flake. Fat, according to Sushma et al. (2016) is an important factor which help in improving mouthfeel, flavour and contributes to the appearance, palatability and texture of baked products. This assertion may influence the panelists in choosing Sample D as the most preferred in terms of taste and overall acceptability than other instant plantain flake samples. The instant plantain flake sample D was highly acceptable by the semi-trained panelists with mean score of 7.52.

Table 5: Sensory properties of the plantain flake samples

Sample	Chewiness	Colour	Crispness	Flavour	Taste	Overall Acceptability
Sample A	6.63±0.11	5.34±0.02	6.10±0.21	4.21±0.08	5.12±0.09	5.41±0.00
Sample B	7.03±0.12	5.66±0.00	7.07±0.63	6.38±0.34	5.96±0.21	6.14±0.03
Sample C	7.54±0.05	7.38±0.21	7.22±0.11	7.47±0.00	6.75±0.06	7.13±0.11
Sample D	7.42±0.14	6.75±0.15	6.54±0.00	6.79±0.23	7.63±0.15	7.52±0.32

All values are expressed as mean ± standard deviation of duplicate determinations. Mean values in the same column with different superscript are significantly different (p<0.05). Sample A = Control (Whole plantain); sample B = Plantain-albumin; sample C = Plantain-yolk; sample D = Plantain-whole egg.

5. Conclusion

The study revealed that an acceptable and nutrient dense instant plantain flake could be produced from the combination of plantain and egg part/whole egg. The instant plantain flake could serve as functional foods especially for hypertensive, diabetic and obese patients considering its high protein, calcium, magnesium, potassium and dietary fibre contents. The high mineral composition of the instant plantain flake shows that it might help to mitigate against some micronutrient deficiencies in its consumers'. The study results showed sample D as a perfect fortification of plantain with whole egg to make instant plantain flake.

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