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Evaluation of Quality and Sensory Characteristics of Spaghetti made from Plantain and Wheat Flour blends

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ABSTRACT

The world is tending towards fortification of cereal, root and tubers food products to increase and enhance its macro and micronutrients content for her teaming population. This study investigated the quality and sensory evaluation of spaghetti produced from plantain and wheat flour blends. The dried plantain chips were milled, sieved to pass through sieve number 60 BS and blends with wheat flour at levels of 100:00%, 85:15%, 80:20%, 75:25%, 70:30%, respectively. The five samples formulated were analyzed for nutritional properties and sensory attributes using a 9-point hedonic scale of preference. All data were subjected to analysis of variance while significant differences were determined at p<0.05, while Duncan multiple range test was used to separate the mean. The study finding shows that nutritionally improved spaghetti products could be produced from mixture of plantain and wheat flour within the range of 15% - 25% wheat flour substitution. The mineral profiles of the study show improvement in quality and quantity compare to the control sample. However, iron, sodium and zinc content of the spaghetti samples were far below recommended daily allowance, hence there is need to supplement such food with fruit- vegetables. The high mean score obtained for the overall acceptability showed that the plantain-based spaghetti samples were accepted by the panellists. Sample with 20% wheat flour substitution level had the highest mean score (6.77) than other wheat flour substituted samples. This might be the perfect blend to make spaghetti from plantain-wheat flour blends.

KEYWORDS

Fruit-vegetables; Fortification; Macro and micronutrients; Plantain-based spaghetti; Recommended daily allowance

1. INTRODUCTION

Spaghetti one of the pasta products is a traditional food of Asia countries made from unleavened dough of durum wheat flour mixed with egg or water and formed into sheets or various shapes, then cooked by steaming or boiling [1], and can also be made with flours from other cereals or grains. It is globally being patronize because of its convenience, nutritional quality, and palatability [2]. Pasta is a good source of low glycemic index (GI)

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carbohydrates, a tight network of gluten proteins which entrap starch granules during the mixing and extrusion process [3]. Wheat gluten protein is very important in the formation and rheology of the dough, and it is the main determining factor of the pasta cooking quality [4].

Plantain is widely grown as a cheap source of calories, excellent for weight control, slow in the release of energy after consumption with a low glycemic index [5]. Fortification of plantain flour with various plant source such as fruit and vegetables, legume flour, mustard protein isolate and plantain flour has been attempted by several workers with a view to enhance its nutrients densities. Plantain have been shown to be rich in dietary fibre (8.82%), resistant starch (16.2%), low in protein and fat content [6]. Dietary fibre in human diets lowers serum cholesterol, reduces the risk of heart attack, colon cancer, obesity, blood pressure, appendicitis and many other diseases [7] while 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 [8].

Plantain can be consumed in the ripe or unripe forms as well as boiled, fried, roasted, or when processed into flour and used to prepare local dough meal known as 'amala' [9]. It has remained the ultimate source of nutrients and non-nutrients that are beneficial to human in many parts of developing countries and they are used for socio-cultural, diabolic, nutritional and therapeutic purposes [10]. Considering the health benefits of plantain, its incorporation as composite blend in the preparation of spaghetti will help in enhancing the nutritional and health status of its consumers, reduce total dependence on wheat flour and incidence of certain chronic non-communicable disease. Quite several studies have utilized plantain flour in the production of different food products but there is scarcity of information on the combinations of plantain spaghetti or related pasta products. The aim of the study therefore is to evaluate the quality and sensory characteristics of spaghetti made from plantain and wheat flour blends.

2. MATERIALS

Freshly harvested matured plantain used for this study was obtained at a local farm in Awe town, Oyo while wheat flour and other materials (egg, methyl cellulose, salt and vegetable oil) used for this study were purchased at Akesan market, Oyo town, Oyo State. The plantain fingers were at stages 5 (firm ripe) of ripeness using the colour index chart as described by Aurore et al. [11].

3. METHODS

Preparation of plantain flour sample

Freshly harvested, matured plantain of about ten kilograms was sorted, washed in portable water, peeled and sliced to 1 cm thickness using manual kitchen slicer. The sliced were transferred into stainless pot that already has water diluted with ascorbic acid solution for about 5 min. The solute was removed; allow to drain at room temperature (28 ± 2°C) for 5 minutes, dried in an air oven (Model: DC 500; Serial number 12B154) at 55 ± 5°C for 48 hours, milled in a laboratory hammer mill (Fritsch, D-55743, Idar-oberstein-Germany), sieved using sieve number 60 (British Standard) to obtain the plantain flour, packed in a low density polyethene bag and store at room temperature (28 ± 2°C) for further use.

Formulation of the plantain spaghetti samples

The formulations of composite flour were done according to the method of Islam et al. [12] with slight modification. The dried firm ripe plantain (stage "5" of ripeness) flours were mixed with wheat flour separately at different proportions of 100%:00%; 85%:15%; 80%:20%; 75%:25%, 70%:30% and coded as sample A, B, C, D and E. Each sample was blended using a Kenwood mixer (Model: HC 750D, Kenwood, UK) to produce composite flour sample B to E while sample A served as control and contained 100% plantain flour.

Other ingredients were added to each of the composite flour for the spaghetti production as shown in table 1 below. A pasta-making machine (Dolly Mini P3, Italy) was used in this study in which thoroughly kneaded dough is forced through the holes in the die under pressure of approximately 6895 Kpa. The extruded spaghetti from the twins were cut into uniform size, steamed for 3 minutes, and dried at 55 ± 5°C for 8 hours using hot air oven (Genlab, DC 500; Serial number: 12B15). It was then allowed to cool and packed in low density polythene bag for further uses.

Material	Sample A	Sample B	Sample C	Sample D	Sample E
Plantain Flour	100	85	80	75	70
Wheat Flour	---	15	20	25	30
Methyl Cellulose	5	5	5	5	5
Salt	2	2	2	2	2
Vegetable Oil	7	7	7.5	8	8.5
Water	8	8	9	10	10
Whole Egg	20	20	20	20	20

Table 1: Plantain spaghetti formulation.
Note: Sample A = 100% Plantain flour, Sample B = 85%:15%, Sample C = 80%:20%, Sample D = 75%:25%, Sample E = 70%:30%.

Proximate composition of the formulated plantain spaghetti samples

Proximate analysis of the samples was carried out using AOAC [13] methods. Moisture content was determined by air oven method at 105°C. The protein content of the sample was determined using micro-Kjeldahl method. Fat was determined by Soxhlet extraction method using petroleum ether as extracting solvent. The ash content was determined by weighing 5 g of charred sample into a tarred porcelain crucible. It was incinerated at 600°C for 6 hours in ash muffle furnace until ash was obtained. Crude fibre was determined by exhaustive extraction of soluble substances in a sample using H_2SO_4 and NaOH solution, after the residue was ashed and the loss in weight recorded as crude fibre. Carbohydrate content was calculated by differences while gross energy value of the samples was estimated (kJ/100 g) by using this formula according to Famakin et al. [14].

Gross energy (kJ/100 g dry matter) = (Protein × 16.7) + (Lipid × 37.7) + (Carbohydrate × 16.7)

Functional properties of the formulated plantain spaghetti samples

Bulk density of the samples was determined according to Onwuka [15] method while emulsion stability was studied by the method described by Sathe and Salunkhe [16]. Wettability index, oil and water absorption capacities were determined according to the method described by Okezie and Bello [17]. Swelling index of each sample was determined as described by Leach et al. [18] while least gelatinization concentration was determined according to the method of Onwuka [15].

Mineral and Vitamin profiles of the formulated plantain spaghetti samples

Mineral profiles were determined as described by AOAC [13] using an inductively-coupled plasma atomic emission spectrometer (ICPAES, USA, TL6000 Model). The ash was digested with 3 cm^3 of 3 M HCl and made up to the mark in a 100 cm^3 standard flask with 0.36 M HCl before the mineral elements (calcium, zinc, magnesium, iron and potassium) were determined by atomic absorption spectrophotometer (PYE Unicam SP 2900, UK). Provitamin A was determined using the method adopted from IVACG [19] while vitamin B1, B2, B3, B6 and vitamin C were determined using the method of AOAC [13].

Sensory attributes of the formulated plantain spaghetti samples

The method described by Akinsola et al. [20] was used. The sensory panellists consisted of twenty consumers who are familiar with pasta and plantain products were selected for the sensory evaluation. The spaghetti prepared from the flour blends were coded and presented in white plastic plates. Water was provided to rinse mouth between evaluations. The samples were evaluated for appearance, colour, flavour, taste, texture and general acceptability. Panellists evaluated the samples using a 9-points, Hedonic scale with 9 = liked extremely, 8 = liked very much, 7 = liked, 6 = liked mildly, 5 = neither liked nor disliked, 4 = disliked mildly, 3 = disliked, 2 = disliked very much and 1 = disliked extremely. They were asked to rate the products in terms of the sensory attributes listed above.

Statistical analysis

The data obtained were analyzed statistically by statistical package for social science, version 18, and using one-way analysis of variance while Duncan multiple range test was used to separate the mean at ($P \leq 0.05$). Data reported on the tables are average values of triplicate determinations.

4. RESULTS

Proximate composition of the formulated plantain spaghetti samples

Proximate composition of the plantain-based spaghetti was as shown in table 2. Statistical differences were not observed in the moisture content of the samples. Moisture content of the spaghetti varied from 8.25 in sample E to 8.79 g/100 g in sample C. There was significant difference ($p < 0.05$) in sample A compared to other samples in term of crude protein, fat, fibre and total ash with increase in values from control sample to sample E. There values ranged from 10.86 g - 15.36 g/100g, 9.12 g- 1184 g/100 g, 2.41 - 2.98 g/100 g and 1.78g - 2.04g/100g, respectively. Carbohydrate content of all the plantain-based spaghetti shown statistical differences at alpha 0.05. There values ranged from 59.53 g/100g in sample E to 67.08 g/100g in sample A. Energy values of the plantain-based spaghetti samples ranged from 1645 kJ in sample A to 1697 kJ in sample E. The table shows that carbohydrate value decrease significantly as wheat flour substitution increases.

Parameters, g/100 g	Sample A	Sample B	Sample C	Sample D	Sample E
Moisture Content	8.75 ± 0.10	8.72 ± 0.00	8.79 ± 0.01	8.64 ± 0.21	8.25 ± 0.17
Crude Protein	10.86 ± 0.07	12.38 ± 0.11	13.62 ± 0.03	14.40 ± 0.12	15.36 ± 0.09
Crude Fat	9.12 ± 0.11	10.67 ± 0.04	10.87 ± 0.12	11.62 ± 0.08	11.84 ± 0.17
Crude Fiber	2.41 ± 0.00	2.78 ± 0.02	2.80 ± 0.03	2.96 ± 0.00	2.98 ± 0.01
Total Ash	1.78 ± 0.02	1.84 ± 0.21	1.92 ± 0.22	1.99 ± 0.02	2.04 ± 0.00
Carbohydrate	67.08 ± 0.59	63.61 ± 0.36	62.00 ± 0.68	60.39 ± 0.34	59.53 ± 0.41
Energy, kJ	1645 ± 4.43	1671 ± 3.81	1673 ± 4.25	1687 ± 2.69	1697 ± 3.78

Table 2: Proximate composition of the formulated plantain spaghetti samples.
Note: Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different at $p < 0.05$. WF = Wheat flour, Sample A = 100% plantain flour, Sample B = plantain flour blends with 15% WF, Sample C = plantain flour blends with 20% WF, Sample D = plantain flour blends with 25% WF, Sample D = plantain flour blends with 30% WF.

Functional properties of the formulated plantain spaghetti samples

Table 3 presented the results of functional properties of the formulated plantain-based spaghetti samples. There was no significant different ($p < 0.05$) in bulk density of the plantain-based spaghetti. There values ranged from 0.52 g/cm^3 in sample E to 0.58 g/cm^3 in sample A. Statistical differences were observed in their emulsion stability and least gelation concentration compare to control sample. There values ranged from 2.46 g/cm^3 - 4.35 g/cm^3 and 34.72°C to 36.68°C for emulsion stability and least gelation concentration, respectively. The oil absorption capacity and swelling index values of the plantain-based spaghetti samples were significant different ($p < 0.05$).

Attributes	Sample A	Sample B	Sample C	Sample D	Sample E
Bulk Density, g/cm^3	0.58 ± 0.00	0.56 ± 0.00	0.54 ± 0.02	0.54 ± 0.00	0.52 ± 0.01
Emulsion Stability, g/cm^3	2.46 ± 0.03	3.24 ± 0.10	3.71 ± 0.00	3.86 ± 0.05	4.35 ± 0.03
Least gelation Concentration, °C	33.56 ± 0.14	34.72 ± 0.32	35.21 ± 0.23	35.59 ± 0.31	36.68 ± 0.28
Oil Absorption Capacity, g/cm^3	2.29 ± 0.02	2.34 ± 0.01	2.87 ± 0.00	3.51 ± 0.02	4.72 ± 0.00
Swelling Index, g/cm^3	3.81 ± 0.00	4.11 ± 0.00	4.37 ± 0.03	4.95 ± 0.10	5.63 ± 0.04
Water Absorption Capacity, g/cm^3	4.12 ± 0.11	4.39 ± 0.08	4.71 ± 0.01	4.93 ± 0.04	5.22 ± 0.03
Wettability Index, seconds	8.17 ± 0.13	9.22 ± 0.09	9.54 ± 0.06	10.12 ± 0.15	10.51 ± 0.08

Table 3: Functional properties of the formulated plantain spaghetti samples.
Note: Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different at $p < 0.05$. WF = Wheat flour, Sample A = 100% plantain flour, Sample B = plantain flour blends with 15% WF, Sample C = plantain flour blends with 20% WF, Sample D = plantain flour blends with 25% WF, Sample D = plantain flour blends with 30% WF.

There values ranged from 2.29 g/cm^3 - 4.72 g/cm^3 and 3.81 g/cm^3 - 5.63 g/cm^3, respectively. Water absorption capacity of the sample values ranged from 4.12 g/cm^3 in sample A to 5.22 g/cm^3 in sample E while wettability index of the plantain-based spaghetti samples ranged from 8.17 seconds - 10.51 seconds for sample A and E, respectively.

Vitamin profiles of the formulated plantain spaghetti samples

Vitamin profiles of the plantain-based spaghetti samples were presented in Table 4. Statistical differences at alpha 0.05 were observed in vitamin A of all the samples. There values ranged from 1132 IU in sample A to 1783 IU in sample E while vitamin B1 content of all the samples ranged from 0.06 -0.08 for sample A and E, respectively. There were no significant differences ($p < 0.05$) in vitamin B2, B3, and B6 of the plantain-based spaghetti samples. There values ranged from 0.66 mg/100 g - 0.70 mg/100 g, 0.48 mg/100 g - 0.58 mg/100 g and 0.28 mg/100 g - 0.39 mg/100 g for B2, B3, and B6, respectively. Statistical differences were observed in vitamin C content of the plantain-based spaghetti samples with values ranged from 19.67 mg/100 g in sample A to 23.11 mg/100 g in sample E. The shows that there were marginal increasement in all the vitamins determined compared to control sample.

Vitamins	Sample A	Sample B	Sample C	Sample D	Sample E
A, IU	1132 ± 3.45	1528 ± 4.11	1654 ± 4.09	1718 ± 3.59	1783 ± 2.88
B_1, mg	0.06 ± 0.00	0.06 ± 0.01	0.07 ± 0.00	0.07 ± 0.01	0.08 ± 0.00
B_2, mg	0.658 ± 0.02	0.695 ± 0.00	0.698 ± 0.02	0.701 ± 0.01	0.704 ± 0.01
B3, mg	0.48 ± 0.01	0.52 ± 0.02	0.52 ± 0.00	0.56 ± 0.00	0.58 ± 0.02
B_6, mg	0.28 ± 0.00	0.32 ± 0.03	0.33 ± 0.01	0.37 ± 0.02	0.39 ± 0.01
C, mg	19.67 ± 0.38	20.36 ± 0.21	20.82 ± 0.12	21.46 ± 0.33	23.11 ± 0.22

Table 4: Vitamin profiles of the formulated plantain spaghetti samples.

Note: Values recorded as triplicate mean ± standard deviation while values with different superscripts within the same row are significantly different at p<0.05. WF = Wheat flour, Sample A = 100% plantain flour, Sample B = plantain flour blends with 15% WF, Sample C = plantain flour blends with 20% WF, Sample D = plantain flour blends with 25% WF, Sample D = plantain flour blends with 30% WF. A* = 6 µg of β-carotene equal 1 retinol activity equivalent (RAE), 1 RAE of vitamin A equivalent to 11 µg of retinol [19].

Minerals profiles of the formulated plantain spaghetti samples

Table 5 presented the results of mineral profiles of the plantain-based spaghetti samples. There were significant differences ($p < 0.05$) in calcium content of the samples with values ranged between 23.11 mg/100 g and 32.04 mg/100 g. The calcium content of the samples ranged from 23.11 mg/100 g in sample A to 30.14 mg/100 g in sample E. Iron content of the samples shows no statistical differences with their values ranging from 0.72 mg/100 g - 0.95 mg/100 g for sample A and E, respectively. The plantain-based samples were also significant different in their potassium and magnesium content. There values ranged from 353.22 mg/100 g - 420.10 mg/100 g and 36.14 mg/100 g - 40.27 mg/100 g, respectively. There were no significant different in the sodium content of all the samples. There values ranged from 4.61 mg/100 g in sample A to 4.83 mg/100 g in sample E while phosphorus content of the sample ranged from 22.17 mg/100 g - 32.13 mg/100 g for sample A and E, respectively. Zinc content of all the samples shown no significant differences at alpha 0.05. There values ranged from 0.26 mg/100 g in sample A to 0.48 mg/100 g in sample E. The Na:K ratio of the plantain-based spaghetti samples were marginally constant (0.01) into 2-decimal place while P:Ca ratio ranged from 1.04 in sample A to 1.07 in sample E.

Minerals (mg/100)	Sample A	Sample B	Sample C	Sample D	Sample E
Calcium, Ca	23.11 ± 0.21	24.23 ± 0.17	26.51 ± 0.38	28.46 ± 0.19	30.14 ± 1.01
Iron, Fe	0.72 ± 0.01	0.75 ± 0.03	0.77 ± 0.01	0.83 ± 0.07	0.95 ± 0.0.3
Potassium, K	353.22 ± 1.92	396.18 ± 3.11	409.23 ± 3.56	417.05 ± 2.94	432.10 ± 4.21
Magnesium, Mg	36.14 ± 0.18	38.35 ± 1.26	38.81 ± 0.1.40	39.22 ± 1.32	40.27 ± 0.98
Sodium, Na	4.61 ± 0.05	4.68 ± 0.02	4.74 ± 0.06	4.77 ± 0.08	4.83 ± 0.26
Phosphorus, P	22.17 ± 0.53	25.20 ± 0.29	28.17 ± 0.32	30.06 ± 0.47	32.13 ± 0.51
Zinc, Zn	0.26 ± 0.01	0.31 ± 0.00	0.38 ± 0.01	0.41 ± 0.01	0.48 ± 0.02
Na:K	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00	0.01 ± 0.00
P:Ca	1.04 ± 0.11	1.04 ± 0.01	1.06 ± 0.02	1.06 ± 0.01	1.07 ± 0.03

Table 5: Minerals profiles of the formulated plantain spaghetti samples.

Note: Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different at p<0.05. WF = Wheat flour, Sample A = 100% plantain flour, Sample B = plantain flour blends with 15% WF, Sample C = plantain flour blends with 20% WF, Sample D = plantain flour blends with 25% WF, Sample D = plantain flour blends with 30% WF.

Sensory attributes of the formulated plantain spaghetti samples

Sensory attributes of the plantain-based spaghetti samples were as presented in table 6. There were significant differences at alpha 0.05 for all the sensory attributes observed in the plantain-based spaghetti. Sample A appearance mean score is higher (5.13) while sample E that was substituted with 30% wheat flour had least (4.35) value. Significant differences were observed in term of colour, sample A had the highest mean score of 6.74 while sample E had the least (4.78). Statistical differences were observed in term of flavour for all the samples with mean score ranged from 4.21 in sample A to 7.04 in sample C, while taste and texture of the formulated plantain-based spaghetti samples mean score ranged from 5.63 - 6.32 and 4.49 - 7.20, respectively. Overall acceptability of the formulated spaghetti sample C had the highest mean score (6.77) and was significantly different at alpha 0.05 compared to other formulated spaghetti samples except sample D. The average mean scores of the samples ranged from 5.24 in sample A to 6.37 in sample C followed by sample D and B, respectively.

Attributes	Sample A	Sample B	Sample C	Sample D	Sample E
Appearance	5.13 ± 0.11	6.24 ± 0.08	6.83 ± 0.05	6.31 ± 0.12	4.35 ± 0.00
Colour	6.74 ± 0.23	6.30 ± 0.47	5.75 ± 0.12	5.56 ± 0.09	4.78 ± 0.01
Flavour	4.21 ± 0.06	5.89 ± 0.13	7.04 ± 0.01	6.12 ± 0.03	6.46 ± 0.12
Taste	5.63 ± 0.03	5.73 ± 0.09	5.88 ± 0.10	6.07 ± 0.1	6.32 ± 0.07
Texture	4.49 ± 0.12	5.85 ± 0.15	5.93 ± 0.08	6.47 ± 0.08	7.20 ± 0.11
Overall acceptability	5.27 ± 0.07	6.26 ± 0.12	6.77 ± 0.03	6.72 ± 0.02	6.28 ± 0.05
Mean	5.24 ± 0.05	6.04 ± 0.11	6.37 ± 0.07	6.21 ± 0.0.4	5.90 ± 0.05

Table 6: Sensory evaluation of the formulated plantain spaghetti samples.

Note: Values recorded as triplicate mean ± SD, while values with different superscripts within the same row are significantly different at p<0.05. WF = Wheat flour, Sample A = 100% plantain flour, Sample B = plantain flour blends with 15% WF, Sample C = plantain flour blends with 20% WF, Sample D = plantain flour blends with 25% WF, Sample D = plantain flour blends with 30% WF.

5. DISCUSSION

Proximate composition of the formulated plantain spaghetti samples

Statistical differences ($p < 0.05$) were observed in all the parameters investigated compare to the control (100% plantain). Low moisture content obtained in this study shows that its shelf-life would be greatly enhance according to other workers reports [21]. Moisture content of the spaghetti product gives indication of its shelf-life and nutrients density. Moisture contents are one of the valuable factors in preservation of food materials. Protein content of the samples increases with wheat flour substitution which may be linked to the protein content in wheat flour and this is in line with the work of Idowu & Akinsola [22] who work on quality of pasta fortified with orange fleshed sweet potato flour. Proteins has been shown to play a vital role in organoleptic properties of foods/feeds, boost immune system, and play a key role in cell division and growth [23]. The study protein values are greater than the recommended value (13 g/100 g - 14 g/100 g) of Anigo et al. [24]. The fat content of all the samples provide more than 28.43% recommended by FAO/WHO [25] as allowance for fat contribution in food. The fat content of the flour was observed to increase with increased level of wheat flour and vegetable oil added. Relatively low-fat content in a food product could be desirable because it will inhibit rancidity in the food leading to keeping its pleasant and odorous compound. Lipids provide very good sources of energy and aids in transport of fat-soluble vitamin, insulates and protects internal tissue and contribute to important cell processes [26].

The crude fibre result in this study is higher than that of Animasaun et al. [27] and Edet et al. [28] who reported crude fibres range of 0.23% to 0.79% and lower than that of Akinsola et al. [20] who reported crude fibres of 6.78% to 7.83%. For plantain and African yam beans flour blends. 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 [29]. Ash content is an indication of raw mineral profiles of food products. The study ash content is like that of reported ash ranging from (1.29% to 1.98%) in rice, acha and soybean flour blends, and that of Animasaun et al. [27] who reported ash range of 0.40% to 1.21% for different roasted sesame and wheat flour blends but lower than that of Akinsola et al. [20] who reported 4.01% - 4.75% for plantain-African yam beans flour blends. The study results show that there was a corresponding decreased in carbohydrate content as wheat flour was added. This could be attributed to high percentage of protein content in wheat flour which agreed with the work of Animasaun et al. [27]. Carbohydrate, apart from supplying 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 [22].

Functional properties of the formulated plantain spaghetti samples

All the samples bulk density was not significantly different (P > 0.05) from one another. The bulk density was found to decrease marginally with increase in the level of wheat flour substitution. This agrees with work of Animasaun et al. [27] who work on wheat flour and roasted sesame flour blends. Bulk density is a function of particle size distribution of the flours. Oke et al. [30] reported that the lower the bulk density value, the higher the amount of flour particles that can stay together and thus increasing the energy content that could be derivable from such diets. Emulsion stability is an index of protein potential in food products development in term of water and oil absorption capacity. Statistical differences were observed at alpha 0.05 in all the samples emulsion stability investigated. The increase in the emulsion stability of the flour blends might be due to increase in the protein content of the flour blends compare to control sample.

Least gelation capacity (LGC) is the lowest protein concentration at which gel remains in the inverted tube. It was observed that gelation temperature increased with increase in substitution level of wheat flour which might be due to break down in starch into high amount of amylose and amylopectin molecules (enzymatic breakdown of carbohydrates) as well as protein hydrolysis during cooking and extrusion methods employed [31]. Low oil absorption is highly desirable for flour product, which indicates the amount of oil that must be taken up a given weight of dry flour to form a paste while Petitot et al. [32] reported that it is an indicator of the rate of which protein binds to fat in food formulation. Swelling index of hydroxyl group association forces within the starch granules. It is also an important factor which determine samples consisting either liquid or semi-liquid. Low level of swelling index obtained in this study may have been caused by the hydrolyzed starch granule which swells less and retains less water. This, however, increases the nutrient and energy densities per unit volume of the blended flour.

The high-water absorption capacity observed in the spaghetti samples could be attributed to the addition of wheat protein Water absorption capacity is the ability of flour to absorb water and swell for improved consistency in food. it is desirable in food systems to improve yield and consistency and give body to the food [33] while wettability index of the plantain-based spaghetti increased marginally from control sample to sample E. Wettability index 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°C) to wet per sec. Wettability time is the time required for all the flour particles to be wetted.

Mineral profiles of the formulated plantain spaghetti samples

The result of mineral profiles of the flour from plantain-wheat flour blends shows significant differences (p < 0.05) to one another in all the samples investigated except iron, sodium and zinc. Samples were significantly different (P > 0.05) from each other for calcium content. There was increasement in the level of calcium as the addition of wheat flour increases. Calcium is an important component of intracellular processes that occur within insulin responsive tissues like skeletal muscle and adipose tissue [20]. Calcium and phosphorus ratio as reported by Koua et al. [34] plays an important role in human diets based on their association with growth and maintenance of bones, teeth and muscles. According to Koua et al. [34], this ratio is an indicator of calcium availability in the diet. Ca:P values which are greater than 1 suggests a good absorption of calcium as reported by Koua *et al*. [34], while values less than 0.5 indicates a poor calcium uptake. In the present study, the ratios Ca:P were higher than1, this constitute a good indication of intestinal absorption of calcium.

The iron content of the study samples was significantly low to recommended daily allowance of 16 mg/day - 18 mg/day for men and 12 mg/day for women. 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. Iron deficiency, anaemia-characterized by small red cells (microcytosis) with low haemoglobin [35]. Potassium content of the composite flour significantly increased as wheat flour substitution increases. The increasement in the potassium content of the sample is inversely proportional to sodium content of the samples value. Studies have shown that low dietary intake of sodium and high dietary intake of potassium, calcium and magnesium reduces risk of diabetes, lowering of blood pressure, hypertension and cardiovascular disease. There were no statistical differences ($p > 0.05$) in the sodium content of all the samples. All the ratio of sodium to potassium content of the formulated spaghetti samples were lower than 1.0 which is an indicator of the dietary potential and mineral availability of such food.

In term of magnesium content, the study values were higher than those of 2.69 mg/100 g - 3.73 mg/100 g reported by Animasaun et al. [27] who work on quality evaluation of pasta fortified with roasted sesame flour. Magnesium is essential for all biosynthetic processes including glycolysis, formation of cyclic ATP, energy dependent membrane transport and transmission of the genetic code [34]. Magnesium is crucial constituent of all cells and necessary for the functioning of enzymes involved in energy utilization and bone formation [36]. 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 [37]. The study indicates significant increase of this mineral as wheat flour substitution level increased while the values obtained for zinc in this study are far lower than the recommended daily allowance of 15 mg/100 g [27]. 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 [35].

Vitamin profiles of the formulated plantain spaghetti samples

Statistical differences were observed in all the sample vitamins investigated at alpha 0.05 except vitamin B_1, B_3 and B_6. 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. Vitamin A is very essential for growth, reproduction, good vision, healthy skin, hair and nail and to balance energy level in the human body. The vitamin A content of this study increases as wheat flour substitution increases. According to Edet et al. [28], vitamin A also regulate the immune system, which helps to fight off infections by producing white blood cells that destroy harmful bacteria and viruses.

The vitamin $B_{complex}$ of the plantain-based spaghetti samples significantly different ($p < 0.05$) from one another except vitamin B_2. 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 [38] while vitamin $B_{2,}$ apart from help in energy metabolism, it is important for normal vision and healthy skin. Pyridoxine is an important B-complex vitamin that has a beneficial role in the treatment of neuritis, anaemia, and to decrease homocysteine levels (one of the causative factors for coronary artery disease and stroke episodes) in the body [39]. Gavrilov [40] reported that vitamin B_3 aids normal functioning of tissues, particularly skin, gastrointestinal tract and nervous systems; used with other vitamins in converting carbohydrates to energy while 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 and builds haemoglobin [38].

Vitamin C is required by the body for maintenance of health, gum, healing of wounds, mopping excess of oxygen from the system and is a powerful antioxidant. Price [38] reported that vitamin C is 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. Moreover, it improves stamina, holds body cells together, prevent infections, colds, fatigue and stress, reduces allergies, heals wounds and burns [40].

Sensory attributes of the formulated plantain spaghetti samples

The sensory attributes of the plantain-based spaghetti prepared from plantain and wheat flour blends shows statistical differences ($p < 0.05$) in all the sample investigated. In terms of appearance, there were significant difference ($P < 0.05$) between the spaghetti samples. Appearance is an important attribute in food choice and acceptance [41]. The spaghetti made from the sample that had 20% wheat flour were more liked in terms of appearance than other spaghetti samples. This could be attributed to the ratio of 1 to 5 of wheat flour to plantain flour that might have enhanced its appearance optically. In term of colour, there were significant differences ($p < 0.05$) between the samples in terms of colour. Substituting plantain with wheat flour more than 20% level significantly ($p < 0.05$) affect the colour and flavour of the spaghetti samples. Flavour plays an important factor in consumer's preferences and products; hence sample C was most preferred than other wheat flour substituted samples. Flavour is an integral part of taste and general acceptance of the food before it is put in the mouth [41]. Based on this study, the spaghetti produced from 20 % wheat flour substitution samples performed better than the other samples.

Taste is an important parameter when evaluating sensory attributes of food. The product might be appealing and having high energy density without good taste, such a product is likely to be unacceptable [41]. The samples with 20% wheat flour were more liked than the other samples. It was observed that as the wheat flour increased than 20% substitution in the mix the less its taste was liked while in term of texture, the panelists preferred the texture of the spaghetti made from sample with 30% wheat flour. Texture is the prevailing textural characteristics of the food product at the point of consumption that usually determine whether such food is swallowable or chewable [42]. The high mean score obtained for the overall acceptability showed that the plantain-based spaghetti samples were accepted by the panelists, however, sample with 20% wheat flour substitution level had the highest mean score than other wheat flour substituted samples. This might be the perfect blend to make spaghetti from plantain-wheat flour blends.

6. CONCLUSION

The study shows that spaghetti made from plantain and wheat flour are nutritionally better than 100% plantain flour spaghetti. The study shows that nutritionally improved spaghetti products could be produced from mixture of plantain and wheat flour within the range of 15% - 25% wheat flour substitution. However, the sensory attribute results indicated that spaghetti produced with 20% of wheat flour substitution had a good sensory attribute when compared with other samples.

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