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ORIGINAL ARTICLE

Quality Characterization of Complementary Food Produced from Orange Flesh Sweet Potato Supplemented with Cowpea and Groundnut Flour

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Abstract

Malnutrition prevalence remains alarming: about 821 million children in the world suffer from severe acute malnutrition, while 2 million children suffer from malnutrition in Nigeria. This study examined the ability of orange flesh sweet potato supplemented (OFSP) with cowpea and groundnut flour to serve as a complementary food. The complementary food was formulated from the flour of Orange flesh sweet potato, cowpea and groundnut to make different blends at different ratios of 50:35:15, 60:25:15, 70:15:15, 80:5:15 and 100% cowpea respectively. The five complementary foods produced were compared with a commercial complementary food brand (Nutrend). The functional properties, proximate composition, anti-nutritional factors, β-carotene and colour parameters of the complementary foods were evaluated. The results obtained showed that the proximate composition of the complementary foods ranged from 4.47 - 15.44% for protein, while the energy value ranged from 349.12 - 383.61 kcal/100 g. These values were slightly higher than the control (Nutrend) but, met the recommended minimum levels for complementary foods by World Health Organization (WHO). Sample AAA (50% OFSP, 35% cowpea and 15% groundnut) had the highest protein content (15.44%) which met 92% of the recommended dietary allowance (16.70%) for infants. Thus, sample AAA could be used with breast milk to help in alleviating protein-energy malnutrition and increase bioavailability of other important micronutrients required by infants.

Practical application

The complementary food produced and observed in this work is made from cheap and locally available raw materials; orange flesh sweet potato, cowpea and groundnut which are readily available. Groundnut has much fat while cowpea is rich in protein and B-vitamins which can be used in alleviating protein energy malnutrition in children and also help to meet their daily energy requirement. The technology of processing can easily be adopted at industrial and household level.

Keywords: Complementary foods, functional foods, proximate, anti-nutritional, malnutrition.

1. Introduction

In developing countries, especially African countries, malnutrition remains a major health problem in infants and pre-school children. Nutrition and lifestyle are important factors in the promotion and maintenance of a good health at every stage of human life cycle. Recently, rapid socioeconomic changes, along with decline in food prices and increased access to foods and urbanization, have resulted in a ''nutritional transition''. Nutrition transition is a shift from primitive mode of nutrition, which is characterized with vegetable consumption to

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more energy-density foods (Popkin, 2001; Astrup *et al.*, 2008; Popkin, 2009). Evidence have shown that nutrition transition is negatively associated with health status, and it is the major factor responsible for the increase in prevalence of diseases like obesity, diabetes, etc. in many countries (Astrup *et al.*, 2008; Popkin, 2009). According to the Food and Agriculture Organization of the United Nations (FAO, 2013), more than 14% of the population in developing countries were undernourished in the period between 2011 and 2013. Malnutrition includes both nutrient deficiencies and excesses and is defined by the World Food Programme as "a state in which the physical function of an individual is impaired to the point where he or she cannot longer maintain adequate bodily performance processes such as growth, pregnancy, lactation, physical work, and resistance to and recovering from disease. It results in disability, morbidity, and mortality, especially among infants and young children (Pelletier, 1994). Malnutrition often begins at the conception, and child malnutrition is linked to poverty, low levels of education, and poor access to health services, including reproductive health and family planning (International Food Policy Research Institute (IFPRI), 2014). Severe acute malnutrition is defined by a very low weight for height (below -3 z scores of the median WHO growth standards) by visible severe wasting (Ciliberto *et al.*, 2005). Undernutrition is mostly associated with developing countries like Nigeria.

Sweet potato (*Ipomoea batatas* L.) ranks seventh among the most important food crops in the world (Tumwegamire *et al.*, 2007). Sweet potatoes are good source of minerals (Luis *et al.*, 2014), carbohydrates, fibre, antioxidants, starch and vitamins (Anderson & Gugerty, 2013). Orange-fleshed sweet potato (OFSP) is rich in beta-carotene, which is a precursor to vitamin A and contributes in alleviating vitamin A deficiency. Sweet potato contains inulin in addition to starch as a carbohydrate reserve (Brecht *et al.*, 2008). Inulin is a soluble, fermentable, non-starch carbohydrate containing fructose as monomers (Brecht *et al.*, 2008). When inulin was added to bread or liquid food in a human feeding trial, it was associated with increased calcium bioavailability (Coudray *et al.*, 1997). Orange fleshed sweet potato was also reported to increase vitamin A intake and serum retinol concentrates in children (Bonsi *et al.*, 2014).

Cowpeas (*Vigna unguiculata*) are probably the most popular grain legume in West Africa. Dry cowpea seeds are important source of protein, B-vitamins and minerals in the predominantly carbohydrate-based diet of people in rural community of Southern Africa (Mwangwela, 2006). Cowpea protein is rich in essential amino acids such as leucine, isoleucine, and lysine, phenylalanine and as such high in both proteins. It also contains some phenolic compounds (Mokgope, 2006).

Groundnut (*Arachis hypogaea*) is the sixth most important oil seed crop in the world. It contains 48-50% oil, 26-28% protein and 11-27% carbohydrate, mineral and vitamin (Mukhtar, 2009). Groundnut is grown on 26.4 million hectares worldwide, with a total production of 37.1 million metric tons and an average productivity of 1.4 metric tons /ha. Developing countries constitute 97% of the global area and 94% of the global production of this crop (FAO, 2011). The production of groundnut is concentrated in Asia and Africa, where the crop is grown mostly by smallholder farmers under rain-fed conditions with limited inputs. The use of cheap and available raw materials with functional properties in the production of complementary food is on the increase. Hence, the objective of this research is to evaluate the nutritional quality of complementary food made from orange-fleshed sweet potato, cowpea and groundnut blends and to determine the anti-nutritional factors in the complementary food.

2. Materials and Methods

2.1. Sources of materials

The orange fleshed sweet potatoes used in this study were bought in November, 2019 from a farm in Agbamu village, Offa, kwara state, Nigeria. The cowpea and the groundnut were obtained from Bodija market in Ibadan, Oyo state, Nigeria while the commercial complementary food (Nutrend) used as the control was purchased in a supermarket in Lagos, Nigeria. All chemical used were of analytical grade.

2.2. Production of Orange-fleshed sweet potato flour

Orange fleshed sweet potato flour was produced by the method described by Eke & Kabari, (2010) with slight modification. The roots were washed under running water to remove soil particles. The cleaned roots were air-dried for 1 h, peeled manually with stainless steel kitchen knife. The peeled roots were sliced into 6 mm thickness and immersed into 0.25% sodium metabisulphite solution to prevent discolouration of the roots, followed by drying at 60 ^{o}C for 18 h in a hot air conventional oven dryer (Plus11 Sanyo Gallenkamp PLC, UK). It was milled into flour using a hammer mill and sieved through a 160 µm aperture screen, to have a uniform size, packed in airtight container and stored in a refrigerator (Model 81739 Munchen, Germany) at -18 °C until usage.

2.3. Production of cowpea flour

Cowpea flour was produced by the method previously described by Olapade *et al.* (2015). Mature and dry cowpea seeds were carefully sorted to remove defective ones, stones and other extraneous matters. The viable seeds were soaked in potable water for just 20 min to soften their seed coat for easy dehulling. The dehulled cowpea was blanched at 60 ^{o}C for 15 min, followed by drying in hot air oven at 65 ^{o}C for 18 h and milled into flour. The flour was sieved through 1500 µm aperture screen. The flour was then packed in polyethylene sachets, sealed and stored in a refrigerator (Model 81739 Munchen, Germany) at -18 °C until usage.

2.4. Production of groundnut flour

Groundnut flour was produced by the method described by Adepeju *et al.* (2014) with slight modification. The matured groundnut was sorted and graded. The viable groundnut was dried in an oven at 70 °C for 6 h, followed by dehulling, milling and sieving through 160µm aperture screen. It was then packed in airtight container and stored in a refrigerator (Model 81739 Munchen, Germany) at -18 °C until usage.

2.5. Formulation of the complementary food

The complementary food was formulated as shown in Table 1. The incorporation of groundnut flour in the blends was fixed at 15% as a result of a previous study conducted by Adenuga (2010), that flavour decreased with increase in peanut flour. The mixture was blended, packaged in high density polythene bags, sealed prior to analysis and stored in a refrigerator (Model 81739 Munchen, Germany) at -18 °C until usage. The samples formulated were compared with a commercial complementary food (Nutrend).

Table 1: Formulation for the complementary food blend (% ratio)

Sample	OFSP	Cowpea	Groundnut
AAA	50	35	15
ABA	60	25	15
ACA	70	15	15
ADA	80	5	15
AGA	100	0	0

OFSP: Orange-fleshed sweet potato flour; AAA: 50% OFSP, 35% Cowpea, 15% Groundnut; ABA: 60% OFSP, 25% Cowpea, 15% Groundnut; ACA: 70% OFSP, 15% Cowpea, 15% Groundnut; ADA: 80% OFSP, 5% Cowpea, 15% Groundnut; AGA: 100% OFSP; AGA: Control (Nutrend)

2.6. Preparation of the complementary food

The complementary food was prepared according to Adenuga (2010). The formulated samples were made into gruel by reconstituting 100 g of the samples in cold potable water; the paste obtained was added to 400 ml of boiling water and cooked for 8 min with continuous stirring.

2.7. Chemical analysis

2.7.1. Determination of proximate composition and energy value of complementary food blends

Proximate composition (moisture content, ash, crude fiber, crude fat and crude protein) of experimental food samples was determined using the standard methods (AOAC, 2012). Carbohydrate content was determined by difference as follow:

Carbohydrate (%) = 100 - (Moisture + Fat + Ash + Crude fibre + Crude protein) %

The gross energy values of the samples were determined (MJ/kg) using Gallenkamp Adiabatic bomb calorimeter (Model CBB-330-01041; UK).

2.7.2. Energy value determination

Energy was determined using Atwater‟s conversion factors (4 x proteins, 9 x fats and 4 x carbohydrates) (Atwater conversion Factor, 1896).

2.8. Functional properties of the complementary food blends

Bulk density was determined according to the previous method described by Asoegwu *et al.* (2006), the swelling power was determined using the procedure of Osundahunsi *et al.* (2003), while water absorption capacity, oil absorption capacity was determined using the method described by Adeleke & Odedeji (2010).

2.9. Determination of anti-nutritional factors of the complementary food blends

Phytate and oxalate content of the samples were determined according to AOAC (2010). While tannin was determined according to the previously described method by Medoua *et al.* (2007).

2.10. Determination of β-Carotene Content of the complementary food blends

β-carotene was determined using the method of Chaturvedi & Nagar (2001). About five grams of the samples was weighed into a separating funnel (250 ml), 2 ml of NaCl solution was introduced into it and shaken vigorously, followed by 10 ml of ethanol, then 20 ml of methane. The mixture was shaken vigorously for 5 min and allowed to stand for 30 min after which the lower layer was run off. The absorbance of the top layer was determined at a wavelength of 460 nm using a Hachdrel/5 model spectrophotometer (England).

$$\text{Total carotenoid (mg/100)} = \frac{\text{Absorbance}}{\text{Specific extinction coefficient} \times \text{path length of cell}} \quad (1)$$

Where, molar extinction coefficient (∑) = 15× 10-4
Specific extinction efficient = ∑ × molar mass of beta carotene
Molar mass of beta-carotene = 536.88 g/mol.
Path length of cell = 1 cm

2.11. Determination of colour of the complementary food blends

A hand-held chromameter CR-310 (Minolta Co. Ltd., Osaka, Japan) was used to determine the colour of flour samples. The chromameter was first calibrated with a white tile. The sample flour was poured to fill a petri dish and then covered. The lens of the chromameter was placed on the petri dish at three different parts. The colour measurements were then taken and recorded as L= darkness/lightness (0 = black, 100 = white), a (-a = greenness and +a = redness), and b (-b = blueness, +b = yellowness).

2.12. Sensory evaluation of the complementary food blends

The cooked samples were evaluated by a 30-member panel selected from the Department of Food Technology, University of Ibadan, Ibadan. A 9-point Hedonic scale was used with 1 representing the least score (Dislike extremely) and 9 the highest score (Like extremely).

2.13. Statistical analysis

Data generated were analyzed using SPSS version 21.0. The mean and standard error of means (SEM) of the triplicate data were analyzed using statistical package. Means were subjected to ANOVA and separated using Duncan New Multiple Range (DNMR) test at $p<0.05$.

3. Results and Discussion

3.1. Functional properties of the complementary flour blends

The functional properties of the samples are revealed in Table 2 and a chart showing the swelling power of the samples at various temperatures is shown in Figure 1. The loose and packed bulk density of the complementary foods ranged between 0.36 to 0.39 g/ml and 0.54 to 0.65 g/ml respectively. The values of the bulk density obtained in this study are comparable with the values for loose bulk density (0.37 to 0.44 g/ml) and packed bulk density (0.50 to 0.63 g/ml) reported by Kolawole *et al.* (2017) for moringa-fortified orange sweet potato complementary food. Nutritionally, loose bulk density promotes easy digestibility and ensure provision of adequate nutrient for children (Osundahunsi & Aworh, 2002). High bulk density reduces the nutrient intake per feed for infants (Ikujenlola *et al.*, 2013), therefore, the low packed bulk density obtained in sample ADA (80% OFSP, 5% Cowpea, 15% Groundnut) (0.54 g/ml) could assist in providing adequate nutrients in smaller volume.

The oil absorption capacity (OAC) of the formulated samples ranged from 3.15 in ABA (60% OFSP, 25% Cowpea, 15% Groundnut) to 3.65 ml/g in AGA (100% OFSP). The values obtained in this study were greater than 0.42 to 0.83 ml/g reported by Kolawole *et al.* (2017). A notable trend was observed, as the concentration of the cowpea decreased the oil absorption increased, the oil absorption could be attributed to retention of flavour by the cowpea.

Table 2: Functional properties (g/ml) of the complementary flour blends

Sample	Loose Bulk density	Packed Bulk density	OAC (ml/g)	WAC (ml/g)
AAA	0.39 ± 0.01^{ab}	0.65 ± 0.01^{a}	3.25 ± 0.21^{d}	2.00 ± 0.14^{d}
ABA	0.38 ± 0.02^{b}	0.61 ± 0.02^{b}	3.15 ± 0.07^{e}	2.15 ± 0.07^{cd}
ACA	0.38 ± 0.00^{b}	0.57 ± 0.00^{bc}	3.35 ± 0.07^{c}	2.45 ± 0.07^{c}
ADA	0.36 ± 0.01^{b}	0.54 ± 0.01^{c}	3.50 ± 0.14^{b}	1.75 ± 0.21^{e}
AGA	0.38 ± 0.01^{b}	0.56 ± 0.00^{c}	3.65 ± 0.49^{a}	2.65 ± 0.21^{a}
AHA	0.42 ± 0.01^{a}	0.52 ± 0.01^{c}	1.95 ± 0.35^{f}	2.60 ± 0.14^{b}

Means (SEM) with different alphabetical superscripts in the same column are significantly different at $P < 0.05$.
OFSP: Orange-fleshed sweet potato flour; AAA: 50% OFSP, 35% Cowpea, 15% Groundnut; ABA: 60% OFSP, 25% Cowpea, 15% Groundnut; ACA: 70% OFSP, 15% Cowpea, 15% Groundnut; ADA: 80% OFSP, 5% Cowpea, 15% Groundnut; AGA: 100% OFSP; AHA: Control (Nutrend)

Water absorption capacity (WAC) is the ability of flour to absorb water and swell, for improved consistency in food. It is desirable for food systems to improve yield and consistency and to give body to the food (Osundahunsi *et al.*, 2003). The water absorption capacity of the samples ranged from 1.75 to 2.65 ml/g. The values are comparable with water absorption values (0.58 to 2.34 ml/g) reported by Ijarotimi & Keshinro

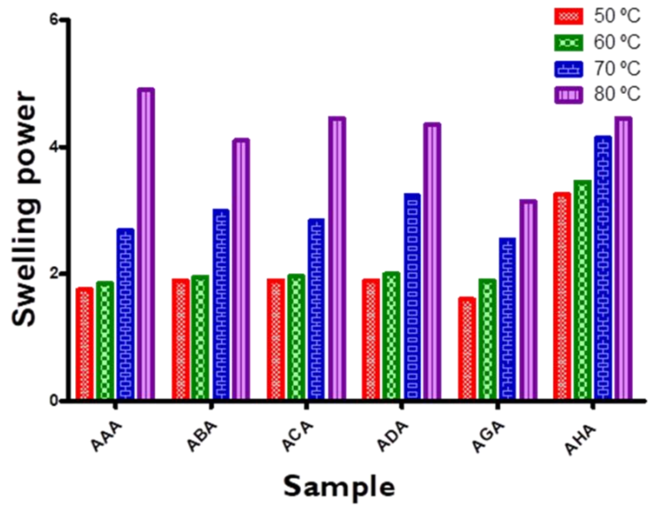

Figure 1: Chart of swelling power of the flour blends at different temperatures

OFSP: Orange-fleshed sweet potato flour; AAA: 50% OFSP, 35% Cowpea, 15% Groundnut; ABA: 60% OFSP, 25% Cowpea, 15% Groundnut; ACA: 70% OFSP, 15% Cowpea, 15% Groundnut; ADA: 80% OFSP, 5% Cowpea, 15% Groundnut; AGA: 100% OFSP; AHA: Control (Nutrend)

(2013). The highest WAC was observed in the sample formulated with 100% OFSP while sample formulated with 80% OFSP, 5% cowpea and 15% groundnut had the lowest water absorption capacity.

The swelling power of the samples was carried out at four different temperatures (50 °C, 60 °C, 70 °C and 80 °C). The values ranged from 1.75 to 1.90, 1.85 to 2.0, 2.55 to 3.25 and 3.15 to 4.90 at 50, 60, 70 and 80 °C respectively. The swelling power increased with the increase of the temperature. The increase observed in swelling power indicates the need for more energy for disruption of strongly bound sites in the starch granule (Henshaw & Adebowale, 2004). The sample formulated with 50% OFSP, 35% cowpea and 15% groundnut had the highest swelling power at 80 °C (5.10) which is greater than the value (4.45) recorded for the control (Nutrend).

3.2. *Proximate composition of the complementary flour blends*

The proximate composition of the complementary food samples is shown in Table 3. The moisture content of the samples ranged from 9.26 in sample AAA (50% OFSP, 35% cowpea, 15% groundnut) to 10.48% and in sample AGA (100% OFSP). This is comparable to the moisture content (7.11-9.40%) for OFSP-sorghum-soybean flour complementary reported by Alawode (2017). The highest moisture content was observed in the complementary food formulated with 100% OFSP while the Control (Nutrend) had the lowest moisture content (2.5%). The moisture content of the samples formulated with 50%, 60%, 70% and 80% OFSP increased as its ratio increases in the blends. Values obtained in this study agreed with the report of Origbemisoye & Ifesan (2019), who reported that low moisture content of flour prevents food spoilage and growth of pathogenic organisms thus, extend the shelf life of the samples.

The protein content of the complementary food ranged from 4.47% in sample formulated with 100% (OFSP) to 15.44% for sample AAA. The protein content (4.47%) of the complementary food formulated with 100% OFSP in this study is comparable to the protein content (4.53%) of OFSP-soybean anchovy powder complementary food earlier reported by Amagloh & Coad (2014). The protein content increased with increase in the level of cowpea flour in the blends. Similar trend was observed by Shakpo & Osundahunsi (2016) in their study involving proximate composition of cowpea enriched maize snack. The study reported that cowpea flour was able to increase the protein content in the maize snack. The values obtained in this study also compare well with the values of 4.37 to 13.13% reported by Kolawole *et al.* (2017) for moringa-fortified orange fleshed sweet potato complementary food. Crude fibre content of the complementary food ranged from 2.63 in AGA to 3.71% in ABA. These values were higher than 0.90 to 0.91% reported by Kolawole *et al.* (2017) for moringa-fortified orange sweet potato complementary food. The values are within the range of less than 5% fibre content recommended for infant feeding (Alvisi *et al.*, 2015). The fat content of the flour blends ranged from 1.34 in AGA to 8.61% in ACA (70% OFSP, 15% cowpea, 15% groundnut). The values obtained in this study were higher than the recommended fat content of not less than 6% for complementary diets (Egounlety, 2002) except for sample AAA. Ash content of the sample ranged from 1.3 to 2.3%. These values are similar ($p<0.05$) with that of moringa-fortified orange sweet potato complementary food (1.14 to 2.55%) reported by Kolawole *et al.* (2017). Ash content is a measure of the mineral composition of foods. They are important in fighting infections and for other metabolic activities in infants (Abidin & Amoaful, 2015). The values obtained in this study indicate that the researched flour blends might contain appreciable amount of important minerals for proper growth and development. Available carbohydrate content was between 61.98 and 79.78%. Starch content in form of carbohydrate is an important factor that determines the textural, rheological and physicochemical properties of sweet potato for industrial applications including the production of complementary foods (Sanoussi *et al.*, 2016). The carbohydrate content increased with increase in the OFSP flour in the blends. The minimum desirable level of energy that complementary foods should provide was suggested to be 370 kcal/100g (on dry weight basis) (Walker, 1990).

Table 3: Proximate composition (%) and energy value of complementary flour blends

Sample	Moisture	Protein	Ash	Crude fibre	Fat	Carbohydrate	Gross Energy (%)
AAA	9.26±0.01^{d}	15.44±0.02^{a}	2.10±0.14^{a}	3.25±0.02^{d}	7.97±0.35^{c}	61.98±0.21^{c}	381.50±0.01^{a}
ABA	9.36±0.02^{c}	13.25±0.01^{c}	1.75±0.07^{c}	3.71±0.02^{b}	8.13±0.38^{bc}	63.80±0.44^{bc}	381.42±0.02^{a}
ACA	9.94±0.02^{b}	12.60±0.03^{d}	1.50±0.14^{c}	3.42±0.03^{c}	8.61±0.18^{b}	63.93±0.33^{bc}	383.61±0.02^{a}
ADA	9.96±0.02^{b}	9.22±0.03^{e}	2.05±0.07^{ab}	3.65±0.03^{b}	8.07±0.52^{bc}	67.05±0.43^{b}	377.76±0.02^{b}
AGA	10.48±0.06^{a}	4.47±0.02^{f}	1.30±0.14^{c}	2.63±0.03^{e}	1.34±0.11^{d}	79.78±0.04^{a}	349.12±0.04^{c}
AHA	2.50±0.00^{e}	15.00±0.00^{b}	2.30±0.00^{a}	7.00±0.05^{a}	9.00±0.00^{a}	64.20±0.00^{bc}	379.82±0.03^{b}

Means (SEM) with different alphabetical superscripts in the same column are significantly different at $P < 0.05$.
OFSP: Orange-fleshed sweet potato flour; AAA: 50% OFSP, 35% Cowpea, 15% Groundnut; ABA: 60% OFSP, 25% Cowpea, 15% Groundnut; ACA: 70% OFSP, 15% Cowpea, 15% Groundnut; ADA: 80% OFSP, 5% Cowpea, 15% Groundnut; AGA: 100% OFSP; AHA: Control (Nutrend)

The samples formulated with 50%, 60%, 70%, and 80% OFSP had higher energy level than 344 Kcal/100 g recommended by FAO/Nutrition (2010). Thus, the formulated complementary food in this study could supply the energy required to sufficiently meet the growth of infants as the stomach size of infants allows them to consume limited amount of foods at a time.

3.3. *Anti-nutritional contents of the complementary flour blends*

Table 4 shows the data obtained for the anti-nutrient contents (Phytate, tannin and oxalate) of the complementary foods. The oxalate content of the complementary foods ranged from 3.94 to 6.19 mg/100 g. The values obtained in this study were higher than the values of complementary foods (0.55 to 0.82 mg/100 g) reported by Ekwere *et al.* (2017). However, the oxalate content of the complementary foods in this study is very low compared with the maximum recommended daily intake of oxalate from food which is 40-50 mg/day (American Dietetic Association, 2005). Foods with oxalate levels greater than 50 mg/100 g are categorized as high oxalate. The oxalate contents in the complementary foods decreased with decrease in the substitution of cowpea in the blends. There was no significant difference in the samples containing 60%, 70%, 80% and 100% OFSP substitution. The phytate contents of the complementary foods ranged from 42.56 mg/100 g in AGA to 61.06 mg/100 g AAA. This is lower than 229.85 mg/100 g level of phytate in OFSP-soybean-anchovy powder reported in a study conducted by Amagloh & Coad (2014). The complementary food formulated in this study could therefore give higher nutritive value than the OFSP-soybean-anchovy powder reported by Amagloh & Coad (2014).

Table 4: Anti-nutrient contents (mg/100 g) of the formulated Complementary flour blends

Sample	Tannin	Phytate	Oxalate
AAA	21.08±0.10^{d}	61.06±0.45^{a}	6.19±0.80^{b}
ABA	23.12±0.08^{c}	58.81±0.13^{b}	4.50±0.00^{c}
ACA	24.16±1.41^{bc}	60.52±1.21^{a}	4.50±0.00^{c}
ADA	26.50±1.65^{b}	48.17±1.48^{c}	4.50±0.00^{c}
AGA	33.09±1.53^{a}	42.56±0.81^{d}	3.94±0.80^{d}
AHA	0.14±0.02^{e}	26.01±0.10^{e}	15.20±0.22^{a}

Means (SEM) with different alphabetical superscripts in the same column are significantly different at $P < 0.05$.

OFSP: Orange-fleshed sweet potato flour; AAA: 50% OFSP, 35% Cowpea, 15% Groundnut; ABA: 60% OFSP, 25% Cowpea, 15% Groundnut; ACA: 70% OFSP, 15% Cowpea, 15% Groundnut; ADA: 80% OFSP, 5% Cowpea, 15% Groundnut; AGA: 100% OFSP; AHA: Control (Nutrend)

The tannin contents of the complementary foods ranged from 21.08 mg/100 g in AAA to 33.09 mg/100 g AGA. These values were higher than the tannin content (14.31 mg/100 g to 15.20 mg/100 g) reported by Ekwere *et al.* (2017). The total acceptable tannin daily intake is 560 mg (WHO, 2003). Thus, based on the findings obtained from this study all of the samples contained low tannin concentrations. The highest tannin was observed in sample formulated with 100% OFSP while the sample with 50% OFSP substitution had the lowest tannin value. The Tannin value increased with increase in the OFSP substitution in the blends. In comparison, the oxalate (0.14 mg/100 g), phytate (26.01 mg/100 g) and tannin (15.20 mg/100 g) contents of the control food sample (Nutrend) were lower than the antinutrient (Oxalate, phytate and tannin) contents of the OFSP based complementary food of this study.

3.4. β-carotene and Vitamin A contents of the complementary flour blends

The Beta-carotene and the vitamin A contents of the complementary foods are presented in Table 5. The Beta-carotene of the samples ranged from 4470 to 6430 µg/100 g. The value of the Beta-carotene increased with increase in the OFSP substitution in the blends. The sample formulated with 100% OFSP had the highest Beta-carotene while the sample formulated with 50% OFSP, 35% cowpea and 15% groundnut had the lowest beta-carotene value. All the OFSP based complementary food had high pro-vitamin A (as Beta- carotene). The Vitamin A contents ranged from 343.84 - 494.63 µg RAE/100 g. This exceeded the recommended level of between 60 and 180 µg RAE/100 kcal for infants. The value of vitamin A obtained in this study is greater than the value of 226.24 µg RAE/100 kcal reported by Amagloh & Coad (2014) for OFSP- soybean- anchovy powder complementary food. There is no tolerable upper limit for Beta-carotene as there are no data on adverse effects of excessive intake (FNB, 2004).

Table 5: β-carotene and Vitamin A contents of the Complementary flour blends

Sample	β-carotene (µg/100 g)	Vitamin A (µg RAE/ 100 g)
AAA	4470±12.73^{f}	343.84±0.01^{f}
ABA	5050±32.53^{e}	388.45±0.01^{e}
ACA	5540±44.55^{c}	426.16±0.01^{c}
ADA	5660±17.68^{b}	435.38±0.01^{b}
AGA	6430±18.38^{a}	494.63±0.01^{a}
AHA	5311±18.38^{d}	408.53±0.01^{d}

Means (SEM) with different alphabetical superscripts in the same column are significantly different at $P < 0.05$.

OFSP: Orange-fleshed sweet potato flour; AAA: 50% OFSP, 35% Cowpea, 15% Groundnut; ABA: 60% OFSP, 25% Cowpea, 15% Groundnut; ACA: 70% OFSP, 15% Cowpea, 15% Groundnut; ADA: 80% OFSP, 5% Cowpea, 15% Groundnut; AGA: 100% OFSP; AHA: Control (Nutrend)

3.5. Colour parameters of the complementary flour blends

The hunter L, a, b of the complementary food are shown in Figure 2. Visually, the colour of the samples could be described as orange to yellow. The L values of the samples ranged from 60.54 to 83.39. The L-values of this study are comparable with the L-values (75.50 to 76.69) reported by Laryea *et al.* (2017). The sample formulated with 50% OFSP, 35% cowpea and 15% groundnut had the highest L value while the lowest value was recorded for the control (Nutrend) and were significantly different from other samples. The highest L value obtained for sample formulated with 50% OFSP, 35% cowpea and 15% groundnut could be as a result of the whiteness in the colour of the cowpea because as the cowpea flour decreased in the blends the lightness decrease.

The a* value of the complementary food varied significantly from 0.55 to 13.77. The sample formulated with 100% OFSP had the highest value while the control (Nutrend) had the lowest value. The a* values obtained in this study were higher than the value (-0.81 to -1.26) earlier reported by Laryea *et al.* (2017). The sample formulated with 100% OFSP had the highest value for a*, this could be as a result of the β-carotene pigment in the OFSP. A decrease was observed as the proportion of OFSP decreased in the blends. The intensity of yellow colour is dependent on the concentration of the β-carotene pigment (Woolfe, 1992).

The b* value ranged from 23.62 to 35.019, the sample formulated with 50% OFSP, 35% cowpea and 15% groundnut had the highest b* value while the control had the lowest value. The b* values (21.7 to 22.19) reported by Laryea *et al.* (2017) were lower than the values obtained in this study. The b* value decreased as the proportion of OFSP decrease in the blends. Similar trend was observed by Laryea *et al.* (2017).

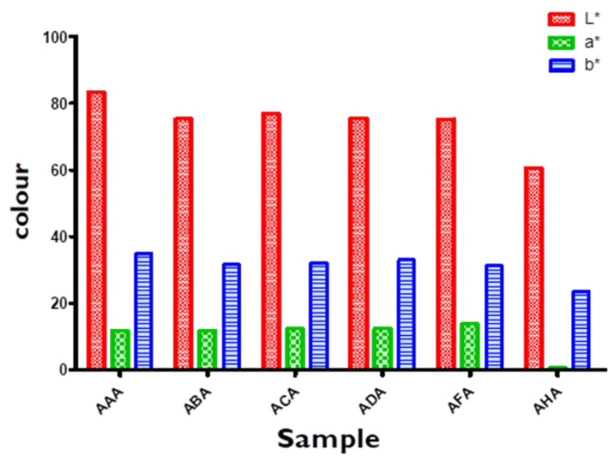

Figure 2: Colour parameters of the complementary flour blends

OFSP: Orange-fleshed sweet potato flour; AAA: 50% OFSP, 35% Cowpea, 15% Groundnut; ABA: 60% OFSP, 25% Cowpea, 15% Groundnut; ACA: 70% OFSP, 15% Cowpea, 15% Groundnut; ADA: 80% OFSP, 5% Cowpea, 15% Groundnut; AGA: 100% OFSP; AHA: Control (Nutrend).

3.6. Sensory evaluation of the complementary food (porridge)

The sensory attributes of formulated complementary food are presented in Table 6. The colour of the porridge ranged from 5.95 to 6.85 for sample formulated with 80% OFSP, 5% cowpea and 15% groundnut and the sample formulated with 100% OFSP respectively. The values obtained for the colour in this study are comparable to the values (5.10 to 6.60) reported by Alawode *et al.* (2017) for orange fleshed sweet potato-sorghum-soy flour complementary food. However, the colour acceptability of this study did not differ significantly (p>0.05). In any new food product development, colour is one of the most important factors to be considered and affect the acceptability of the product (Kikafunda *et al*., 2006).

Table 6: Sensory attributes of the complementary food

Sample	Colour	Aroma	Taste	Consistency	Overall Acceptability
AAA	6.35^{c}	5.20^{d}	5.30^{c}	5.80^{b}	5.85^{b}
ABA	6.40^{bc}	5.05^{e}	5.10^{d}	5.80^{b}	5.65^{b}
ACA	6.35^{c}	5.50^{c}	5.55^{bc}	5.95^{b}	5.95^{b}
ADA	5.95^{d}	5.45^{c}	5.80^{bc}	5.70^{b}	5.85^{b}
AFA	6.85^{b}	5.95^{b}	6.35^{b}	6.40^{b}	6.30^{b}
AGA	7.10^{a}	7.55^{a}	8.00^{a}	7.45^{a}	7.95^{a}

Means (SEM) with different alphabetical superscripts in the same column are significantly different at P < 0.05.

OFSP: Orange-fleshed sweet potato flour; AAA: 50% OFSP, 35% Cowpea, 15% Groundnut; ABA: 60% OFSP, 25% Cowpea, 15% Groundnut; ACA: 70% OFSP, 15% Cowpea, 15% Groundnut; ADA: 80% OFSP, 5% Cowpea, 15% Groundnut; AGA: 100% OFSP; AHA: Control (Nutrend)

The aroma score of the formulated complementary food ranged from 5.05 to 5.95 for sample formulated with 60% OFSP, 25% cowpea, 15% groundnut and the sample formulated with 100% OFSP respectively. The results obtained in this study are within the range of values (5.92 to 6.58) reported by Alawode *et al.* (2017) for orange fleshed sweet potato-sorghum-soy flour complementary food. The control (Nutrend) had the highest value (7.55) for aroma as compared with the formulated porridges in this study. This might be due to the fact that the consumers are used to the aroma of control sample. Taste values of the porridges were between 5.10 and 6.35, the highest taste value (8.0) was scored by the control (nutrend) while the lowest score (5.10) was recorded for the porridge formulated with 60% OFSP, 25% cowpea and 15% groundnut. These values were within the range of the values (5.64 to 7.00) reported by Alawode *et al.* (2017) for orange fleshed sweet potato-sorghum-soy flour complementary food.

The consistency score of the porridge ranged from 5.70 to 6.40 for sample formulated with 80% OFSP, 5% cowpea, 15% groundnut and the sample formulated with 100% OFSP. The values obtained for the consistency in this study is comparable to the values (5.10 to 6.68) reported by Alawode *et al.* (2017) for orange fleshed sweet potato-sorghum-soy flour complementary food. The low values for consistency of the porridges as compared with the control (nutrend) could be as a result of high percentage of OFSP in the blends which resulted in high viscosity. The pseudoplastic nature of OFSP feels sticky in the mouth after eating (Osman, 2007).

Overall acceptability of the porridges ranged from 5.65 to 6.30 for sample formulated with 60% OFSP, 25% cowpea, 15% groundnut and the sample formulated with 100% OFSP respectively. The control (Nutrend) had the highest value (7.45) for overall acceptability. The values obtained for the overall acceptability of the porridges formulated with OFSP showed that they are within the range (5.72 to 6.96) reported by Alawode *et al.* (2017) for orange fleshed sweet potato-sorghum-soy flour complementary food.

4. Conclusion

It is concluded that, supplementation of orange-fleshed sweet potato with cowpea and groundnut can serve as a complementary food with improved energy and nutrients. Sample AAA in this study met the minimum value stipulated for energy, fat, ß-carotene (Vitamin A precursor), anti-nutritional content of infants' complementary foods and its protein met 92% of the recommended dietary allowance (16.70%). Hence, the sample AAA could help in alleviating vitamin A deficiency, protein-energy malnutrition and increasing the bioavailability of other micronutrients required by infants.

Conflict of interest

The authors declare that there are not conflicts of interest.

Ethics

This Study does not involve Human or Animal Testing.

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