Quality Assessment and Sensory Evaluation of Complementary Food from Orange Flesh Sweet Potato (OFSP), Soybean, and Tropical Almond Seed Composite Flour.

ABSTRACT

Childhood malnutrition especially vitamin A deficiency and protein-energy malnutrition are widely prevalent in many parts of the world, particularly in developing countries due to the high cost of commercial infant food. Complementary food from OFSP, Soybean and Tropical Almond Seed Flour was produced to improve the nutritional content of locally made infant food. The study evaluated the quality and sensory attributes of complementary food. A commercial sample was used as a reference standard. The sample formulations were in the ratios; 100:0:0, 90:5:5, 80:15:5, 70:25:5. The anti-nutrient composition ranged thus: alkaloid (0.122-0.961%), trypsin inhibitor (0.003-0.455%), tannin (0.036-0.321%), oxalate (0.017-0.049%). The total essential and total non-essential amino acid composition respectively ranged thus in the samples; 14.12-59.55 g/100g of protein and 30.21-41.65 g/100g of protein. Sensory evaluation results showed that all the complementary food samples were generally accepted by the panelists. The composite flour herein produced significantly ($p<0.05$) increased the nutritional, amino acid, and sensory attributes of the complementary food in contrast to the control sample.

Keywords: Antinutrients. Composite Flour. Sensory Evaluation. Malnutrition. Amino Acid Profile.

Introduction

Eating a diet with insufficient or excessive nutrients can result in malnutrition and other health problems. Malnutrition in all its manifestations, including undernutrition (stunting and underweight), micronutrient deficiencies, as well as overweight and obesity, constitutes a triple burden of disease, particularly for low- and middle-income countries. It is one of the main factors contributing to ill health and a significant barrier to the global realization of human potential and personal growth (Okoronkwo et al., 2023; Amoroso, 2016).

Complementary feeding (CF) begins when an infant's nutritional requirements surpass the adequacy of breast milk alone, necessitating the introduction of complementary meals and liquids alongside breastfeeding (Abolaji et al., 2019). The significance of complementary foods (CF) lies in facilitating the transition from milk feeding to family foods, addressing both nutritional and developmental needs. Newborns endure rapid growth and development throughout the CF period, which also sees noticeable dietary changes as a result of exposure to novel foods, tastes, and eating experiences. During this time, infants are particularly vulnerable to nutritional deficiency (Fewtrell et al., 2017).

Initiating the gradual introduction of soft, semisolid, and solid foods is implemented as a complementary feeding strategy for infants starting at the age of six months. Additionally, it is important to start supplemental feeding practices on schedule and to breastfeed infants (Dagne et al., 2019). According to Obasi1 et al. (2018), complementary foods are combinations of various nutrient qualities that are high in protein, fats, carbohydrates, vitamins and minerals and are derived from grains, fruits, milk, and different food origins.

and organismal function, such as ATP synthesis, nucleotide synthesis, and redox balancing. To acquire energy and biomass and to rewire their metabolism after activation to sustain growth, proliferation, and effector functions, immune cells are crucially dependent on such pathways. In addition to supporting enhanced protein synthesis in immune cells, amino acid metabolism is important for this metabolic rewiring (Kelly & Pearce, 2020).

Anti-nutritional factors are those substances or chemical compounds that are harmful to humans and reduce the body's ability to absorb nutrients. They can be found in fruits and other foods in general. Depending on the type of food, how it is produced, the chemicals used in crop growth as well as those employed in food storage and preservation, anti-nutritional agents are present in various food items in diverse degrees.

Sensory evaluation is a science that measures, analyses and interprets the reaction of the senses of sight, smell, sound, taste, and texture to a product (Darko, 2010). Food fortification is effective when it is acceptable to the consumer and complies with the use thereof and consumer compliance and acceptability should precede micronutrient fortification projects. Sensory evaluation is one of the methods used for consumer compliance and acceptability for evaluating product quality, describing the sensory properties of the product (i.e., descriptive evaluation), and determining its acceptability by consumers (Aburime, 2012).

To formulate a cheap and affordable complementary food and also make this food functional, OFSP, soybean, and almond seed flour will be used. Hence, this research seeks to use OFSP, Soybean, and Tropical Almond Seed Flour Composite to produce and evaluate the nutritional and sensory attributes of nutrient-dense complementary foods. This complementary food will remedy malnutrition and hunger.

Materials and methods

Preparation of OFSP flour

Orange-fleshed sweet potato flour was produced following the steps outlined by Kudadam et al. (2021). The OFSP roots were manually sorted and peeled with a stainless-steel knife into uniform slices 3 mm thick. Slices were blanched in hot water at 80 °C for 3 min to inactivate the action of the enzymes. The chips were removed from the water, drained, and dehydrated in a dehydrator (model: ST-02) at 70 °C for 48 h. The chips were ground in a roller mill (model: DE-200g) and sieved to pass through a 0.5 mm mesh size. The flour was packaged in polypropylene plastic containers for future use.

Soybean flour production

The soybean flour was prepared using the modified method of Shiriki *et al.* (2015). The soybean was destoned and winnowed, soaked in clean tap water for 12 h and washed by rubbing between the palms to remove the testa and endosperm. The soybean was washed again several times with more water until most of the testa was washed out. It was then boiled for 15 min in water, sun-dried for 48 h and then dried in a hot air oven at 70 °C for 30 min. The dried grains were ground in a roller mill (model: DE-200g) and sieved to pass through a 0.5 mm mesh size. The flour was packaged in polypropylene plastic containers for future use.

Almond flour production

The method described by Akpakpan & Akpabio., (2012) was used to produce Almond flour. Almond fruits were sun-dried for 7 days and cracked open to remove the seeds. The seeds were oven-dried at 60 °C for 24 h and ground into powder using a roller mill (model: DE-200g). The flour was sieved using a 0.5 mm mesh sieve. The flour was packaged in polypropylene plastic containers for future use.

Table 1: Formulation of the complementary food samples

Sample	OFSP (%)	Soybean (%)	Almond (%)
ComF1	100	0	0
ComF2	90	5	5
ComF3	80	15	5
ComF4	70	25	5
ComF5	Reference sample		

Amino acid analysis of the complementary food

Amino acids composition was quantified after hydrolysis using model 120A PTH amino acid analyzer (HPLC) in the reversed-phase column, after derivatization with 9-fluorentylmethyl chloroformate and a fluorescence detector (AOAC, 2015). The sample was dried at 70 °C to constant weight, defatted, hydrolyzed, evaporated in a rotary evaporator, and loaded into the biosystem PTH Amino Acid Analyzer. The concentration of the individual amino acids was calculated about the protein content.

Determination of selected antinutrients/phytochemical composition of the complementary food

i. **Determination of phytate content.**

Phytate content was determined using the spectrophotometric method described by ((Ijarotimi, 2022). Two grams (2 g) of the sample was weighed into a five-hundred-milliliter (500 mL) flat-bottom flask. The flask with the sample was laced in a shaker and extracted with one hundred milliliters (100 mL) of 24% HCL for one hour at 25 °C. The aliquot was decanted and filtered. Five milliliters (5 mL) of 0.1 M sodium chloride were added to ten milliliters (10 mL) of the diluted sample and passed through a What man no. 1 filter paper to elute in organic phosphorus, and fifteen milliliters (15 mL) of 0.7 sodium chloride was also added to elute the phytate, which was mixed on a vortex mixer for 5 s. The mixture was centrifuged for 10 min, and the supernatant was read at a 520 nm wavelength in a UV spectrophotometer. The phytate concentration was read off from the standard curve prepared with standard inositol phytate, and the value was expressed in mg/100g using the following formula:

(mg/100g) = (1)

ii. **Determination of oxalate content**

Oxalate was determined by AOAC method (AOAC, 2015). 1 g of the sample was weighed into 100 ml conical flask. 75 ml of 3 M H2SO4 was added and the solution was carefully stirred intermittently with a magnetic stirrer for about 1 h and then filtered using what man No.1 filter paper. The sample filtrate (25 mL) was collected and titrated against hot [80 - 90 °C] 0.1 N KMnO4 solution to the point when a faint pink color appeared that persisted for at least 30 sec. The concentration of oxalate in each sample was obtained from the calculation: 1 ml 0.1 permanganate = 0.006303 g oxalate.

iii. Determination of trypsin inhibition activity (TIA)

The trypsin inhibition activity was assayed in terms of the extent to which an extract of the sample inhibited the action of bovine trypsin on the substrate benzoyl-DL-arginine-p-nitrianilide (BAPNA) hydrochloric. The sample (1 g) was extracted with 50 mL of 10 mM NaOH, and continuously shaken using a mechanical shaker at pH 9.4 (1 M NaOH) and ambient temperature for 3 h. After extraction, the suspension was shaken and diluted with distilled water such that 1 cm3 of the extract produced trypsin inhibition of 40 - 60% at 37 °C. The respective dilutions were noted. Consequently, TIA was calculated in terms of mg pure trypsin TIA = 2.632DA mg pure trypsin inhibited g^{-1} sample S, Where D is the dilution factor, A is the change in absorbance at 410 mm due to trypsin inhibition per cm^3 diluted sample extract and S is the weight of the sample (Ijarotimi, 2022).

iv. Determination of tannin content

Tannin content was determined by the modified vanillin-HCl methods. The sample (5 g) was extracted with 50 mL 99.9% methanol for 20 min at room temperature with constant agitation. After centrifugation for 10 min at 653 x g, 5 mL of vanillin-HCl [2% vanilli and 1% HCl] reagent was added to 1 mL aliquots, and the color developed after 20 min at room temperature was read at 500 nm. Correction for interference light natural pigments in the sample was achieved by subjecting the extract to the conditions of the reaction but without vanillin reagent (Ijarotimi, 2022). A standard curve was prepared using cate-chin [Sigma Chemical, St. Louis, MO] after correcting for blank, and tannin concentration was expressed in g/100 g. Tannin content was calculated as Tannin (g/100 g) = concentration of standard ×Absorbance of the sample.

v. Determination of alkaloids

5g of the sample was weighed into a 250ml beaker and 200ml of 20% acetic acid in ethanol was added covered and allowed to stand for 4 hours at 250C. It was then filtered and the filtrate was concentrated using a water bath (members) to one-quarter of the original volume. Concentrated ammonium hydroxide was added dropwise to the extract until the precipitation was complete. The whole solution was allowed to settle and the precipitate was collected and washed with dilute NH4oH solution. It was then filtered using a pre-weighed filter paper (Rocedure & Nalysis, 2015). The residue on the filter paper is the alkaloid and was dried in the precision oven at 800C. The alkaloid content was calculated and expressed as a percentage of the weight of the sample analyzed, thus:

% Weight of alkaloid = X 100 (2)

Sensory evaluation of gruels produced from the complementary food

The five different samples of complementary diets were evaluated for sensory characteristics and overall acceptability by panelists of 15 judges consisting of mothers living around the CEFTER hostel using a 9-point hedonic scale preference test. The hedonic was used to compare commercially formulated food and traditionally formulated food from Orange Fleshed Sweet Potatoes, soybeans, and Almond to know which complementary diet was preferable in appearance, mouth feel, consistency or viscosity, aroma, taste, and general acceptability. The quantities evaluated were rated on a scale ranging from one to nine (1 to 9)(Ezeokeke & Onuoha, 2016).

Statistical Analysis.

Statistical analysis was done using Statistical Package for Social Science (SPSS) computer software. All experiments were conducted in triplicates and reported as mean ± Standard deviation. Analysis of variance (One-way ANOVA) was used to ascertain any significant difference in the treatments at a 95% ($p<0.05$) significant level. The Duncan multiple range test (DMRT) was used to separate the means.

1. **Results and Discussion.**

Amino acid profile of the complementary food

There are nine essential amino acids: histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. The composition of essential amino acids in the formulated samples is presented in Table 2. The total essential amino acid content ranged from 14.12 g/100g in ComF1 to 59.55 g/100g in ComF4. There was a significant increase in the essential amino acid content of the samples as soybean flour substitution increased.

Amino acid	ComF1	ComF2	ComF3	ComF4	ComF5	LSD
Leucine	$3.21^{e}\pm0.01$	$6.52^{d}\pm0.02$	$6.83^{c}\pm0.00$	$7.31^{b}\pm0.02$	$9.02^{a}\pm0.03$	0.00
Lysine	$1.07^{e}\pm0.07$	$2.30^{c}\pm0.01$	$2.72^{b}\pm0.02$	$3.21^{a}\pm0.01$	$2.23^{d}\pm0.02$	0.04
Isoleucine	$1.30^{e}\pm0.06$	$3.44^{c}\pm0.06$	$3.85^{b}\pm0.02$	$4.15^{a}\pm0.07$	$3.20^{d}\pm0.02$	0.08
Phenylalanine	$1.77^{e}\pm0.01$	$3.18^{d}\pm0.03$	$3.43^{c}\pm0.15$	$3.82^{b}\pm0.02$	$4.13^{a}\pm0.03$	0.10
Tryptophan	$0.12^{d}\pm0.01$	$0.54^{c}\pm0.01$	$0.65^{b}\pm0.01$	$0.77^{a}\pm0.01$	$0.66^{b}\pm0.02$	0.00
Valine	$3.88^{a}\pm0.06$	$3.63^{c}\pm0.03$	$3.59^{cd}\pm0.01$	$3.56^{d}\pm0.02$	$3.71^{b}\pm0.01$	0.04
Methionine	$0.44^{d}\pm0.01$	$1.12^{c}\pm0.02$	$1.21^{b}\pm0.01$	$1.25^{a}\pm0.02$	$1.14^{c}\pm0.02$	0.00
Histidine	$1.00^{d}\pm0.12$	$1.77^{c}\pm0.01$	$1.99^{b}\pm0.02$	$2.33^{a}\pm0.02$	$2.27^{a}\pm0.01$	0.08
Threonine	$1.33^{e}\pm0.01$	$2.54^{d}\pm0.01$	$2.82^{c}\pm0.01$	$3.15^{a}\pm0.02$	$3.00^{b}\pm0.02$	0.00
TEAA	14.12	25.04	27.09	59.55	28.36	

Table 2 Essential Amino Acid Composition (g/100g of protein) of the Complementary Food Samples

Key: ComF1- 100% Orange Fleshed sweet potatoes flour: ComF2- 90% Orange Fleshed sweet potatoes flour, 5% Soybean flour, 5% Almond seed flour: ComF3- 80% Orange Fleshed sweet potatoes flour, 15% Soybean flour, 5% Almond seed flour, ComF4- 70% Orange Fleshed sweet potatoes flour, 25% Soybean flour, 5% Almond seed flour, ComF5- Reference sample, LSD- Least Significant Difference, TEAA- Total Essential Amino Acids. Values represent mean ± SD of triplicate determinations. Means in the same row with different superscripts are significantly different at $p<0.05$.

Non-essential Amino Acid Composition of the Complementary Food Samples

The non-essential amino acids analyzed in the samples were: alanine, arginine, aspartic acid, cysteine, glutamic acid, glycine, proline, serine, and tyrosine and the results are presented in Table 3.

The total non-essential amino acid content ranged from 30.21 g/100g in ComF1 to 41.64 g/100g in ComF4. There was a significant increase as soybean flour substitution in the samples increased.

Table 3: Non-essential Amino Acid Composition of the Complementary Food Samples

Amino acid	ComF1	ComF2	ComF3	ComF4	ComF5	LSD
Proline	2.20^{e}±0.02	3.26^{d}±0.02	3.40^{c}±0.03	3.67^{b}±0.01	5.11^{a}±0.01	0.00
Arginine	2.48^{d}±0.11	4.47^{c}±0.01	5.15^{b}±0.06	5.63^{a}±0.02	4.37^{c}±0.01	0.08
Tyrosine	3.33^{a}±0.01	3.10^{b}±0.02	3.06^{b}±0.17	3.00^{b}±0.09	3.05^{b}±0.02	0.13
Cysteine	0.93^{b}±0.01	0.86^{c}±0.02	0.84^{d}±0.01	0.81^{e}±0.01	1.29^{a}±0.01	0.00
Alanine	10.31^{a}±0.02	8.51^{b}±0.01	6.43^{c}±0.01	4.16^{d}±0.03	4.03^{e}±0.04	0.04
Glutamate	5.02^{e}±0.07	9.66^{d}±0.03	10.10^{c}±0.12	11.23^{a}±0.03	10.43^{b}±0.01	0.09
Glycine	1.14^{d}±0.03	2.25^{c}±0.01	2.33^{b}±0.01	2.36^{b}±0.01	2.58^{a}±0.02	0.00
Serine	1.24^{e}±0.02	3.19^{d}±0.02	3.36^{c}±0.01	3.62^{b}±0.02	3.84^{a}±0.03	0.00
Aspartate	3.56^{d}±0.03	6.05^{c}±0.06	6.63^{b}±0.02	7.17^{a}±0.01	6.65^{b}±0.02	0.04
TNEAA	30.21	41.35	41.3	41.65	41.35	

Key: ComF1- 100% Orange Fleshed sweet potato flour: ComF2- 90% Orange Fleshed sweet potatoes flour, 5% Soybean flour, 5% Almond seed flour: ComF3- 80% Orange Fleshed sweet potato flour, 15% Soybean flour, 5% Almond seed flour, ComF4- 70% Orange Fleshed sweet potatoes flour, 25% Soybean flour, 5% Almond seed flour, ComF5- Reference sample, LSD- Least Significant Difference, TNEAA- Total Non-Essential Amino Acids. Values represent mean ± SD of triplicate determinations. This means that the same row with different superscripts is significantly different.

Anti-nutrient composition of the complementary food

The antinutrients analyzed in the samples were alkaloids, phytates, tannins, and trypsin inhibitors. Table 4 shows the antinutrient composition of composite flour. The alkaloid content of the complementary food samples ComF1 to ComF5 varied from 0.122% to 0.387%, the trypsin inhibitor content of the sample varied from 0.003% to 0.399%, the tannin content ranged from 0.036% to 0.308%, the oxalate content varied from 0.0017% to 0.011%. There was a significant increase (p<0.05) in the anti-nutrient content of the samples as substitution with soybean flour increased.

Table 4: Anti-nutrient Composition (%) of the Complementary Food Samples

Sample	Alkaloid	Trypsin inhibitor	Tannin	Oxalate
ComF1	0.122^{d}±0.011	0.003^{c}±0.002	0.036^{b}±0.002	0.017^{d}±0.004
ComF2	0.411^{c}±0.057	0.036^{c}±0.001	0.045^{b}±0.002	0.023^{c}±0.000
ComF3	0.642^{b}±0.037	0.394^{b}±0.002	0.066^{b}±0.002	0.029^{b}±0.001
ComF4	0.961^{a}±0.025	0.455^{a}±0.045	0.321^{a}±0.022	0.049^{a}±0.003
ComF5	0.387^{c}±0.014	0.399^{b}±0.010	0.308^{a}±0.033	0.011^{c}±0.000
LSD	0.04	0.01	0.01	0.01

Key: ComF1- 100% Orange Fleshed sweet potato flour: ComF2- 90% Orange Fleshed sweet potato flour, 5% Soybean flour, 5% Almond seed flour: ComF3- 80% Orange Fleshed sweet potatoes flour, 15% Soybean flour, 5% Almond seed flour, ComF4- 70% Orange Fleshed sweet potatoes flour, 25% Soybean flour, 5% Almond seed flour, ComF5- Reference sample, LSD- Least Significant Difference. Values represent mean ± SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05.

Sensory attributes of gruels from the complementary food

Table 5 represents the sensory attributes of gruels from the complementary food samples such as appearance, aroma, taste, consistency, and overall acceptability.

Table 5: Sensory Attributes of Gruels from Complementary Food Samples

Sample	Appearance	Aroma	Taste	Consistency	Overall acceptability
ComF1	8.25^{a} ± 0.79	7.55^{a} ± 1.00	7.65^{a} ± 0.81	7.50^{a} ± 0.89	7.60^{a} ± 0.68
ComF2	7.75^{ab} ± 0.79	7.75^{a} ± 0.72	7.80^{a} ± 0.95	7.70^{a} ± 0.98	7.80^{a} ± 0.62
ComF3	7.60^{b} ± 0.88	7.55^{a} ± 1.54	7.75^{a} ± 1.16	7.95^{a} ± 0.94	7.95^{a} ± 0.94
ComF4	7.75^{ab} ± 0.79	7.50^{a} ± 1.54	7.55^{a} ± 1.43	7.90^{a} ± 0.91	7.65^{a} ± 1.39
ComF5	7.55^{b} ± 1.00	8.10^{a} ± 0.72	8.15^{a} ± 0.75	8.10^{a} ± 0.79	8.05^{a} ± 0.76
LSD	1.07	1.46	1.32	1.13	1.15

Key: ComF1- 100% Orange Fleshed sweet potatoes flour: ComF2- 90% Orange Fleshed sweet potatoes flour, 5% Soybean flour, 5% Almond seed flour: ComF3- 80% Orange Fleshed sweet potatoes flour, 15% Soybean flour, 5% Almond seed flour, ComF4- 70% Orange Fleshed sweet potatoes flour, 25% Soybean flour, 5% Almond seed flour, ComF5- Reference sample, LSD- Least Significant Difference. Values represent mean ± SD of triplicate determinations. Means in the same row with different superscripts are significantly different at $p<0.05$.

Discussions

There was a significant increase ($p<0.05$) in the total essential amino acid content of the samples as the level of substitution with soybean increased. The significant increase in the total essential amino acid between ComF1 and the rest of the formulated sample is also attributed to the substitution of the samples with protein-rich almond seed flour. These results are in line with that reported by Mariam, (2005) who reported a high amino acid content in soybean based complementary foods. Leucine (3.21 to 9.02 g/100g), isoleucine (1.30 to 4.15 g/100g), and phenylalanine (1.7 to 4.13 g/100g) were the most abundant essential amino acids in the formulated samples as the level of substitution of soybean increased. These results were expected as soybean is rich in these essential amino acids (Kovalenko et al., 2006)). Tryptophan (0.12 g/100g) and Methionine (0.44 to 1.25 g/100g) were the least essential amino acids present in the formulated sample and were significantly low ($p<0.05$) in ComF1 (control) compared to the other formulated samples and the reference sample (ComF5). The results are slightly lower than the 1.71 to 1.90 g/100g of methionine reported in cookies formulated from orange fleshed sweet potatoes, mush room and sorghum by Akinbode et al., (2023)

There was a significant increase ($p<0.05$) in the non-essential amino acid content as substitution with soybean increased except for tyrosine and alanine which were significantly higher ($p<0.05$)

in ComF1 (control sample) compared to the other formulated samples and the reference sample. This is in line with results from literature which showed that orange fleshed sweet potatoes are rich in these amino acids (Pereira et al., 2019). The significant increase (p<0.05) in the non-essential amino acid content of the formulated sample as substitution of soybean increased agrees with results of (Mariam, 2005) who reported similar results in diets containing soybean. Glutamic acid was observed to be the most abundant non-essential amino acid (5.02 to 11.23 g/100g) present in all the samples and has been found to be useful to maintain the acid/alkaline balance in the body after conversion to glucose or sugar (Akinbode et al., 2023)The higher amount of acidic amino acids (glutamic acid and aspartic acid) in the samples might have positive contributory effects on the sensory attributes of the formulated samples (Uzoaga et al., 2020).

Anti-nutrient composition of the complementary food

The alkaloid contents of the flour blends ranged from 0.122% to 0.387% as the level of incorporation of SBF increased. In the flour samples, ComF1 had the lowest phytate contents while ComF5 had the highest concentration. As observed, there was a significant increase ($p<0.05$) in the phytate contents between ComF1 and ComF5. This could be due to the fact that soybean and tropical almond also contain some significant amount of alkaloids as reported by Oduro et al., (2009). Alkaloids belong to a class of naturally occurring organic compounds that mostly contain basic nitrogen atoms. These compounds include related compounds with neutral and even weakly acidic properties. Some synthetic compounds of similar structure also belong to the class of alkaloid. Alkaloid is seen as bye-products of plant metabolism, and they also act as protein reservoirs (Bukuni et al., 2022). They generally possess high level of bitterness and thus become universal feeding deterrent in plant-herbivores interactions (Ee Wei, 2011). The results herein obtained are significantly lower than those reported by Bukuni et al., (2022).

The trypsin inhibitor contents of the flour blend samples ranged from 0.036mg/g to 0.455mg/g. Increasing levels of incorporation of SBF didn't have a significant effect on the trypsin inhibitors in the flour blend samples. There was a significant increase in the trypsin inhibitor content between ComF1and ComF4 to ComF5. This could be due to the fact that soybean is known just like many legumes to contain high concentrations of trypsin inhibitors (Gaydhane et al., 2018). The presence of protease inhibitors in the diet had been reported to form an irreversible trypsin enzyme-trypsin inhibitor complex, causing a trypsin drop in the intestine and a decrease in the diet protein digestibility, leading to slower growth. In this condition, the organism increases the secretory activity of the pancreas, which could cause pancreatic hypertrophy and hyperplasia (Wilhelmi, 1955). The results of this study follow the same trend as those reported by Bukuni et al., (2022) and (Medic et al., 2014) but are lower comparatively.

The tannin content of the samples was generally low and the results ranged from 0.036% to 0.308%. The least tannin content was observed in the internal (ComF1) control sample which was significantly different ($p<0.05$) from the other sample. Tannins are considered nutritionally undesirable because they precipitate proteins, inhibit digestive enzymes and affect the utilization of vitamins and minerals. Ingesting large amounts of tannins may result in adverse health effects, such as impaired microbial enzyme activity such as forming irreversible as well as reversible complexes with these enzymes (Ram et al., 2020)

The content of oxalate in the flour blend samples ranged from 0.017% - 0.011% There was a significant difference ($p<0.05$) between ComF5 (external control) and the other flour blend samples. Bukuni et al., (2022) reported an oxalate content of 0.11 mg/100g of complementary food produced from a composite flour of yellow maize, Bambara groundnuts and mango flesh, and from this result, it can be concluded that processing reduced the oxalate content of the samples. These results show that the oxalate content in the flour blend samples was generally low which agrees with the 0.049 mg/100g of oxalate reported in flour blend samples (Uzoaga et al., 2020).

The mean scores for the appearance of the gruel samples ranged from 8.25% in ComF1 to 7.55% in ComF5 (reference sample). There was a significant difference ($p<0.05$) in the appearance of the gruel samples. The preference scores of tastes ranged between 7.55 and 8.15. The 100% reference sample complementary food (ComF5) was most preferred (with a mean score of 8.15); however, it was not significantly ($p>0.05$) different from the composite complementary food. The mean scores for aroma ranged from 7.50 (ComF4) to 8.10 (ComF5). The mean scores for consistency ranged from 7.50 (ComF1) to 8.10 (ComF5). ComF5 gruel was the most preferred in terms of consistency. The overall acceptability mean score recorded by the gruel samples ranged between 7.06 and 8.05 with ComF1 recording the lowest mean of 7.06 which indicates 'like moderately' on the hedonic scale. There was however no significant difference ($p<0.05$) in terms of overall acceptability between the composite gruel and the control gruel (ComF1). However, ComF1 (the control sample) had the highest mean score (8.05) while ComF1 had the least mean score of 7.06.

The highest value (8.25) for appearance was observed in ComF1 which indicates "like very much" on the hedonic scale which was significantly different ($p<0.05$) from all the other samples except for ComF2. Beta carotenoids in OFSP have a significant role in colour (An orange colour which is very attractive) (Mitra, 2016). The lowest value (7.55) for appearance was observed in ComF5 which is the control sample. Orange fleshed sweet potatoes contain beta carotenoids and antioxidants that influence the overall color of the samples. Color is known as the only quality which consumers can base their purchasing decisions (Mitra, 2016).

These scores indicate a taste preference 'like moderately'. ComF4 was the least preferred with a mean score of 7.55 indicating 'like moderately'. The low taste score for ComF4 and generally for the composite of OFSP, Soybean, and Tropical Almond could be attributed to the residual soybean flour which contains alkaloids (Medic & Atkinson, 2014). The lower preference scores for the composite gruel could be due to the inclusion of tropical almond which gave it a nutty taste (Akpakpan & Akpabio, 2012b)There was however no significant difference ($p> 0.05$) between the control and the composite gruels. This means that the composite gruel compared favorably with the control sample. This could be due to the great aromatic flavor contributed by soybean flour as well as the tropical almond flour (owing to the roasting of soybean flour giving a highly flavored product) (Ezeokeke & Onuoha, 2016). The Panelists accepted all the composite gruel since their mean score indicated 'like moderately' on the hedonic scale. Aroma is the main decisive factor that makes a product to be liked or disliked (Abu-Salem & Abou-Arab, 2011) ComF5 gruel was the most preferred in terms of consistency. There was however no significant difference ($p> 0.05$) between the control and the composite gruels. This means that the composite gruel compared favorably with the control sample. This could be due to the increase in proteins substitution SBF contributed as well as the tropical almond flour (owing to the roasting of soybean flour giving a good textured product) and agrees with Okoronkwo et al., (2023). The low values of consistency for sample ComF1 could be a result of the high percentage of OFSP in the blends, which resulted in high viscosity. The pseudo-plastic nature of OFSP feels sticky in the mouth after eating Okoronkwo et al., (2023). The results obtained in this study are higher than the values (5.10 to 6.68) reported by Okoronkwo et al., (2023)for orange-fleshed sweet potato–sorghum–soy flour complementary food. but disagrees with the study reported by Bukuni et al., (2022)whose consistency reduced from 6.90 - 6.20. The Panelists accepted all the composite gruel since their mean score indicated 'like moderately' on the hedonic scale.

ComF1 (the control sample) had the highest mean score (8.05) while ComF1 had the least mean score of 7.06. This could be attributed to similar characteristics of the composite gruel in terms of color, consistency, taste and aroma to the control (100% reference sample). The comparatively lower ratings for the composite gruel samples with respect to ComF1 (control sample) could be due to the slight color difference (orange) and the taste. The composite gruel samples ComF2 and ComF3 compared more favorably with the control sample in terms of overall acceptability. The overall acceptability shows how much or less a product is globally accepted. Acceptability may not always depend solely on the sensory attributes of the product but also on other determinants such as physiological, behavioral and cognitive factors, related to the consumer (Laryea et al., 2017).

Conclusion

Production of complementary food from OFSP, Soybean, and Tropical Almond Seed Flour composite flour could provide all essential and non-essential amino acids. Leucine (3.21 to 9.02 g/100g), isoleucine (1.30 to 4.15 g/100g), and phenylalanine (1.7 to 4.13) were the most abundant essential amino acids in the formulated samples as the level of substitution of soybean increased. Amino acids are the building blocks of proteins necessary for growth and development. Antinutrient analysis highlighted lowered concentrations due to processing methods, enhancing the bioavailability of essential nutrients in complementary foods.

From the study, ComF3 was the most preferred. Sensory attributes indicated general acceptability of the formulated samples, yet overall scores fell below those of the reference sample (ComF5), signaling potential areas for improvement in sensory attributes to match or exceed consumer expectations. Complementary foods were successfully produced from OFSP, Soybean, and Tropical Almond Seed using ComF3 (80% OFSP, 15% soybean, 5% almond seed).

Author contributions Data availability: the data sets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval Not applicable

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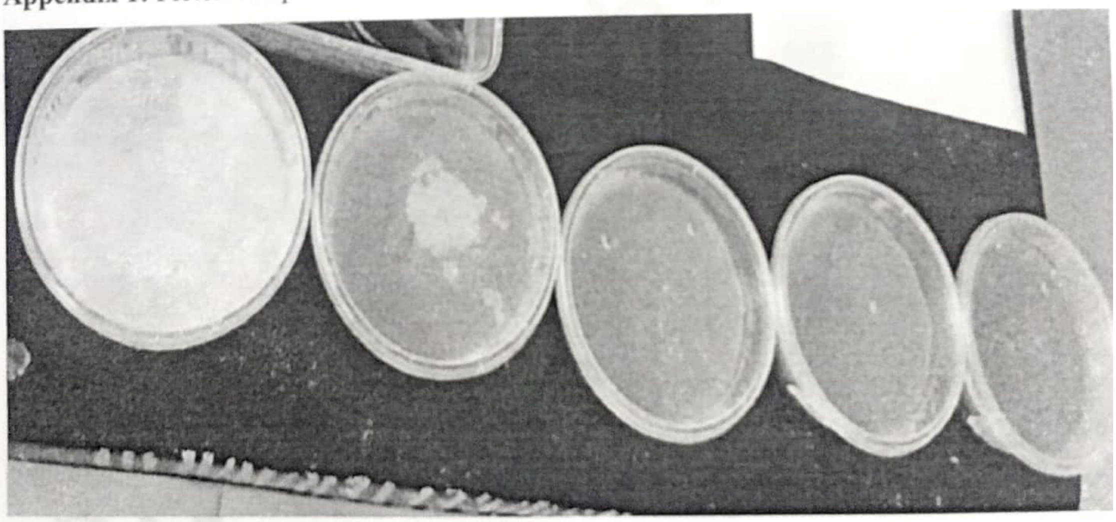
Appendix 1: Pictorial representation of the complementary food samples



ComF5 ComF4 ComF3 ComF2

ComF1