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Assessment of some attributes of unripe cooking banana (*Cardaba Musa ABB*), pigeon pea (*Cajanus cajan*) and orange fleshed sweet potato (*Ipomoea batatas*) flour blends for use as complementary feeding

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ABSTRACT

This study assessed the nutrient composition, physicochemical, functional and sensory properties of flour blends prepared from cooking banana, pigeon pea and orange fleshed sweet potato flour blends for use as complementary food. Fourteen blends were generated using the simplex centroid mixture design. All data obtained were subjected to analysis of variance and the mean values were separated using Duncan's Multiple Range Test. The protein, crude fibre, crude fat, ash and carbohydrate of the blends were significantly ($p \leq 0.05$) different with values ranging from 10.60-21.65%, 0.36-1.24%, 1.2-1.43%, 0.77 - 2.25% and 65.86 -75.36%, respectively. There was no significant ($p \leq 0.05$) difference in the moisture content, total carotenoid content and pH value of the blends. The L* value (40.77 to 45.25) showed no significant ($p \leq 0.05$) difference while the redness (a*) and yellowness (b*) value were significantly ($p \leq 0.05$) different with values ranging from 2.32 - 4.59 and 11.88 - 15.88 respectively. There was a significant ($p \leq 0.05$) difference in the bulk density (0.73 – 0.78 g/ml), water absorption capacity (122.05-178.10%), swelling power (6.21 - 8.48%) and solubility (3.77-7.30%) values. Gruels obtained from the flour blends had sensory scores of above 6.00 (on a 9-point Hedonic scale), signifying high acceptability for all the sensory attributes evaluated.

Introduction

Hunger and malnutrition remain among the most devastating problems facing majority of the world's population and continue to dominate the health of the world's health poorest nations. In many developing countries including Nigeria, protein energy malnutrition (PEM) is endemic (Twum et al., 2015). The PEM is found to be more frequent among children because they are weaned abruptly into starchy foods.
Inadequate intake of proteins in developing countries has led to various forms of malnutrition in both children and adults (Ijarotimi and Oluwalana, 2013). It has been reported that in developing countries such as Nigeria protein malnutrition persists as a principal health problem among children below the age of five (UNICEF, 2009). Therefore, the need to find inexpensive sources of protein food of good quality cannot be over emphasized. The protein calorie sources of vegetable origin have been proposed as a solution to this problem (UNICEF, 2009).
According to Daelmans and Saadeh (2003), complementary feeding is the gradual withdrawal of breast-milk and introduction of other foods such as semi-solid or solid foods. This transition period is often associated with high prevalence of malnutrition in many African children below 5 years of age due to poor quality of complementary foods. According to Brown et al. (1998), the amounts of some nutrients needed in complementary foods for a child aged 6 months and above who consumes average amount of breast-milk are: energy 50-70%; protein 20-45%;

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vitamin A 5-30%; thiamine 50-80%; riboflavin 50-65%; calcium 60%; zinc 85% and iron 100%.

The commercially standardized complementary food is generally very good and helps meet the nutritional requirements of young children both in developing and developed countries (Amagloh et al., 2012). However, the development of low cost, high protein complementary food supplements for weaning infants is a constant challenge for developing countries where traditional foods used during the weaning process are frequently characterized by low nutrient density and high bulk which can adversely affect infant's health (Obiakor-Okeke et al., 2014). Hence the need for further research into the use of available crops such as cooking banana, pigeon pea and sweet potato for the production of high nutrient dense semi-solid food product.

Cooking banana (*Cardaba Musa* ABB) is an under-utilized banana variety. It is predisposed to rapid postharvest spoilage due to its physiological metabolic activities and high moisture content (Ayo-Omogie et al., 2010). Unripe cooking banana flour contains 73.4 % total starch content, 17.5 % resistant starch content, 14.5 % dietary fibre (Ayo-omogie and Ogunsakin, 2013). It is a known source of polyphenols and antioxidants. It is rich in vitamins A and C and minerals such as phosphorous, potassium, magnesium, selenium and iron (Ayo-omogie and Ogunsakin, 2013). Studies have shown that banana flour can be used to produce food (biscuits, spaghetti etc.) for the health challenged groups such as celiac, diabetic and cardiovascular patients (Adeyemi et al., 1991; FAO, 1995; Okezie et al., 2003; Adeniji et al., 2006; Ovando-Martinez et al., 2009).

Pigeon pea (*Cajanus cajan*) is one of the oldest food crops known to mankind, ranked 6th in importance among edible legumes of the world (Salunkhe et al., 1986; Syed and Wu, 2018). It is a rich source of protein (17-30%), carbohydrates, dietary minerals and soluble vitamins making it an ideal raw material for producing complementary foods (Salunkhe et al., 1986; Okpala and Mamah, 2001; Onu and Okongwu, 2006).

Orange fleshed sweet potato (*Ipomoea batatas*) is an untapped food resource that can serve as source of vitamins (especially vitamin A, C and E), minerals (iron, zinc and manganese), carbohydrate, polyphenols and carotenoids. These nutrients have biological and antioxidant properties of interest to human needs (Obiakor-Okeke et al., 2014). Sweet potatoes are mostly consumed in Nigeria as a snack, roasted, boiled, used with fresh yams in pounded yam and as a sweetener in beverage production. Processing sweet potato into flour could increase its utilization. Several researchers reported that addition of sweet potato flour contributes to the flavour, colour and dietary fibre of processed food products (Woolfe, 1992; Hagenimana et al., 1998).

In view of the aforementioned, the blending of flours from cooking banana, pigeon pea and orange fleshed sweet potato should help in alleviating malnutrition cases in children. This study, therefore, explored the possibility of processing a complementary food from the composite flour of unripe cooking banana, orange fleshed sweet potato and pigeon pea by assessing the nutrient composition, physicochemical, functional and sensory attributes of the blends.

Materials and method

Source and collection of materials

Sweet potato root (orange fleshed variety) was purchased from the Directorate of University Farms, Federal University of Agriculture, Abeokuta Nigeria. Pigeon pea was gotten from Kuto market, Abeokuta, Ogun State, Nigeria. Unripe cooking banana was purchased from Osiele market in Abeokuta, Ogun State, Nigeria.

Preparation of unripe cooking banana flour (UBF)

A modified method of Daramola and Osanyinlusi (2006) was used. Unripe cooking banana was sorted. The sorted fingers were washed and peeled. The banana fingers were thinly sliced and soaked in 0.3% w/v citric acid to minimise browning, for 10 minutes. They were drained and dried using cabinet dryer at 60°C to a constant weight. The banana chips were milled using a local milling machine, sieved into fine flour (250 μm) and packaged in LDPE bag for further use.

Production of orange fleshed sweet potato flour (OFSPF)

A modified method of Singh et al. (2007) was used. Sweet potato roots were sorted, peeled, and washed to remove adhering soil and dirt. The roots were washed, peeled and sliced. The slices were dried at 60 ºC for 5 h in a cabinet dryer, milled using a local milling machine, sieved (250 μm) into fine flour and packaged (LDPE) for further use.

Production of pigeon pea flour (PPF)

A modified method of Fasoyiro et al. (2010) was used. Pigeon pea seeds were sorted and cleaned to remove all contaminants such as stones, and pod fragments, etc. after which it was parboiled for 20 minutes. It was drained, and the seeds were broken using Philips blender (model HR 3868/90), and the seed coats were removed. The dehulled peas were dried in an oven at 60°C for 5 h. The seeds were milled into fine flour using a local mill, sieved (250 μm) and packaged in a LDPE bag.

Formulation of flour composite blends

As shown in Table 1, the simplex centroid mixture design (Sahin et al., 2016) was used to prepare the various mixtures of the three flours. The flours were thoroughly mixed to obtain a homogenous blend.

Analysis of composite flour

Proximate composition: The proximate analysis of the flour blend samples was carried out according to the procedures described by the Association of Official Analytical Chemist (AOAC, 2010).

Energy content: Energy content was determined by using the calculation

Energy content = (Protein x 4.0 + Fat x 9.0 + Carbohydrate x 4.0)

pH

The pH levels of composite flour blend was determined with glass electrode pH meter. The pH meter was first calibrated with buffer pH 4 and 7 by placing the electrode in each buffer and rinsing before placing in test samples. About 10g of the sample was dissolved in 100ml of distilled water. The mixture was allowed to equilibrate for 3minutes at room temperature and the pH was determined.

Total carotenoid content

The total carotenoid content was determined by the method described by Chan and Cavaletto (1982) using UV/Visible spectrophotometer (Model: CE 2021 2000 series, serial no 923-41). About 30 g flour was mixed with about 5 g of hyflosupercel (celite, a filtration aid) and 75 ml of 70% methanol (v/v), and filtered through a Buchner funnel with filter paper. The residue was extracted two more times with 75 ml acetone-petroleum ether 1:1 (v/v). The extracts were then transferred to 500 ml separatory funnel. About 25 ml of 10% KOH in methanol (v/v) was added and the mixture allowed to stand for 1.5 hours. Partition was achieved by adding 75 ml of petroleum ether and 100 ml of 20% NaCl (w/v), and mixing gently. The hypophasic (lower) layer was discarded. The epiphasic (upper) layer was washed three times with 200 ml of distilled water to remove excess acetone, filtered through a small funnel containing about 15 g anhydrous sodium sulphate to remove residual water. The funnel was plugged with glass to hold the sodium sulphate. The filtrate was made up to 250 ml with petroleum ether and the absorbance measured at 450nm, the wavelength of maximum absorption for β-carotene in petroleum ether (Rodriguez-Amaya and Kimura, 2004). The total carotenoids were expressed as β-carotene equivalents (µg/100 g) of fresh weight.

Calculation:

$$Total\ carotenoids\ content\ (\mu g/100g) = \frac{A \times Volume\ (mL) \times 10^4}{A_{1cm}^{1\%}\ \text{X Weight of sample}} \quad (1)$$

Where:

A =Absorbance,

Volume = total volume of extract and

$A_{1cm}^{1\%}$ = Absorption coefficient of β-carotene in petroleum ether (2,592).

Table 1. Mixture blends of unripe cooking banana, pigeon pea and orange fleshed sweet potato flour blends

Formulation ID	UBF (%)	PPF (%)	OFSPF (%)
A	10	80	10
B	45	45	10
C	10	10	80
D	21.67	56.67	21.67
E	45	10	45
F	10	45	45
G	10	10	80
H	33.33	33.33	33.33
I	56.67	21.67	21.67
J	10	80	10
K	80	10	10
L	45	10	45
M	80	10	10
N	21.67	21.67	56.67

Where UBF= Unripe cooking banana Flour; PPF = Pigeon pea Flour; OFSPF = Orange Fleshed Sweet potato flour; UBF + PPF + OFSPF = 100%

Colour

Colour measurements of the flour samples were carried out in triplicate using Colorimeter chroma meter (model CR-400/410) on the basis of L*, a* and b* values according to Kaushal et al. (2012). The instrument was calibrated against a standard white-coloured reference tile. A glass cell containing flour was placed above the light source, covered with white plate and L*, a* and b* colour values were recorded.

Bulk density

This was determined according to the method described by Adeleke and Odedeji (2010). A known weight of sample was put into a 100 mL graduated measuring cylinder and tapped several times on a laboratory bench to a constant volume. The bulk density was taken as the weight of the sample divided by the volume of sample after tapping.

Water absorption capacity (WAC)

It was determined according to the method described by Ruales et al. (1993). About 1.25 g sample was suspended in 15 mL distilled water, and centrifuged at 2,500 rpm for 30 min. The supernatant was decanted, and the weight of the sediment recorded. The water absorption capacity was taken as the sediment weight per sample weight.

Swelling power and solubility indeks

These were determined according to the method described by Julianti et al. (2017). About 1 g sample in a centrifuge tube was mixed with 50 mL distilled water and heated at 90 °C for 15 min, with frequent shaking during heating in order to prevent clumping of flour. The tube with its content was centrifuged at 3,000 rpm for 10 min. The supernatant was decanted immediately after centrifugation and dried to constant weight. The weight of the sediment was also taken.

Solubility power = (weight of starch paste/ weight of dry starch sample) x 100 (2)

Solubility = (weight of solid after drying/initial weight of sample) x 100 (3)

Sensory evaluation

Gruels were prepared by mixing each of the flour blends with cold water at a ratio of 1:10 (w/v). This mixture was stirred into 100 mL of boiling water for about 5 min. The gruels were dished into coded plates and served to 50 nursing mothers. The nursing mothers were requested to assess the sensory properties of the gruels using a 9-point Hedonic scale, according to the method of Iwe (2002). Attributes such as colour, texture, aroma, taste, and overall acceptability were evaluated.

Statistical analysis

Data obtained were subjected to analysis of variance (ANOVA) and means were separated using Duncan’s Multiple Range Test at 5% level using the statistical package for special sciences (SPSS) version 16.0 (SPSS Inc. Chicago, IL).

Results

There were significant ($p<0.05$) differences in the proximate composition of the flour blends from unripe cooking banana, pigeon pea and orange fleshed sweet potato as presented in Table 2. The values ranged from 10.30 to 21.70%, 0.36 to 1.24%, 1.20 to 1.43%, 0.75 to 2.68%, 65.85 to 75.68% for protein, crude fibre, fat, ash and carbohydrate, respectively but no significant ($p<0.05$) difference was observed for moisture content (8.42 - 10.21%) of the complementary food.

Energy content which was significantly ($p<0.05$) different for all the samples ranged from 324.96 kcal in 10:10:80 (UBF:PPF:OFSPF) blend to 389.69 kcal in 21.67:56.67:21.67 (UBF:PPF:OFSPF) blend . There was no significant ($p\leq0.05$) difference in the total carotenoid (which ranged from 0.01 to 0.13 μg/100g) of the composite flour. The pH values of the blends which ranged from 5.1 to 6.7 did not vary significantly ($p\leq0.05$), except for 80:10:10 and 21.67:56.67:21.67 (UBF:PPF:OFSPF) blends (Table 3).

The colour of the flour blends prepared from cooking banana, pigeonpea and orange fleshed sweetpotato is shown in Table 4. The lightness (L*) of the flour blends were not significantly ($p\leq0.05$) different with values that ranged from 40.77 to 45.25 in which 80:10:10 (UBF:PPF:OFSPF) blend had the highest and 10:10:80 (UBF:PPF:OFSPF) blend had the lowest L*. The redness (a*) and yellowness (b*) of the flour blends were significantly ($p\leq0.05$) different with values that ranged from 2.32 to 4.59 and 11.88 to 15.88 respectively. The highest a* and b* values were observed in 80:10:10 (UBF:PPF:OFSPF) blend and 21.67:21.67:56.67 (UBF:PPF:OFSPF) blend, respectively. Composite flour from 21.67:21.67:56.67 (UBF:PPF:OFSPF) had the lowest a* while 33.33:33.33:33.33 (UBF:PPF:OFSPF) blend had the lowest b*.

Table 2. Proximate composition of composite flour of cooking banana, pigeon pea and orange fleshed sweet potato

Sample	Protein (%)	Crude Fibre (%)	Crude Fat (%)	Ash (%)	Carbohydrate (%)	Moisture (%)
A	21.70±0.14^{c}	0.36±0.01^{a}	1.37±0.01^{b}	0.75±0.06^{a}	66.46±0.23^{a}	9.36±0.03^{a}
B	19.55±0.21^{c}	1.10±0.00^{b}	1.27±0.01^{a}	2.30±0.14^{c}	65.85±0.37^{a}	9.94±0.03^{a}
C	12.58±0.03^{b}	1.23±0.01^{b}	1.27±0.01^{a}	1.80±0.00^{b}	74.53±0.09^{b}	8.63±0.03^{a}
D	18.93±0.04^{b}	0.75±0.01^{a}	1.25±0.01^{a}	2.00±0.00^{bc}	75.68±0.00^{b}	9.39±0.02^{a}
E	10.60±0.14^{a}	1.11±0.01^{b}	1.20±0.00^{a}	2.25±0.07^{c}	75.35±0.11^{b}	9.49±0.02^{a}
F	20.35±0.07c	0.64±0.01^{a}	1.43±0.02^{b}	1.91±0.01^{b}	67.25±0.12^{ab}	8.42±0.03^{a}
G	12.59±0.04a	1.24±0.01^{b}	1.24±0.01^{a}	2.32±0.15^{c}	65.86±0.38^{a}	9.95±0.03^{a}
H	19.37±0.66^{bc}	1.04±0.02^{b}	1.33±0.01^{b}	2.13±0.03^{c}	67.78±0.62^{ab}	8.37±0.01^{a}
I	16.30±0.14^{b}	1.10±0.02^{b}	1.21±0.01^{a}	2.20±0.00^{b}	68.99±0.12^{ab}	10.21±0.27^{a}
J	21.65±0.07^{c}	0.37±0.01^{a}	1.36±0.01^{b}	0.77±0.06^{a}	66.46±0.24^{a}	9.38±0.00^{a}
K	10.30±0.14^{a}	1.12±0.01^{b}	1.30±0.01^{b}	2.18±0.02^{c}	75.22±0.16^{b}	9.88±0.06^{a}
L	10.62±0.13^{a}	1.12±0.02^{b}	1.22±0.01^{a}	2.27±0.07^{c}	75.36±0.11^{b}	9.49±0.03^{a}
M	18.45±0.07^{b}	1.20±0.01^{b}	1.24±0.01^{a}	2.68±0.04^{c}	66.57±0.11^{a}	9.87±0.01^{a}
N	10.32±0.14^{a}	1.12±0.01^{b}	1.32±0.01^{a}	2.20±0.03^{c}	75.23±0.16^{b}	9.89±0.04^{a}

Means within the same column with different superscripts are significantly different at p≤0.05

Table 3. Energy content, pH and total carotenoid content of composite flour of cooking banana, pigeon pea and orange fleshed sweet potato

Sample	Energy content (Kcal)	Total carotenoid (μg/100g)	pH
A	364.97^{m}	0.10±0.001^{a}	5.55±0.07^{a}
B	353.03^{d}	0.08±0.01^{a}	5.45±0.07^{a}
C	359.87^{i}	0.11±0.01^{b}	5.60±0.14^{a}
D	389.69^{n}	0.01±0.01^{a}	6.70±0.14^{b}
E	354.60^{g}	0.01±0.00^{a}	5.80±0.14^{a}
F	363.27^{k}	0.01±0.01^{a}	5.50±0.03^{a}
G	324.96^{a}	0.11±0.01^{b}	5.62±0.14^{a}
H	360.57^{j}	0.13±0.01^{b}	5.80±0.00^{a}
I	352.05^{c}	0.02±0.01^{a}	5.30±0.00^{a}
J	364.68^{l}	0.10±0.01^{a}	5.56±0.07^{a}
K	353.78^{e}	0.01±0.01^{a}	6.50±0.01^{b}
L	354.90^{h}	0.01±0.00^{a}	5.10±0.16^{a}
M	351.24^{b}	0.01±0.01^{a}	5.65±0.10^{a}
N	354.08^{f}	0.01±0.01^{a}	6.52±0.01^{b}

Means within the same column with different superscripts are significantly different at p≤0.05

Table 4. Colour of composite flour of cooking banana, pigeon pea and orange fleshed sweet potato

Sample	L*	a*	b*
A	45.09±1.78^{a}	2.52±0.25^{a}	11.88±0.40^{a}
B	42.42±4.35^{a}	3.31±0.79^{ab}	12.00±2.25^{a}
C	45.25±1.50^{a}	2.55±0.15^{a}	13.55±1.20^{a}
D	40.71±1.93^{a}	4.58±0.52^{b}	13.25±1.03^{a}
E	41.99±1.02^{a}	3.72±0.63^{c}	13.76±0.93^{a}
F	43.11±2.32^{a}	3.20±0.05^{ab}	13.49±2.08^{a}
G	44.09±1.75^{a}	2.58±0.25^{a}	14.67±0.43^{b}
H	45.44±1.78^{a}	2.57±0.35^{a}	11.54±0.44^{a}
I	42.65±4.35^{a}	3.51±0.79^{ab}	13.00±2.21^{a}
J	45.35±1.57^{a}	2.55±0.17^{a}	12.55±1.23^{a}
K	40.77±1.93^{a}	4.59±0.52^{b}	13.26±1.03^{a}
L	42.29±1.32^{a}	3.76±0.73^{c}	13.67±0.73^{a}
M	43.11±2.12^{a}	3.20±0.15^{ab}	13.59±2.08^{a}
N	45.19±1.18^{a}	2.32±0.45^{a}	15.88±0.45^{b}

Means within the same column with different superscripts are significantly different at p≤0.05

There was a significant ($p<0.05$) difference in the selected functional properties of the flour blends as presented in Table 5. Bulk density ranged from 0.73 to 0.78 g/mL, WAC ranged from 122.05 to 178.10%, swelling power ranged from 6.21 to 8.48% and solubility index was between 3.77 and 7.30%.

Table 5. Functional properties of composite flour of cooking banana, pigeon pea and orange fleshed sweet potato

Sample ID	Bulk density (g/mL)	WAC (%)	Swelling power (%)	Solubility (%)
A	0.73^{b}	156.15^{ab}	8.48^{a}	7.30^{a}
B	0.75^{ab}	142.60^{bc}	8.09^{b}	7.20^{b}
C	0.74^{ab}	178.10^{a}	4.65^{g}	3.77^{j}
D	0.75^{ab}	152.95^{abc}	7.33^{c}	6.79^{c}
E	0.75^{ab}	132.45^{bc}	7.20^{d}	6.33^{d}
F	0.74^{ab}	163.20^{ab}	6.36^{e}	5.50^{g}
G	0.75^{ab}	178.10^{a}	4.65^{g}	3.77^{j}
H	0.78^{a}	142.65^{bc}	6.21^{f}	5.67^{f}
I	0.78^{a}	122.05^{c}	7.30^{cd}	6.09^{c}
J	0.74^{ab}	156.15^{ab}	8.48^{a}	7.30^{d}
K	0.78^{a}	152.31^{ab}	7.21^{cd}	5.31^{b}
L	0.75^{ab}	132.45^{bc}	7.20^{cd}	6.33^{d}
M	0.78^{a}	145.50^{abc}	7.26^{cd}	5.10^{i}
N	0.78^{a}	152.30^{abc}	7.21^{cd}	5.32^{b}

Means within the same column with different superscripts are significantly different at p≤0.05` Where: WAC – Water Absorption Capacity

Table 6. Sensory scores of cooked gruel prepared from composite flour of cooking banana, pigeon pea and orange fleshed sweet potato

Sample	Colour	Texture	Aroma	Taste	Overall acceptability
A	8.10^{b}	7.40^{h}	6.40^{gh}	6.70^{def}	7.20^{f}
B	7.80^{c}	6.60^{b}	6.70^{c}	7.50^{b}	7.40^{h}
C	8.70^{a}	6.70^{c}	6.70^{f}	6.70^{def}	8.00^{i}
D	7.50^{f}	6.60^{b}	7.50^{b}	7.10^{c}	6.80^{b}
E	7.70^{d}	7.60^{i}	6.40^{gh}	6.80^{d}	7.30^{g}
F	7.00^{i}	7.00^{f}	6.60^{f}	6.50^{f}	6.70^{a}
G	7.70^{d}	6.80^{d}	7.00^{d}	7.00^{d}	7.00^{d}
H	7.30^{b}	6.90^{c}	6.40^{gh}	6.20^{g}	6.70^{a}
I	7.00^{i}	6.60^{b}	6.40^{gh}	6.60^{ef}	6.70^{a}
J	7.50^{fg}	6.80^{d}	6.20^{i}	8.30^{a}	6.90^{c}
K	7.00^{i}	6.40^{a}	7.70^{a}	7.00^{c}	7.00^{d}
L	7.40^{g}	7.91^{j}	6.30^{hi}	6.60^{ab}	7.10^{e}
M	7.60^{cf}	7.20^{g}	7.40^{b}	6.70^{def}	7.30^{g}
N	7.50^{ef}	6.70^{c}	6.40^{gh}	6.70^{def}	7.00^{d}

Means within the same column with different superscripts are significantly different at p≤0.05

The sensory qualities of gruel samples from cooking banana, pigeonpea and orange fleshed sweetpotato flour blends are shown in Table 6. There was a significant ($p<0.05$) difference in all the sensory attributes evaluated. Sensory scores for with respect to colour, texture, aroma, taste and overall acceptability were 7.70 – 8.70, 6.40 – 7.91, 6.40 – 7.70, 6.50 – 8.30 and 6.70 – 8.00, respectively. Blend from 10:10:80 (UBF:PPF:OFSPF) had the highest overall acceptability.

Discussion

There was a variation in the proximate composition of composite flour as affected by the variation in the percentage inclusion of cooking banana, pigeonpea and orange fleshed sweet potato. Protein content decreased in the formulation as the percentage inclusion of PPF decreased. The range of values obtained for protein in this study was higher than those reported by Mazaher et al. (2011) and Twum et al. (2015) for sorghum - pigeon pea and banana - sweet potato based complementary foods. The amount of protein obtained in this study showed that the composite flours could supply 73.57 to 155% of the recommended dietary intake of protein for 1 to 3 years upon consuming 100 g of complementary food (NHMRS, 2006). Hence, these flour blends could be appropriately used as a cheap means of reducing protein deficiency in school age children. Fibre is important in the diet for enhancing bowel movement, preventing overweight and constipation and reducing the risk of colon cancer (Ayinde et al., 2012). The crude fibre content increased as OFSP and UBF pea increased in the formulation. Banana and sweet potato are good sources of dietary fibre (Ayo-omogie and

Ogunsakin, 2013; Hua et al., 2015) In addition, crude fibre content of infant food is expected to be low (less than 1) as food high in fibre content tends to cause indigestion in babies (Olorunfemi et al., 2006). Hence samples with low fibre content are rated good as potential weaning foods. The low fat content exhibited by the flour blends could be attributed to the low fat content possessed by the individual flours of unripe cooking banana, pigeonpea and orange fleshed potato (Amankwah, et al., 2011). The low fat content observed shows that it will not compromise the keeping qualities of the food.

The ash content of the flour blends increased as the amount of pigeon pea and orange fleshed sweet potato increased in the formulation since pigeonpea and orange fleshed sweetpotato are good sources of minerals (Amarteifio et al., 2006). Carbohydrate content decreased as amount of pigeon pea increased in the formulation.

The moisture contents of the flour blends may signify good storability of the products because milled food products with moisture content less than 13% are more stable from moisture dependent deterioration. High moisture may promote microbial growth and survival especially that of mould and yeast, as well as proliferation of insects which may deteriorate the food during storage (Potter and Hotchkiss, 1995).

The level of the β-carotene in the blends could be attributed to the orange fleshed sweet potato. β-carotene is essential for the development of infants and young children. In sub-Sahara Africa where vitamin A deficiency continues to be a problem, development of a complementary food with high content of β-carotene is essential (Temesgen et al., 2015). The total carotene content obtained in this study was lower than the value reported by Haque et al. (2013) and Bonsi et al. (2014). The variation in colour intensity of complementary food was affected by the increased inclusion of the pigeonpea and orange fleshed sweet potato.

Bulk density increased as the amount of PPF reduced. The high bulk density is not desirable in complementary foods. However, the bulk density may indicate that flour blends are heavy and that they would occupy less space per unit weight. A high bulk density is a good physical attribute when determining the mixing quality of a particular matter and suggests their suitability for use in various food preparations.

Water absorption capacity (WAC) which gives an indication of the amount of water available for gelatinization increased as the amount of OFSPF increased. The observed variation in WAC may also be due to amount of carbohydrate in the flour blends particularly from sweetpotato and cooking banana. Carbohydrates have also been reported to influence water absorption capacity of foods. It may also be due to different protein concentration, their degree of interaction with water and their conformational characteristics (Anthony et al., 2014).

Swelling power increased as the amount of OFSPF decreased and PPF increased. Swelling power usually shows the ability of starch to imbibe water. It usually depends on the temperature, availability of water, amount of fat in a starch sample, species of starch and other carbohydrate and protein (Oppong et al., 2015).

The high solubility (SI) observed in composite flour blends with high inclusion of PPF suggests that composite blends are more digestible and could therefore be suitable for use as ingredient in infant food formulations. SI decreased as the amount OFSPF decreased and PPF increased in the formulation. The amount of lipid in a starch sample can affect its solubility index (Oppong et al., 2015).

The sensory scores for colour of the gruel increased as the percentage inclusion of OFSPF and PPF increased while scores for aroma increased as percentage inclusion of PPF decreased. The variation in the composition of the composite flour had no significant effect on the sensory score for texture and overall acceptability. The entire composite flours had sensory scores of above 6.00 which signify high acceptability for all the sensory attributes evaluated.

Conclusion

The flour blends of cooking banana, pigeon pea and orange fleshed sweet potato could serve as cheap means of improving the protein intake and supplying the energy requirement of children in developing countries. The flour blends exhibited high solubility index, an indication that they could be suitable for use as ingredient in infant food formulations. Gruel prepared from 10% cooking banana flour, 10% pigeon pea flour and 80% orange fleshed sweet potato was the most acceptable by nursing mothers.

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