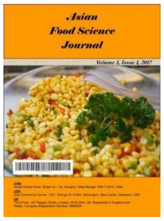

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Chemical, Functional and Sensory Properties of Extruded Breakfast Strips Produced from a Blend of Orange-fleshed Sweet Potato, Soybean and Plantain Flour

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Authors' contributions

This research is a dissertation work and was carried out in collaboration among all authors. Author DBKK is the Lead Supervisor who designed the study and wrote the protocol. Author OMA is the Co-Supervisor while Author UAU is the Masters student who wrote the first draft of the manuscript, managed the literature searches, managed the analyses of the study and performed the statistical analysis under close guidance of the Supervisors. All authors read and approved the final manuscript.

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ABSTRACT

Breakfast strips were produced from different blends of orange-fleshed sweet potato (*Ipomea batatas*), plantain (*Musa paradisiaca*) and soybean (*Glycine max*) flours with substitution ratios of 100:0:0, 90:10:0, 90:0:10, 80:10:10, 70:15:15, 60:20:20 and 50:25:25 and labelled as samples A, B, C, D, E, F and G, respectively. The blends were evaluated for functional properties, total carotene, vitamins (B2 and B6) and sensory properties of the breakfast strips with a commercial breakfast food (Flakes) as control (sample H) . For the functional properties, the water absorption capacity decreased while the oil absorption increased with an increase in substitution levels of the soybean flour. The bulk density, solubility, swelling power and swelling volume were higher in sample A. The least gelation capacity maintained a constant rate of 4% across the blends. The moisture content of the strips ranged from 7.25-9.40%. The Ash contents were below 3% for all the blends. The protein contents increased with an increase in substitution with soybean flour while

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sample A - breakfast strips from 100% orange-fleshed sweet potato flour showed the highest value for fats (5.62%). The fibre content ranged from 0.69 to 5.14% and carbohydrate content reduced with an increased substitution with soybean flour (72.25-78.70%). The energy value ranged from 351.90-384.80 Kcal/100 g which was within the limit recommended for breakfast foods. Total carotene content increased with increased substitution with orange-fleshed sweet potato (15.18-33.56 mg/kg) which is significantly higher than the control at 0.75 mg/kg. The result of the sensory evaluation showed that the overall acceptability of the samples produced compared favourably with the control. Sample A and B showed a vitamin B_2 of 4.70 and 4.00 mg/kg, respectively. However, the values decreased with increase in the addition of soybean while vitamin B_6 increased with increase in soybean.

Keywords: Breakfast strips; orange-fleshed sweet potato; plantain; soybean; carotene; sensory properties.

1. INTRODUCTION

Ready-to-eat breakfast foods are increasingly gaining acceptance in developing countries like Nigeria and gradually replacing most traditional foods used as breakfast. This is generally due to convenience, flavour, aesthetic appeal, status symbol and ease of preparation especially for urban dwellers with high job demands. Some breakfast foods such as oatmeal requires cooking while others are processed ready-to-eat which are usually consumed with milk or eaten dry. Most ready-to-eat breakfast foods lack essential nutrients such as protein which is highly needed for growth and development. Therefore, supplementation is an effective way of combating issues related to protein calorie malnutrition and also fighting the malady of Vitamin A deficiency.

Sweet potato (*Ipomea batatas*) is a sweet starchy dicotyledonous root tuber belonging to the family *convolvulaceae* and it exists in different varieties. The common varieties include the red, brown, white, purple and orange fleshed. The varieties with or pale yellow flesh are less sweet and contains low moisture compared to the red, pink and orange fleshed varieties [1]. All varieties of the sweet potato contain beta-carotene; a vitamin A precursor but its content is more significant in the orange fleshed variety. Its tubers contain good amount of protein and are used pharmaceutically for diabetics [2]. It is a source of natural sugar and enhances the taste of the product being processed as well as a distinctive colour and flavour. When orange-fleshed sweet potato is processed, it has a high potential for complementing the conventional wheat flour and can impart its natural sweetness and flavour to processed food products.

Soybean is a cheap source of protein which can be very helpful in developing nations. It has been identified as the only plant source that contains all the essential amino acids and a good source of minerals [3]. Plantain is rich in Vitamins A, B and C [4], as well as minerals which include zinc, calcium, magnesium and potassium [5].

Despite its numerous health benefits of orange-fleshed sweet potato, it has been underutilized. It has the potential of bridging food gap due to diversified processing and utilization technologies that have been produced but not yet fully exploited [6]. The aim of this work therefore is to produce and evaluate breakfast strips from a blend of orange-fleshed sweet potato, plantain and soybean flours.

2. MATERIALS AND METHODS

The Orange-fleshed Sweet Potato was purchased from the NRCRI Umudike, Abia State, Nigeria. The plantain was purchased from Local farmers at Etche Local government while the Soybean was purchased from Rukpokwu market, Port Harcourt, River State, Nigeria.

2.1 Methods of Processing

The sweet potato and plantain were washed, peeled and sliced manually to thin slices to facilitate drying. The sliced potato and plantain were then blanched separately in hot water at 90°C for 10min and oven (DH6-9140A, China) dried at 60°C for 12h. The dried products were milled separately and sieved with 0.25 mm particle size sieve to yield a flour of fine texture. The soybean was sorted and cleaned to remove stones, dust and chaffs. After which it was steeped for 48 h with the water changed daily. After steeping, the bean was drained and de-hulled manually. The bean was further boiled for 30min, drained and dried with an oven (DH6-9140A, China) at 60ºC for 12 h. The dried bean was milled and sieved with 0.25 mm particle size sieve to yield flour.

2.2 Product Formulation

The flour blends were formulated to produce seven samples using orange-fleshed sweet potato, plantain and soybean flours in different ratios of 100:0:0, 90:0:10, 90:10:0, 80:10:10, 70:15:15, 60:20:20 and 50:25:25 and labelled A, B, C, D, E, F and G samples, respectively. Corn flakes (Good morning brand) was used as control and labelled as sample H.

2.3 Production of Extruded Breakfast Strips

Orange-fleshed sweet potato was used in the preparation of the breakfast foods at different levels of substitution with soybean and plantain flour. Two hundred grams (200 g) of each composite flour was mixed manually with 25 g of sugar, 0.5 g of salt and 200 ml of distilled water. The dough was extruded using an Eurosonic (Globe 150) cold extruder. The strips were reduced to 1cm, dried in an air circulating oven at 135ºC for 45 min and packaged. The Samples were put in an air tight bottle labelled consecutively and stored for analysis.

2.4 Functional Properties of the Flour Blends

The functional properties of the flour blends were determined using the method described by Onwuka [7]. The pH of the flour was determined by weighing 5g of the sample and disposing in 50mL of distilled water. The solution was further mixed in an orbital shaker for 30 min. The pH meter (PHS-2F, China) was calibrated using buffer solutions pH of 4 and 7. The pH was measured by inserting the electrode into the sample suspension. For bulk density, each sample was slowly filled into l0mL measuring cylinder. The bottom of the cylinder was gently tapped on a laboratory bench until there was no further lessening of the sample after filling to l0mL mark. Bulk density was estimated as mass per unit volume of the sample and duplicate measurements were taken. The Oil/Water absorption capacities were determined on the flour using the method described by Beuchat [8]. One gram (1 g) of each of the samples were mixed with 10 mL of distilled water/oil in a centrifuge tube previously weighed and placed on a multifunctional shaker and mixed for 20 min. The samples were allowed to stand at room temperature (28±1ºC) for 30 min. The volume of the supernatant was measured using a 10mL tube, the centrifuge tube weighed and the amount of water/oil was calculated. For the least gelaton capacity, twenty percent (20%) W/V suspension of each of the samples was prepared in 5mL distilled water in test tubes. The sample test tubes were heated for 1h in a boiling water bath which was followed by rapid cooling under running tap water. The test tubes were further cooled for 2 h at 4ºC. The least gelation concentration was determined as that concentration at which the sample from the inverted test tube did not fall down or slip visually. The method described by Takash and Sieb [9] was used for solubility, swelling power and swelling volume. One gram (1 g) of the sample was weighed and transferred into a conical flask and 15 mL of distilled water was added and shaken vigorously. The solution was sent to a shaker bath at a set temperature of 100ºC for 1 h. The heated sample was cooled under running water. After cooling, it was transferred into a previously dried and weighed centrifuge tube and centrifuged at 3000rpm for 30 min using a digital control centrifuge (L-600, China). After centrifuging, the swollen volume was read directly from the tube using the height of the swollen sediment. The clear portion of the liquid was decanted into a previously weighed moisture can and dried with a hot air oven at 105ºC for 1 h, after which it was cooled in a desiccator and weighed to get the solubility. The weight of the centrifuge tube was taken to calculate the swelling power and swelling Volume.

2.5 Proximate Analysis of the Strips

The proximate analysis was carried out using AOAC [10] standard method. Moisture content was determined using a moisture analyzer, (model A&B-5). Fat content was measured using the micro soxhlet apparatus. Crude protein was determined using the Kjehdah method and calculated using 6.25 conversion factor. Crude fibre was calculated after 2 g of the sample was defatted, hydrolysed and filtered; the residue was washed free from acid and incinerated in a muffle furnace. The total carbohydrate content was estimated by difference while the energy values in Kcal/100 g were determined by standard calculations (at water factor), where factors of 4, 4, and 9 were used for protein, carbohydrate and fat, respectively.

2.6 Total Carotene and Vitamin Content of the Strips

2.6.1 Total carotene

The total carotene was determined using the method described by Harborne [11]. Five hundred milligrams (500 mg) of the sample was weighed into a centrifuge tube; 10 mL of 80% acetone was added, mixed properly and centrifuged at 4000 rpm for 10min. The supernatant was made up to a volume of 15mL using 80% ethanol. The optical density (absorbance) was read at 480nm using the UV visible spectrophotometer (Cecil CE 1000, UK) and total carotenoid calculated using the Equation 1.

$$\text{Total carotenoid}\left(\frac{\text{mg}}{\text{kg}}\right) = \frac{4\ x\ Absorbance\ x\ Total\ Volume\ of\ Samples\ x\ 100}{Weight\ of\ Sample} \quad (1)$$

Total carotene = Total carotenoid - Xanthophyll

Where xanthophyll = 22% of total carotenoid

2.6.2 Vitamin B_2

Vitamin B_2 was determined using the method described by Eitenmiller and Landen [12]. Twenty milligrams (20 mg) of the sample was weighed into a 10 mL volumetric flask and then dissolved with 0.1 NHCl, 5mL of the standard (1.0 – 10 mg/mL) and sample was taken in marked test tubes. In each of the test tubes, 5 mL of NH_4OH (0.1 mol/L) and 0.5 mL 4-Amino phenol solution was added and mixed well. The solution was kept for 5 min, 10 mL of chloroform was added to separate the chloroform layer. The absorbance of the chloroform layer was measured at 430 nm against the blank. The amount of Vitamin B_2 present in the samples was computed from its calibration curve.

2.6.3 Vitamin B_6

Twenty milligrams (20mg) of the sample was weighed into a 10ml volumetric flask and then dissolved with 0.1 NHCl, 5mL of the standard (0.5-2.0mg/mL) and sample hydrolysis solution was taken in marked test tubes. In each test tube, 1 mL of ammonium buffer, 1 mL of 20% sodium acetate, 1 mL of 5% boric acid and 1 mL dye (2,6 di-chloroquinone chorimide) solutions were added. The absorbance was recorded at 650 nm against the blank. A plot of the vitamin standard was done and the amount of Vitamin B_6 present in the samples was computed from its calibration curve [12].

2.7 Sensory Evaluation of the Strips

The Colour, flavour, taste, crispiness, mouthfeel and overall acceptability of the breakfast strips were carried out for consumer acceptance using 20 semi-trained panelist comprising of students of the River State University, Nkpolu-orowurukwo, Port Harcourt, Rivers State, Nigeria. At each session, the samples were served with water and milk in transparent plates identified with codes A-H. A five point hedonic Likert-type Scale was used where 1 represent Dislike Extremely and 5 Like Extremely.

2.8 Statistical Analysis

The data obtained for all the analysis carried out were subjected to statistical analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS) software, version 21.0 (SPSS Inc.). Complete Randomized design was used and the significant difference between the means obtained using Duncan Multiple Range Test. All statistical tests were performed at 5% significant level.

3. RESULTS AND DISCUSSION

3.1 Functional Properties of Flour Blends

The result for the functional properties is presented in Table 1. The water absorption capacity for the samples ranged from 2.39 to 3.79 g/mL. The carbohydrate content of foods is a major contribution to a high water absorption capacity of foods [13]. A significant difference ($p<0.05$) existed among the samples which could be attributed to the dissociation of amylose and amylopectin in the starch granules, thereby producing weak forces facilitating the entry of water. The oil absorption capacity increased with the addition of soybean flour and this is due to the hydrophobic nature of protein which plays a vital role in the absorption of fat [14]. The values obtained were slightly above those reported by Okafor and Usman [15] for the physical and functional properties of breakfast cereals from blends of maize, African yam bean, defatted coconut cake and sorghum extract which ranged from 0.87 to 1.32 g/mL. Sample A (100% orange-fleshed sweet potato flour) recorded the highest bulk density of 0.62 g/g which might be due to the unique and fine texture of the orange-fleshed sweet potato flour which is more compatible than the other flours used. According to Agunbiade and Ojezele [16], the higher the bulk density, the less packaging space required for packaging of the product. Mbaeyi [17] recorded a similar result (0.53-0.73 g/g) for the production of breakfast cereals from blends of acha and fermented soybean paste. The solubility of the blends showed a significant difference ($p<0.05$) with sample A having the highest solubility of 51.67%. The sample with 100% orange-fleshed sweet potato flour had the highest swelling power of 2.45 g/mL. There was a reduction in the swelling power with an increased addition of soybean which could be due to the hydrophobicity of proteins. The least gelation capacity for all the samples analyzed did not differ significantly ($p>0.05$) from each other. The samples maintained a constant least gelation capacity of 4.0% which could be attributed to the high content of starch present in the formulations analyzed.

3.2 Proximate Composition of Breakfast Strips

The result for the proximate composition is shown in Table 2. The moisture content of samples ranged from 7.25 to 9.40%. Reduced moisture content helps to keep out micro-organisms, thereby prolonging the shelf life of the product. High moisture content will encourage the growth of micro-organisms which brings about the onset of food spoilage and a reduced shelf life of products. The moisture content of the samples were lower than the commercial product (flakes). Ash is the residue after the inorganic food matter has been combusted. The ash content recorded an increase in the flour blends which could be attributed to the inclusion of salt and sugar during production. Gabriel and Faith [18] reported lower values of ash (1.97-2.05%) for the production of extruded ready-to-eat snacks from breadfruit, cashew nut and coconut. The result of the fat content indicated that the samples were all significantly different ($p>0.05$). The control had the least fat content of 0.58%. The reasons for the high fat content recorded could be due to the use of full fat soybean in the formulation of the product. The presence of a high fat content would be suitable for growing children in need of a full fat diet. According to FAO [19] essential fatty acids provided dietary fats, improves the taste and overall acceptability of food products, slow bowel movements, increasing satiety and speeds up the rate of absorption of fat-soluble vitamins. The protein content increased with an increased addition of soybean which is due to the fact that soybean contains a high amount of protein. Protein content in extruded snacks increases as the proportion of a high protein ingredient in the formulation is increased [20,21]. All samples excluding A and B compared favourably with the control. The fibre content recorded the highest value in sample D (5.14%). There was an increase in the fibre content as compared to the flour blends due to increased moisture content and the high dietary fibre content of sweet potato. Fibre has been proven to be very effective in the prevention of constipation and helps in a healthy bowel movement. The results obtained from this study were higher than that reported by Gabriel and Faith [18] with a range of 0.32 to 1.47% for the produced extruded ready-to-eat snacks from breadfruit, cashew nut and coconut. The carbohydrate content of the samples ranged from 72.25 to 80.06%. The reasons for the high content of carbohydrate were attributed to the predominant content of the orange-fleshed sweet potato and plantain flour blends. This study shows that the product could be a good source of energy which is needed for proper functioning of the body. Honi et al. [22] recorded results within the range of 366.13-396.94 Kcal for extruded orange-fleshed sweet potato and Bambara groundnut-based snacks.

3.3 Total Carotene and Vitamins

Carotene, a precursor of vitamin A has been very effective in curbing the menace of vitamin A deficiency which is the cause of childhood blindness. The total carotene content of the strips decreased with an increased addition of soybean and plantain flour in the blends. The total carotene content ranged from 0.75-44.56 mg/kg which was higher than results obtained by Honi et al. [22] for extruded orange-fleshed sweet potato and Bambara groundnut-based snacks (0.54-17.33 mg/kg). This difference could be attributed to the addition of plantain flour in the blend which also contributed to the high content of Total carotene in the breakfast strips. Vitamin B_2 acts as a major contributing factor in the metabolism of essentials nutrients in the body while also maintaining the skin and eye tissues [23]. The vitamin B_2 content ranged from 3.30-4.70 mg/kg with significant difference ($p<0.05$) among all samples analyzed. The results obtained from this study were higher than the US Recommended Daily Allowance (RDA) of

Table 1. Functional properties of the orange-fleshed sweet potato, plantain and soybean flour blends

Samples	Water Absorption (g/ml)	Oil Absorption (g/ml)	Bulk Density (g/g)	Solubility (%)	Swelling Power (g/ml)	Swelling Volume (ml)	Least Gelation Capacity (%)	pH
A	3.79±0.28^{a}	1.32±0.42^{a}	0.62±0.16^{a}	51.67±2.35^{a}	2.45±0.07^{a}	11.34±0.32^{a}	4.00±0.00^{a}	5.50±0.00^{d}
B	3.15±0.91^{b}	1.20±0.28^{a}	0.55±0.01^{a}	35.00±0.47^{b}	2.15±0.07^{ab}	10.81±0.07^{ab}	4.00±0.00^{a}	5.35±0.07^{e}
C	3.69±0.14^{a}	1.42±0.92^{a}	0.53±0.21^{a}	31.67±0.47^{c}	2.10±0.14^{b}	10.08±0.46^{ab}	4.00±0.00^{a}	5.60±0.00^{c}
D	3.19±0.00^{b}	1.35±0.71^{a}	0.56±0.01^{a}	33.67±1.41^{bc}	2.20±0.14^{ab}	9.27±0.37^{b}	4.00±0.00^{a}	5.50±0.00^{d}
E	3.19±0.00^{b}	1.43±0.11^{a}	0.56±0.01^{a}	32.33±1.41^{bc}	2.10±0.14^{b}	10.04±1.07^{ab}	4.00±0.00^{a}	5.60±0.00^{c}
F	2.39±0.57^{c}	1.30±0.04^{a}	0.55±0.01^{a}	34.67±0.94^{bc}	2.25±0.21^{ab}	10.13±1.56^{a}	4.00±0.00^{a}	5.70±0.00^{b}
G	2.59±0.28^{c}	1.21±0.04^{a}	0.55±0.01^{a}	28.00±0.00^{d}	2.05±0.07^{b}	11.11±0.57^{ab}	4.00±0.00^{a}	5.80±0.00^{a}

Mean Values are of duplicate determination. Mean values within a column with the same superscript are not significantly different (p>0.05).
Key: A = Orange-fleshed sweet potato/Plantain/Soybean (100:0:0); B = Orange-fleshed sweet potato/Plantain/Soybean (90:10:0); C = Orange-fleshed sweet potato/Plantain/Soybean (90:0:10); D = Orange-fleshed sweet potato/Plantain /Soybean (80:10:10); E = Orange-fleshed sweet potato/Plantain /Soybean (70:15:15); F = Orange-fleshed sweet potato/Plantain /Soybean (60:20:20); G = Orange-fleshed sweet potato/Plantain /Soybean (50:25:25)

Table 2. Proximate composition of extruded breakfast strips produced from orange-fleshed sweet potato, plantain and soybean flour blends

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	Carbohydrate (%)	Energy (Kcal)
A	7.50±0.42^{b}	2.64±0.35^{ab}	5.62±0.15^{a}	4.87±0.00^{e}	0.69±0.00^{d}	78.70±0.93^{a}	384.80±2.37^{a}
B	9.40±0.28^{a}	2.93±0.63^{a}	2.65±0.12^{d}	5.28±0.00^{e}	1.28±0.01^{cd}	78.49±1.03^{a}	358.87±3.02^{cd}
C	7.40±0.00^{b}	2.19±0.01^{c}	4.58±0.06^{b}	7.89±0.00^{bc}	1.22±0.05^{cd}	76.73±0.11^{b}	379.66±0.12^{a}
D	7.25±0.07^{b}	2.67±0.28^{ab}	2.52±0.02^{d}	7.73±0.68^{c}	5.14±1.68^{a}	74.70±1.22^{cd}	352.36±7.39^{d}
E	7.25±0.07^{b}	2.59±0.00^{ab}	3.21±0.28^{d}	8.33±0.00^{b}	2.60±0.42^{bc}	76.04±0.08^{bc}	366.26±2.86^{bc}
F	7.55±0.21^{b}	2.28±0.13^{b}	4.06±0.10^{c}	9.56±0.00^{a}	2.66±0.22^{bc}	73.92±0.40^{d}	370.44±0.72^{b}
G	7.70±0.01^{b}	2.39±0.13^{b}	4.33±0.57^{b}	9.99±0.00^{a}	3.35±0.74^{b}	72.25±0.66^{e}	367.93±2.15^{b}
H	9.20±0.28^{a}	2.35±0.64^{b}	0.58±0.01^{e}	6.62±0.00^{d}	1.20±0.71^{cd}	80.06±0.28^{a}	351.90±1.07^{d}

Mean values are of duplicate determination. Mean values within a column with the same superscript are not significantly different (p>0.05).
Key: A = Orange-fleshed sweet potato/Plantain/Soybean (100:0:0); B = Orange-fleshed sweet potato/Plantain/Soybean (90:10:0); C = Orange-fleshed sweet potato/Plantain/Soybean (90:0:10); D = Orange-fleshed sweet potato/Plantain /Soybean (80:10:10); E = Orange-fleshed sweet potato/Plantain /Soybean (70:15:15) F = Orange-fleshed sweet potato/Plantain /Soybean (60:20:20); G = Orange-fleshed sweet potato/Plantain /Soybean (50:25:25) H = Control (Flakes

Table 3. Total carotene and vitamin properties of extruded breakfast strips produced from orange-fleshed sweet potato, plantain and soybean flour blends

Samples	Total Carotene (mg/kg)	Vitamin B_2 (mg/kg)	Vitamin B_6 (mg/kg)
A	33.56±0.20^{a}	4.70±0.04^{a}	7.20±0.02^{d}
B	26.26±0.06^{b}	4.00±0.02^{ab}	8.60±0.03^{c}
C	25.73±0.64^{b}	3.40±0.01^{b}	4.30±0.02^{f}
D	22.05±0.06^{c}	3.40±0.01^{b}	4.90±0.01^{f}
E	20.08±0.06^{c}	3.40±0.01^{b}	8.00±0.01^{c}
F	17.32±0.13^{d}	3.30±0.03^{b}	11.00±0.01^{b}
G	15.18±0.03^{d}	3.30±0.01^{b}	12.10±0.04^{a}
H	0.75.±0.00^{e}	3.60±0.06^{b}	6.00±0.01^{e}

Mean values are of duplicate determination. Mean values within a column with the same superscript are not significantly different (p>0.05).
Key: A = Orange-fleshed sweet potato/Plantain/Soybean (100:0:0); B = Orange-fleshed sweet potato/Plantain/Soybean (90:10:0); C = Orange-fleshed sweet potato/Plantain/Soybean (90:0:10); D = Orange-fleshed sweet potato/Plantain /Soybean (80:10:10); E = Orange-fleshed sweet potato/Plantain /Soybean (70:15:15)
F = Orange-fleshed sweet potato/Plantain /Soybean (60:20:20); G = Orange-fleshed sweet potato/Plantain /Soybean (50:25:25)
H = Control (Flakes)

Table 4. Sensory properties of extruded breakfast strips produced from orange-fleshed sweet potato, plantain and soybean flour blends

Sample	Colour	Flavour	Crispiness	Taste	Mouthfeel	Overall Acceptability
A	4.15±0.81^{a}	4.05±1.00^{a}	4.25±0.85^{ab}	4.20±0.70^{a}	3.90±0.72^{b}	4.20±0.62^{ab}
B	3.90±1.07^{a}	3.90±0.72^{a}	4.55±0.83^{ab}	4.30±0.66^{a}	4.25±0.85^{ab}	4.35±0.49^{ab}
C	4.30±0.73^{a}	3.70±1.03^{a}	3.60±0.99^{c}	3.90±0.97^{a}	3.80±0.77^{b}	4.00±0.65^{b}
D	4.00±0.97^{a}	3.83±0.75^{a}	4.30±0.86^{ab}	4.05±0.89^{a}	4.15±0.67^{ab}	4.30±0.57^{ab}
E	4.15±0.67^{a}	4.15±0.59^{a}	4.50±0.61^{ab}	4.20±0.83^{a}	4.10±0.79^{ab}	3.90±0.79^{b}
F	4.20±0.62^{a}	4.05±0.76^{a}	4.60±0.60^{ab}	4.15±0.67^{a}	4.20±0.70^{ab}	4.20±0.52^{ab}
G	4.15±0.75^{a}	3.85±0.88^{a}	4.10±0.72^{b}	4.15±0.67^{a}	4.00±1.03^{ab}	3.95±0.69^{b}
H	4.45±0.76^{a}	3.90±1.12^{a}	4.75±0.55^{a}	4.40±0.82^{a}	4.55±0.69^{a}	4.50±0.69^{a}

Mean values within a column with the same superscript are not significantly different (p>0.05)
Key: A = Orange-fleshed sweet potato/Plantain/Soybean (100:0:0); B = Orange-fleshed sweet potato/Plantain/Soybean (90:10:0); C = Orange-fleshed sweet potato/Plantain/Soybean (90:0:10); D = Orange-fleshed sweet potato/Plantain /Soybean (80:10:10); E = Orange-fleshed sweet potato/Plantain /Soybean (70:15:15)
F = Orange-fleshed sweet potato/Plantain /Soybean (60:20:20); G = Orange-fleshed sweet potato/Plantain /Soybean (50:25:25)
H = Control (Flakes)

1.70 mg/kg [24]. The vitamin B_6 content of the breakfast strips ranged from 4.30-12.10 mg/kg which was higher than the US RDA of 2.0 mg/kg. The reasons for the high content could be attributed to the composite flour blends used in the product formulation. Vitamin B_6 helps in building strong immune system, aids in blood formation and also increases the amount of oxygen transported by the blood [25].

3.4 Sensory Properties of Strips

The sensory scores of the breakfast strips are presented in Table 4. There was no significant difference ($p>0.05$) in colour among all the samples. This might be attributed to the distinctive colour of orange-fleshed sweet potato evident in all samples. Sample H had the best mean score of 4.45 followed by sample C with a mean of 4.30. Sample F had a mean score of 4.20 while samples A, E and G had same mean score of 4.15. Samples D had a mean of 4.00 while sample B had the least mean score of 3.90. As regards to flavour, there was no significant difference ($p>0.05$) in all the samples analyzed. Sample E had the highest mean score of 4.15 while sample C had the least of 3.70. The mean scores for crispiness showed that there was a significant difference ($p<0.05$) among the samples. Sample H (4.75) was most preferred while sample C (3.60) was least preferred.

Sample H (4.40) was more preferred for taste while sample C (3.90) was least preferred. The results indicated that there was no significant difference ($p>0.05$) among the samples. As regards to mouthfeel, sample C (3.80) was least preferred while sample H (4.55) was most preferred. Significant difference ($p<0.05$) existed among the samples. Sample B had the second best score of 4.25 followed by 4.20 for sample F. Samples D, E and G had mean scores of 4.15, 4.10 and 4.00, respectively. The result of the overall acceptability showed that sample H (4.50) was more preferred followed by sample B (4.35) while E (3.90) was least preferred.

4. CONCLUSION

Breakfast strips were successfully produced from the blends of orange-fleshed sweet potato, plantain and soybean flours. The flour blends recorded good functional properties. The produced breakfast strips were higher in protein and compared favourably with the control. The protein, fat and energy content were higher than the commercial flakes used as control. The control also contained the least amount of total carotene. The presence of vitamins B_2 and B_6 in the produced breakfast strips was within acceptable limits. Blends with 15, 20 and 25% substitution levels improved the nutrient composition of the products. The overall acceptability of the samples produced compared favourably with the control. Production of breakfast foods with these raw materials should be encouraged. This will create a healthier substitute compare to other commercially available breakfast foods and will also help in the utilization of orange-fleshed sweet potato. Further studies on anti-nutritional properties, amino acid profile and mineral bioavailability should be carried out.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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