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FORMULATION AND QUALITY EVALUATION OF COMPLEMENTARY FOOD MADE FROM ORANGE-FLESHED SWEET POTATO MAJOR COMPONENT

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ABSTRACT

Introduction of appropriate complementary foods after 6months of life of infants is very important for optimum growth and prevention of malnutrition. This study formulated four samples containing varying proportions of orange fleshed sweet potato, acha grain, soybean and groundnut including sample A (60:10:25:5), sample B (60:10:20:10), sample C (55:15:25:5) and sample D (50:20:20:10). Chemical analysis of the samples was done according to the official method of analysis described by the Association of Official Analytical Chemist (AOAC) while sensory evaluation was done using a 5-point hedonic scale. All analysis was carried out in triplicate and the generated data was analyzed with ANOVA to compare different variables using IBM SPSS statistics version 20. The results revealed that sample A had the highest amount of carbohydrate, fat and crude fibre while sample D had the lowest ash content. Sample B had the highest content of calcium (36.39 mg/100g) and magnesium (62.25/100 g) while highest amount of potassium, iron, zinc and beta carotene were recorded in sample A. There were no significant differences (p > 0.05) in the carbohydrate, potassium and zinc contents of the food samples but significant differences existed for other nutrients. The microbial load of the samples was low (0.00 to 0.01 cfu/g). Sample C had the highest overall acceptability (4.00) for sensory evaluation. Incorporating orange flesh sweet potato into complementary food can help to prevent vitamin A deficiency which is prevalent among infants and pre-school children in Nigeria.

Key words: Complementary food, Orange fleshed sweet potato, Acha, Soy bean, Groundnut

INTRODUCTION

After 6 months of age, breast milk alone cannot meet the nutritional requirements of infants. This is why both WHO and UNICEF recommend introduction of nutritionally adequate and safe complementary foods at this stage. They also encourage continued breastfeeding till the child's second birthday or beyond. The first 2 years of a child's life are particularly important as optimal nutrition during this period lowers morbidity and mortality, reduces the risk of chronic disease, and fosters better overall development (WHO, 2021). Inappropriate transitioning from exclusive breastfeeding to complementary food can result in malnutrition (micronutrient and macronutrient deficiencies) mostly because infants have higher nutrient demands relative to increased energy requirement (Qasem *et al.,* 2015). Protein energy malnutrition like marasmus, kwashiorkor and micronutrient deficiencies exist among children alongside vitamin A iron, iodine, zinc deficiencies (Manyike *et al.,* 2014).

Most unfortified homemade cereal based complementary foods produced in under developed countries are made from maize, sorghum, millet, guinea corn and wheat which are naturally poor in β-carotene (Adetola *et al.,* 2020). Incorporating orange fleshed sweet potato (*Ipomoea batatas*) which is rich in β-carotene, the precursor of vitamin A will help alleviate vitamin A deficiency is prevalent amongst infants and pre-school children in Nigeria (Low, 2017) and even globally. Orange fleshed sweet potato is good source of carbohydrate (providing 293-460kJ of energy) and contains vitamin C, potassium, iron and zinc. It contains β-carotene which is converted to vitamin A when consumed which is better absorbed from it than other leaves and vegetables (Adejuwon *et al.,* 2020). It is however low in protein and fat hence, it should be complemented with legumes, cereals and grains to make it wholesome as a complementary food (Adetola *et al.,* 2020).

Acha (*Digitallia exilis*), also be called fonio or hungry rice, is an important cereal crop and suggested to be the oldest African indigenous cereal. Acha is one of the most nutritious grains rich in the amino acids methionine and cysteine that are vital to human health and also deficient in cereals today. It can be used for complementary foods of high calorie density (Ikujenlola *et al.,* 2017). Soybean is a protein-rich legume consumed worldwide and is also used as and enrichment for food formulations. It contains about 40% protein, it also yields other amino acids except methionine and cysteine but rich in vitamins like thiamine and folic acid. Soybean is rich in lecithin and linoleic acid but is a poor source of calcium and fair source of carotene and vitamin D (Edet *et al.,* 2017). Groundnut (*Arachis hypogaea*) is also a leguminous plant which is a good source of plant protein and dietary fiber. Research has shown that groundnut can be an allergy among infants and children, however recent researches have shown evidence that regular intake of peanut or foods that tend to be allergic in general can reduce the risk of allergies (West, 2017).

Using locally available crops to formulate affordable but nutrient-dense complementary food can alleviate malnutrition resulting from the high rate of poverty in Nigeria. Orange fleshed sweet potato is underutilized in this part of the world. Therefore, it should be complemented with legumes and/or cereals when used for complementary foods. Incorporating orange flesh sweet potato with other cereals and legumes (such as acha, soybean and groundnut) which are a good source of protein, fiber and healthy fat can efficiently reduce the problem of malnutrition. For instance, soybean is a source of protein but lacks amino acids like methionine and cysteine which are abundant in acha grains. A blend of these cereals and legumes to form a new complementary food including peanuts will improve the protein quality. This study therefore aimed at developing and evaluating the blends of complementary foods produced from orange fleshed sweet potato, acha grain, soy bean and groundnut.

MATERIALS AND METHODS

Source of materials

The orange fleshed sweet potato, acha and soybean were purchased from OLOLAG VEGGIES in Jos, Plateau State while the groundnut was purchased from Ikenne market, Ogun State. Equipment and utensils used for the samples preparation were provided by the Department of Nutrition and Dietetics laboratory at Babcock University in Ilishan-Remo, Ogun State.

Preparation of flour from orange fleshed sweet potaoto, soybean, acha grain, and groundnut

The orange fleshed sweet potato was sorted, peeled, washed, chipped and dried in a hot oven and the dried potato chips were milled into flour. Soybean sorted, roasted and de-hulled because of the anti-nutrients presents like tannins and milled into flour. The acha was cleaned after removing particles from the grains and the chaff was removed from the grains. The acha grains were washed again to remove unwanted dirt, dried in the oven and allowed to cool down before milling. Groundnuts sorted, washed and dried in the oven before grinding into fine powder. After processing the flour for each ingredient, it was packed in polyethylene bags and stored ready for formulation and analysis.

Proximate analysis of samples

Proximate composition (moisture, carbohydrate, protein, fat, ash, crude fibre) of the flour samples and formulated products were determined using the AOAC (1990) methods.

Determination of Ca, Mg, K, Zn and Fe

The concentration of Ca, Mg, K, Zn, and Fe were determined using Atomic Absorption Spectrometer (Spectra AA220FS Model). The mineral contents of samples were calculated and the results were expressed in mg/100g.

Formulation of the complementary food

The complementary food was produced in four samples using the ratios in Table 1 below:

Table 1: Formulation of the complementary food

Samples	Orange-fleshed sweet potato	Acha grain	Soybean	Groundnut
A	60%	10%	25%	5%
B	60%	10%	20%	10%
C	55%	15%	25%	5%
D	50%	20%	20%	10%

Complementary food preparation

At 85^0C 500ml of water was added to 100g of processed orange flesh sweet potato complementary food flour samples (using the different ratios as shown in table 1for each sample). The mixtures were stirred using a ladle until a paste was formed.

Sensory evaluation

Sensory evaluation was done using 10 panelists comprising of mothers who are staff of the departments of Nutrition and Dietetics and Agriculture and Industrial Technology, Babcock University. The samples were served to them in disposable cups for assessment. The evaluation was carried out for 3 days. The samples were assessed based on color, thickness, consistency, sweetness, aftertaste and overall acceptability using a 5-point hedonic scale (1- dislike very much and 5- like very much). Water was provided for the panelist to rinse their mouths in between the evaluation.

Determination of β – carotene

The β-carotene content of the samples was determined using the method described by Imungi and Wabule (1990).

Determination of microbial load

The microbial load of the samples was analyzed for Staphylococcus aureus, yeast, mould coliforms (Escherichia coli) and total plate count.

Statistical analysis

All the data collected were in triplicate with the exception of sensory evaluation. The data was analyzed using IBM SPSS statistics version 20 and mean, standard deviation, frequency and percentage was used in describing the data obtained. Analysis of Variance (ANOVA) was used to compare different variables together at $p< 0.05$.

RESULTS

Table 2 shows the proximate composition of the complementary food. There were significant differences in the moisture, ash, crude protein, fat and crude fibre contents while there was no significant difference in the carbohydrate content of the complementary food samples. Sample A had the highest amount of carbohydrate, fat and crude fibre. However, sample D had the highest moisture and ash content but the lowest ash content. The highest amount of protein was found in sample C (21.04%) while sample A had the lowest protein content (13.57%).

The micronutrient composition of the complementary food is presented in table 3. The calcium, magnesium, iron and beta carotene contents differed significantly but there were no significant differences in the potassium and zinc contents. Sample B had the highest (36.39mg/100g) content of calcium and magnesium (62.25mg/100g) but the lowest amount of potassium (230.13±0.13 mg/100g). Highest amount of potassium, iron, zinc and beta carotene were recorded in sample A while the lowest value of iron and zinc was found in sample D.

Table 4 shows the microbial load of the complementary food. The microbial load of the complementary food samples was low (0.00 to 0.01 cfu/g) in terms of yeast and mould count, *Escherichia coli* and *Staphylococcus aureus* counts of the complementary blends.

The sensory attributes of the complementary food blends is presented in Table 5. There was no significant difference in the sensory properties of the samples. The result showed that sample A had the highest score for colour (3.90) and after taste (3.60), while sample C had the highest score for thickness (4.10), consistency (3.40), sweetness (3.80) and overall acceptability (4.00).

Table 2: Proximate composition of the complementary food blends

Samples	Moisture (%)	Ash (%)	Crude protein (%)	Fat (%)	Crude fibre (%)	Carbohydrate (%)	Energy (kcal)
A	$9.19^{b}\pm0.02$	$4.59^{bc}\pm0.02$	$13.57^{c}\pm0.03$	$14.77^{a}\pm0.02$	$9.82^{a}\pm0.03$	$48.06^{a}\pm0.10$	254.71
B	$8.44^{d}\pm0.02$	$4.31^{c}\pm0.02$	$19.56^{b}\pm0.13$	$14.45^{b}\pm0.02$	$8.62^{d}\pm0.02$	$46.46^{a}\pm3.29$	263.36
C	$8.96^{c}\pm0.02$	$5.00^{ab}\pm0.03$	$21.03^{a}\pm0.04$	$13.15^{c}\pm0.02$	$9.38^{b}\pm0.04$	$45.89^{a}\pm5.95$	266.01
D	$9.33^{a}\pm0.07$	$5.37^{a}\pm0.48$	$20.77^{a}\pm0.35$	$12.53^{d}\pm0.03$	$8.78^{c}\pm0.14$	$46.17^{a}\pm4.65$	285.95

Values are presented as mean ± SD, n = 3. Values bearing different superscripts in the same column are significantly different (p<0.05)

Table 3: Micronutrients composition of the complementary food blends

Mineral (mg/100g)	Sample A	Sample B	Sample C	Sample D
Calcium	31.12 ± 0.70^{d}	36.39 ± 2.45^{a}	32.63 ± 1.11^{c}	32.95 ± 1.97^{b}
Magnesium	60.26 ± 0.13^{b}	62.25 ± 0.46^{a}	48.63 ± 0.33^{c}	45.40 ± 0.39^{d}
Potassium	232.36 ± 1.51^{a}	230.13 ± 0.13^{d}	231.32 ± 2.13^{b}	231.24 ± 0.55^{c}
Iron	26.88 ± 0.95^{a}	22.10 ± 0.01^{b}	11.67 ± 0.22^{c}	7.33 ± 0.35^{d}
Zinc	0.77 ± 0.20^{a}	0.67 ± 0.21^{b}	0.62 ± 0.10^{c}	0.43 ± 0.06^{d}
Beta carotene	75.40 ± 0.40^{a}	66.10 ± 0.12^{b}	51.97 ± 2.56^{d}	61.84 ± 1.31^{c}

Values are presented as mean ± SD, n = 3. Values bearing different superscripts in the same row are significantly different (p<0.05)

Table 4: **Bacterial composition of the complementary food blends**

MICROBIAL LOAD (cfu/g)	Sample A	Sample B	Sample C	Sample D
Yeast and Mould count	0.00 ^{b}	0.01^{a}	0.00^{b}	0.01^{a}
Staphylococcus aureus	0.01^{a}	0.00 ^{b}	0.00 ^{b}	0.01^{a}
Escherichia coli	0.00 ^{b}	0.01^{a}	0.00 ^{b}	0.01^{a}

Values are presented as mean ± SD, n = 3. Values bearing different superscripts in the same row are significantly different (p<0.05)

Table 5: Mean scores of the organoleptic attributes of the complementary food blends

Samples	Colour	Thickness	Consistency	Sweetness	After taste	Overall acceptability
A	3.90^{a} ± 1.00	4.00^{b} ± 0.70	2.50 ^{d} ± 1.40	2.70 ^{c} ± 1.41	3.60^{a} ± 1.43	3.00^{d} ± 1.33
B	3.40 ^{d} ± 1.00	3.90 ^{c} ± 1.12	2.90 ^{b} ± 1.40	3.60 ^{b} ± 1.40	3.10 ^{c} ± 1.30	3.60 ^{b} ± 1.40
C	3.70 ^{c} ± 1.00	4.00 ^{b} ± 1.12	2.70 ^{c} ± 1.30	3.60 ^{b} ± 1.10	3.30 ^{b} ± 1.34	3.50 ^{c} ± 0.90
D	3.80 ^{b} ± 0.80	4.10 ^{a} ± 0.90	3.40 ^{a} ± 1.00	3.80 ^{a} ± 1.31	3.10 ^{c} ± 1.53	4.00 ^{a} ± 0.82

Values are presented as mean ± SD, n = 10. Values bearing different superscripts in the same column are significantly different (p<0.05)

DISCUSSION

The focus of this study was to explore the use of orange-flesh sweet potato as a potential food ingredient that can add value to complementary foods. The proximate composition of the complementary food samples show that the energy content was between 254.711kcal and 285.951kcal. Energy values for complementary food for infants in low income countries produced by Amagloh *et al.* (2012) were higher (463.42kcal to 491.34kcal respectively). According to WFP (2018), the minimum energy content per 100g powder of complementary food should be 400kcal. The moisture content of the samples was below 10% and it agrees with the study of Mosha and Vicent (2005). Such low moisture content can reduce microbial load and increase shelf life. There was significant difference in the crude protein content (p<0.05). It was noticed that crude protein was higher in samples that had the largest quantity of acha grain and soybean which are samples C (15%, 25%) and D (20%, 20%) respectively. This is relatively high when compared to the result of Omeire *et al.* (2014) who made formulations from acha, soybean and coconut but slightly similar to the findings of Ijarotimi and Keshinro (2013). Previous reports on acha/pigeon pea (Olagunju *et al.,* 2018) and acha/soybean (Ayo and Kajo, 2016) blends also showed increases in the protein contents of the composite flours ratio of legumes increased. The fat content was within the recommended range of 10% to 25% (WHO/FAO/UNU, 2004) and noticed to reduce from sample A to sample D, which is higher than the values reported by similar studies (Gemede, 2020; Laryea *et al.,* 2018). The crude fibre values (8.62% - 9.82%) were significantly higher than the values recorded by Adejuwon *et al.,* (2020) to be between 2.43% - 3.17% and above the recommendation of less than 5% for complementary foods as stated by WHO (1991). Low fibre content reduces bulkiness of food and encourages high digestibility and absorption of essential nutrients like proteins and minerals in children (Adegbanke *et al.,* 2017). The carbohydrate content of the samples ranged from 46.17%-48.06% which was higher than the value obtained by Ijarotimi *et al.,* (2022) for complementary food produced from orange fleshed sweet potato, sorghum, full fat milk, soycake/oil and moringa leaves but lower than the result recorded by Adejuwon *et al.,* (2020) for sorghum-soybean complementary food. The crude ash content ranged from 4.31% to 5.37% and meets WHO/FAO (2004) recommendation that the ash contents of complementary food should be less than five, except for sample C which was more than 5%. This high ash content signifies the presence of minerals and is higher than results from similar studies where lower ash contents were recorded (Marcel *et al.,* 2022; Olatunde et al., 2020; Laryea *et al.,* 2018).

The micronutrients result shows that there was no significant difference in the calcium levels of the complementary food. The calcium content in this study is higher compared to that of (Laryea *et al.,* 2018) for complementary food produced from orange fleshed sweet potato, millet and soybean. Iron is essential for mental and physical well-being of children, and in the synthesis of haemoglobin in the body. After the age of 6 months nearly all the iron need is gotten from complementary food as the concentration of iron is low in breast milk (Paesano *et al.,* 2014). Soybean added a significant amount of iron to the complementary food and was significantly higher in sample A. Zinc was low in the four samples as none of the four samples met the recommended daily intake which is 2-3mg/100g according to Koletzko *et al.* (2008).

The value of magnesium decreased from sample A to sample D. Kolawole *et al.* (2020) made emphasis that 10% soybean in addition to a formulated complementary food containing 10% OFSP increased the magnesium content. Magnesium is crucial for steady heart rhythm, bone strength, healthy immune system, normal muscle and nerve function (Ndife *et al.,* 2020). The level of potassium was relatively high compared to the value obtained from Mohammed *et al.,* (2021). Orange flesh sweet potato is a rich source of pro vitamin A especially β-carotene (Bibiana *et al.,* 2014; Abidin *et al.,* 2015). This is evident in the result as beta carotene was present in all samples but highest in sample A which had the highest ratio of orange flesh sweet potato.

The microbial load was low in all the complementary food samples, implying their safety for consumption. The yeast and mould count was lower than values of Sanoussi *et al,* (2013) and Nigusse *et al.* (2019). The standard for yeast and mould in complementary foods has been reported to be less than 2.48 log10 cfu/g for ready-to-eat foods made for infants and 3 log10 cfu/g for foods that require cooking (CAC, 2008). *E. coli* count and *Staphylococcus aureus* were not detected. This is in agreement with the findings of Sanoussi *et al.* (2013) and Laryea *et al.* (2018). The standard for *E. coli* in complementary foods should be 0 as reported by CAC (2008).

The sensory attributes of the complementary food shows that although sample A had the highest colour preference, it had the lowest overall acceptability. This is similar to the study of Ukom *et al.* (2019) where the sample with the highest content of orange flesh sweet potato was more preferred in terms of colour but had low overall acceptance.

CONCLUSION

This study has shown the importance of incorporating orange flesh sweet potato into complementary food production. Most unfortified homemade cereal based complementary foods produced developing countries are made from legumes, cereals and grains which are naturally poor in β-carotene. The formulated food samples are safe for consumption and exhibited considerable level of compliance to recommended standards for energy – for infants aged 6-11 months (254.71-285.95%), protein (13.57±0.03-21.03±0.04%), iron (7.33±0.35-26.88±0.95mg/100g) zinc (0.43±0.06-0.77±0.20mg/100g) and beta carotene (51.97±2.56-75.40±0.40mg/100g) when converted to retinol (vitamin A). It was observed that the higher the ratio of orange-fleshed sweet potato, the higher the beta carotene content of the complementary food. Sample D had the highest score for thickness, sweetness, consistency and overall acceptance. Although sample A had the lowest amount of crude protein (13.57±0.03%) and energy (254.71Kcal), it had the highest content of carbohydrate (48.06±0.10%), crude fibre (9.82±0.03%), iron (26.88±0.95mg/100g), zinc (0.77±0.20mg/100g), potassium (232.36±1.51mg/100g), and beta carotene (75.40±0.40mg/100g). All samples are rich in beta carotene and can help in alleviating vitamin A deficiency which is prevalent amongst infants and pre-school children in Nigeria.

Author's contributions

Ani, Alfa, Adetola, Ajani and Ajuzie designed and conducted the research and wrote the paper. Ajani provided the materials. Akinlade, Alfa and Omotoye analyzed the data. Ajani and Omotoye produced the complementary food samples and carried out the sensory evaluation.

Conflict of interest

There is no conflict of interest

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