Assessment of Nutritional and Functional Properties of Complementary Food from Orange-Fleshed Sweet Potato, Soybean and Tropical Almond Seed Composite Flour

ABSTRACT

The study evaluated the quality characteristics of complementary food produced from orange fleshed sweet potato, soybean and tropical almond seed flour. The individual flours (OFSP, SBF and TASF) were produced and analyzed using standard methods. Four variations of orange fleshed sweet potato, soybean and tropical almond seed flour in 100:0:0, 90:5:5, 80:15:5, 70:25:5 were the experimental lots and labeled ComF1 to ComF4 respectively while a commercial complementary food labeled ComF5 was used as a reference standard. The functional properties of the complementary food from the flour ranged thus respectively; bulk density (0.50-0.72 g/mL to 0.50-0.85 g/mL), swelling capacity (1.04-2.40% to 1.52-3.19%), WAC (1.66-3.64 mL/g; 3.64-4.93 mL/g), OAC (0.61-2.77 mL/g; 0.61-1.88 mL/g) and Gelatinization temperature (57.5-83.7 °C; 57.5-66 °C). the pasting properties of the food samples ranged thus: peak viscosity (143.67-296.67 RVU), Trough viscosity (55.47-94.04 RVU), Breakdown viscosity (87.11-202.63 RVU), setback viscosity (702.87-2642.29 RVU), final viscosity (758.33-2736.33 RVU), peak time (4.10-5.37 Min) and pasting temperature (72.40-79.47 °C). The Proximate composition of flour and complementary food samples from the flours respectively ranged thus: Moisture (4.24-13.09 %; 4.58-6.55%), fats (1.39-7.58%; 1.39-3.61%), Protein (3.37-26.55%: 3.67-14.15%), ash (1.94-4.68%; 1.94-2.78%), crude fibre (1.67-5.02%; 1.67-3.48%), carbohydrates (49.28-87.09%; 69.53-87.09%) and energy values (354.52-375.55 kcal/100g; 364.89-375.55 kcal/100g). the mineral composition of the samples ranged thus: Calcium (0.62-4.98 mg/100g), magnesium (1.54-2.25 mg/100g), potassium (11.23-23.28 mg/100g), sodium (1.24-6.42 mg/100g), iron (3.01-8.00 mg/100g) and zinc (1.24-2.75 mg/100g). The vitamin composition of the samples was as follows: Beta carotene (6.65-27.61 mg/100g), vitamin C (0.30-1.54 mg/100g), vitamin B1 (0.65-1.39 mg/100g), vitamin E (0.72-4.29 mg/100g). The composite flour herein produced demonstrates great potential for its use in the development of complementary foods given its great nutrients and improved functional characteristics as seen with the formulated samples.

Keywords: [Complementary food, flour, orange-fleshed sweet potatoes and soybean}

1. INTRODUCTION

Complementary feeding is the process that begins when breast milk is no longer enough to meet an infant's nutritional needs and additional meals and liquids are required in addition to breast milk. complementary foods are crucial in the transition from milk feeding to family foods since they are required for both nutritional and developmental reasons. Newborns endure rapid growth and development throughout the complementary 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

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vulnerable to nutritional deficits and excesses, (Fewtrell et al., 2017). Extensive research has so far been done on breast and formula feeding unlike complementary feeding.This concerns the kind of meals provided and whether or not the period of complementary feeding has an impact on later health, development, or behavior (Fewtrell at al., 2017).The cost of the commercially available supplementary foods is high for low-income households in developing nations. These families then look for other means of nourishing their kids by preparing supplementary foods using local staple crops. In Africa, complementary foods are typically derived from cereal grains or root crops (Oladiran at al., 2022).

From a dietary and nutritional standpoint, orange fleshed sweet potatoes was rated as the best vegetable. a significant dietary source of VAC (vitamin A carotenoids) and NPVAC (non-pro-vitamin A carotenoids) (Mohammad at al., 2016). Due to the importance of vitamin a (VA) in eradicating vitamin A deficiency (VAD) in developing nations, OFSP is valued (Girard et al., 2017). Intensified research on OFSP has been conducted in the last 10 years to increase its production and consumption in many nations as a result of the many favorable characteristics of agriculture, nutritional security, and food security in contrast to white-fleshed sweet potatoes (WFSP), the OFSP has appealing sweet flavor and a pleasing yellow to orange color for kids (Kaguongo, 2012).

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The most significant seed legume in the world is soybean (G*lycine max l. merril*), which produces 25% of the world's edible oil and almost two-thirds of the protein concentrate used in cattle feed. Among these legumes, beans stand out because, in addition to the health advantages already described, they are a rich source of isoflavones, which lower the risk of cancer, heart disease, and osteoporosis. Therefore, dietitians should make a deliberate effort to encourage people to eat more beans generally and more soy foods in particular given the nutritional profile and phytochemical contribution of legumes (Laswai, 2010). The soybean has the ability to significantly improve farmers' life while also providing for the nutritional needs of the population and putting some much-needed money in their pockets.

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One of the less well-known tree nuts found in the tropics and in the ecology of Nigeria is the tropical almond (*Terminalia catappa*). A huge deciduous tree that does well as an ornamental tree is the almond. Almonds are the second most abundant source of phytosterols in tree nuts, behind cashews, and contain about 21.2 percent protein in their seeds and 6.3 g of protein in a meal of 30 grams of almonds (USDA, 2018). Studies have revealed that in addition to having great nutritional content, almonds also have a variety of health benefits, including control of blood glucose swings, a decrease in postprandial plasma lipids, and free radical scavenger activity. Edible nuts are widely consumed around the world and are prized for their sensory, nutritional, and health benefits. They can be grown in a variety of environments and climates. they are abundant providers of fats and proteins, and edible nuts also have significant levels of a number of vitamins and minerals (South, 2011).

2. MATERIAL AND METHODS

2.1 Sourcing of Material

Orange Fleshed Sweet Potatoes *(Ipomoea batatas L.)*, Soybean (*Glycine max L. Merril*) and the tropical Almond (*Terminalia catappa*) were purchased from Wurukum market, Makurdi Benue State, Nigeria. All reagents used were of analytical grade. The unit operations for the production of OFSP flour, soybean flour and tropical almond seed flour are presented in page 1-3 and blend formulation as in table 1.

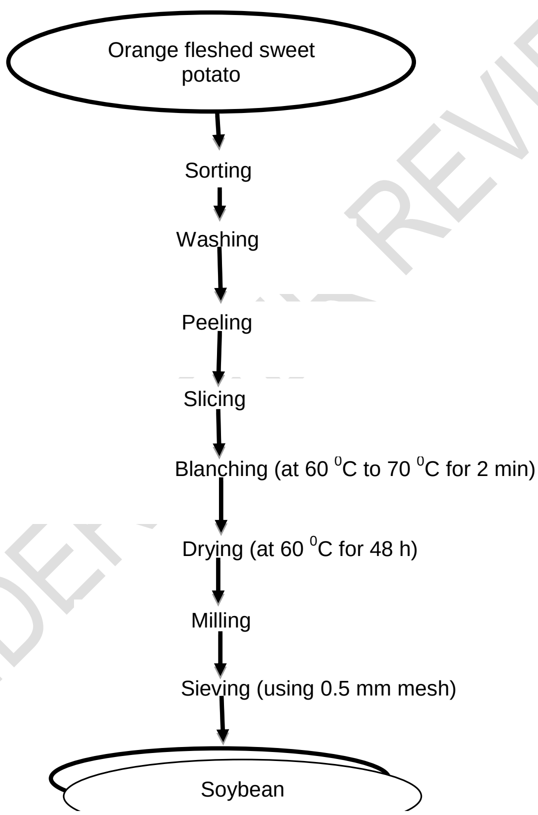
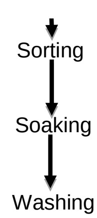


Figure 1: Flow chart for the production of OFSP flour (Kudadam *at al*.**, 2021)**



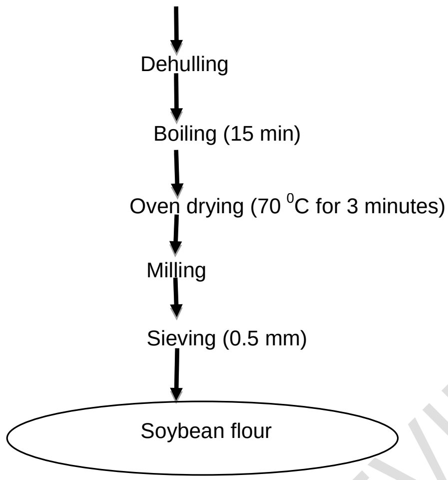
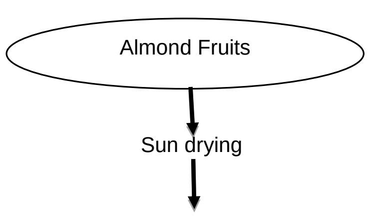


Figure 2: Flow chart for the production of soybean flour (Shiriki *at al***., 2015).**



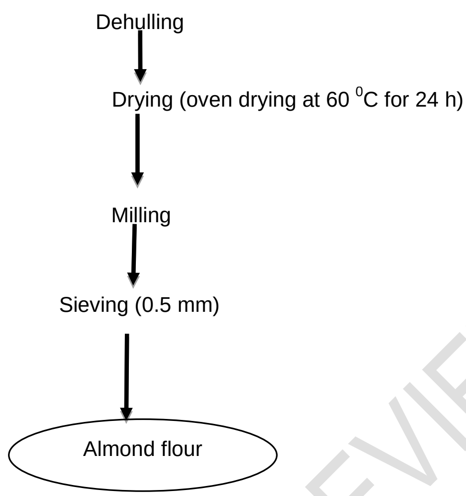


Figure 3: Flow chart for the production of Almond flour (Akpakpan and Akpabio, 2012).

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		

2.2 Analytical methods

2.2.1 Determination of Functional and Pasting Properties

Bulk density was carried out by the method described by Bukuniet al. (2022). Water absorption capacity, gelation temperature, swelling index and pasting properties were determined using the official method of AOAC, (2015).The pasting properties of each flour sample was determined using a Parten Rapid ViscoAnalyzer (AOAC, 2015). The sample (3.5 g) of flour was added into a canister already containing 25 mL of distilled water, a paddle was placed into the canister and the canister inserted into the instrument.

2.2.2 Proximate Analysis of Samples

The crude protein, moisture content, crude fat, crude fiber, and ash content was determined using the official method of AOAC, (2015). The carbohydrate content determined using the method described by Nielsen (Siyame et al., 2021). The energy value was determined using the method described by Farzana and Mohajan (Siyame*at al*., 2021).The Kjeldahl method AOAC (AOAC, 2015) was used to analyze crude protein content in each sample, according to Chang and Zhang. Firstly, a mixture of K2SO4 (10 g), CuSO4 (1 g), and selenium powder (0.1 g) was prepared and used as a Kjedahl catalyst

2.2.3 Determination of Vitamins

Thiamine (vitamin B1), Riboflavin (vitamin B2), Niacin (vitamin B3), Ascorbic acid (vitamin C), Tocopherol (vitamin E) was done by method described by AOAC (AOAC 2015).Five grams of the sample was weighed into a 100 mL volumetric flask, 2 mL of 20% metaphosphoric acid was added as a stabilizing agent, and the solution was diluted to volume with distilled water.

2.2.4 Determination of Minerals

Calcium, potassium, iron, sodium and magnesium was determined doneby Atomic Absorption Spectrophotometry (AAS) using Atomic Absorption Spectrophotometer (AOAC, 2015). One gram (1 g) of the sample will first be digested with 30 mL of aqua regia, which is a mixture of concentrated Nitric acid and Hydrochloric acid, in a ratio of 1:3. The digested sample was filtered and increased up to 50 mL with deionized water. The aliquots of the digested filtrate were used for AAS using filters that match the different elements.

2.2.5 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 significance difference in the treatments at 95% ($p<0.05$) significant level. The Duncan multiple range test (DMRT) was used to separate the mean.

3 RESULTS AND DISCUSSION

3.1 RESULTS

Table 2: Functional Properties of Orange Fleshed Sweet Potato, Soybean and Tropical Almond Seed Flours.

Sample	Bulkdensity (g/mL)	Swelling Capacity (%)	WAC (mL/g)	OAC (mL/g)	GT (°C)
ComF1	$0.50^{e}\pm0.02$	$2.40^{b}\pm0.27$	$3.64^{d}\pm0.39$	$0.61^{d}\pm0.01$	$57.5^{c}\pm1.5$
ComF2	$0.61^{d}\pm0.02$	$1.81^{c}\pm0.05$	$4.23^{bc}\pm0.21$	$1.03^{c}\pm0.07$	$61.0^{b}\pm1.0$
ComF3	$0.78^{b}\pm0.01$	$1.65^{cd}\pm0.01$	$4.50^{b}\pm0.08$	$1.43^{b}\pm0.03$	$64.0^{a}\pm1.0$
ComF4	$0.85^{a}\pm0.06$	$1.52^{d}\pm0.01$	$4.93^{a}\pm0.05$	$1.88^{a}\pm0.01$	$66.0^{a}\pm1.0$
ComF5	$0.73^{c}\pm0.02$	$3.19^{a}\pm0.01$	$3.90^{cd}\pm0.10$	$1.45^{b}\pm0.01$	$65.5^{a}\pm1.5$
LSD	0.04	0.18	0.30	0.04	1.71

Values represent mean ± SD of triplicate determinations. Means in the same column with different superscripts are significantly different at $p<0.05$

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Table 3: Mineral Composition (mg/100g) of the Complementary Food Samples

Sample	Ca	Mg	K	Na	Fe	Zn
ComF1	$0.62^{e}\pm0.01$	$1.54^{c}\pm0.01$	$11.23^{d}\pm0.00$	$1.24^{d}\pm0.01$	$3.01^{d}\pm0.00$	$1.24^{d}\pm0.00$
ComF2	$1.82^{d}\pm0.01$	$1.87^{b}\pm0.01$	$22.93^{b}\pm0.02$	$2.36^{c}\pm0.02$	$4.74^{c}\pm0.01$	$1.85^{c}\pm0.04$
ComF3	$3.88^{c}\pm0.02$	$2.12^{a}\pm0.02$	$22.98^{b}\pm0.11$	$2.38^{c}\pm0.10$	$6.12^{b}\pm0.01$	$1.88^{c}\pm0.01$
ComF4	$4.93^{a}\pm0.01$	$2.14^{a}\pm0.17$	$23.28^{a}\pm0.01$	$3.47^{b}\pm0.00$	$8.00^{a}\pm0.00$	$2.75^{a}\pm0.01$
ComF5	$4.45^{b}\pm0.00$	$2.25^{a}\pm0.04$	$20.88^{c}\pm0.00$	$6.42^{a}\pm0.01$	$6.12^{b}\pm0.01$	$2.39^{b}\pm0.01$
LSD	0.00	0.11	0.08	0.06	0.00	0.00

Values represent mean ± SD of triplicate determinations. Means in the same column with different superscripts are significantly different at $p<0.05$

Table 4: Pasting Properties of the Complementary Food Samples

Sample	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (Min)	Pasting temperature (°C)
ComF1	296.67^{a}±1.53	94.04^{a}±0.01	202.63^{a}±1.52	2736.33^{a}±1.53	2642.29^{a}±1.52	5.37^{a}±0.10	79.47^{a}±0.06
ComF2	282.67^{b}±0.58	87.35^{b}±0.01	195.32^{b}±0,58	2593.67^{b}±0.58	2506.32^{b}±0,57	5.20^{b}±0.10	78.83^{b}±0.06
ComF3	181.00^{c}±1.00	78.73c^{c}±0.15	102.27^{c}±0.85	1135.00^{c}±1.00	1056.27^{c}±0.96	4.40^{c}±0.10	76.70^{c}±0.10
ComF4	145.67^{d}±0.58	58.56^{d}±0.99	87.11^{d}±0.57	999.00^{d}±1.00	940.44^{d}±1.00	4.27^{c}±0.10	74.53^{d}±0.25
ComF5	143.67^{e}±0.58	55.47^{e}±0.12	88.20^{d}±0.69	758.33^{e}±5.13	702.87^{e}±5.02	4.10^{d}±0.10	72.40^{e}±0.10
LSD	1.31	0.63	1.29	3.50	3.44	0.12	0.60

Values represent mean ± SD of triplicate determinations. Means in the same column with different superscripts are significantly different at $p<0.05$

Table 5: Proximate Composition of the Complementary Food

Sample	%						(kcal/100g)
	Moisture	Fat	Proteins	Ash	Fibre	Carbohydrates	Total calories
ComF1	4.58^{d}±0.39	1.39^{c}±0.03	3.67^{e}±0.46	1.94^{e}±0.07	1.67^{c}±0.15	87.09^{a}±0.87	$375..55^{a}$±1.97
ComF2	4.98^{c}±0.80	1.61^{c}±0.02	7.37^{d}±0.49	2.33^{d}±0.02	2.72^{b}±0.09	80.99^{b}±0.30	367.96^{b}±3.07
ComF3	5.91^{b}±0.00	2.35^{b}±0.05	9.22^{c}±0.29	2.48^{c}±0.08	3.23^{a}±0.33	76.80^{c}±0.32	365.26^{b}±1.25
ComF4	6.55^{a}±0.06	3.61^{a}±0.29	14.15^{a}±0.04	2.63^{b}±0.05	3.48^{a}±0.02	69.53^{d}±0.32	367.20^{b}±1.33
ComF5	4.86^{cd}±0.05	1.39^{c}±0.03	11.56^{b}±0.41	2.78^{a}±0.02	2.88^{b}±0.13	76.53^{c}±0.54	364.89^{b}±0.92
LSD	0.56	0.19	0.54	0.08	0.25	0.73	2.64

Values represent mean ± SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05

Table 6: Vitamin Composition (mg/100g) of the Complementary Food Samples

Sample	Vitamin C	Vitamin B1	Vitamin E	Beta carotene
ComF1	$1.54^{a}\pm0.01$	$1.39^{c}\pm0.18$	$0.72^{c}\pm0.15$	$27.61^{a}\pm0.82$
ComF2	$1.26^{b}\pm0.05$	$1.78^{b}\pm0.01$	$1.19^{bc}\pm0.08$	$24.13^{b}\pm0.29$
ComF3	$1.19^{b}\pm0.06$	$1.88^{ab}\pm0.02$	$1.24^{bc}\pm0.03$	$21.38^{c}\pm0.36$
ComF4	$0.77^{c}\pm0.04$	$1.95^{a}\pm0.05$	$1.34^{b}\pm0.06$	$18.37^{d}\pm0.30$
ComF5	$0.30^{d}\pm0.01$	0.65d±0.02	$4.29^{a}\pm0.61$	$6.65^{e}\pm0.36$
LSD	0.07	0.12	0.40	0.67

Values represent mean ± SD of triplicate determinations. Means in the same column with different superscripts are significantly different at p<0.05

3.2 DISCUSSION

3.2.1 Functional properties of the complementary

The functional properties of the complementary food samples are presented in Table 2. The functional properties of the flours in this research are similar to that reported by Ukom et al., (2019) for orange fleshed sweet potato based complementary food. The major chemical compositions that enhance the water absorption capacities of flours are proteins, fiber and carbohydrates since these constituents contain hydrophilic parts such as polar or charged side chains. Therefore, the increase in the WAC of the flour is due to the increase in the protein and fiber content of the flour as the quantity of the high-protein-dense rich SBF and TASF were added. A similar trend was observed by Ojinnaka et al., (2013) who used composite flours of soybean, ginger, modified cocoyam starch and noted an increase in WAC with increase in the incorporation of the different flours to the modifies cocoyam starch.

As observed, the BD of the complementary food samples increased with increase in the incorporation of SBF. Flours from legumes have been reported to have high BD (Bongjo et al., 2022) and this could also be one of the reasons for the significant increase ($p<0.05$) in the BD from sample ComF1 to ComF5. A similar trend was observed by Ojinnaka et al., (2013). It is clear that decreased the proportion of OFSP increased the bulk density of the composite flours. The high bulk density of the flours suggests their suitability for use in food preparations. Bulk density is a measure of the heaviness of a flour sample. The BD of a flour is one of the parameters used to determine its packaging requirements and is a function of the particle size and moisture content of flours (Oladele & Aina, 2007).

The OAC as observed in this study increased with increase in the addition of SBF. This could be due to the high protein content in soybean and tropical almond. The higher the amount of heat treatment given to a protein, the more hydrophobic the protein becomes, as a result of a higher number of hydrophobic groups exposed through the unfolding of the protein molecules (Hasmadi et al., 2020). This could further explain the significant increase ($p<0.05$) in the OAC of the flours with increase substitution of ComF6 (produced by a series of heat treatment procedures including roasting) (Bongjo et al., 2022). The results of this study agree with those of Adesanmi et al., (2020). OAC is the ability of the fat in flour to bind to the non-polar side chain of proteins. The Oil absorption capacity is an essential functional property that contributes to enhancing mouth feel while retaining the food products' flavor (Iwe et al., 2016a). Increase incorporation of SBF witnessed a significant increase ($p<0.05$) from COMF1 to COMF5. However, increase incorporation from ComF2 to ComF4 witnessed a significant change ($p>0.05$) in SC. The swelling capacity of flour is the volume in milliliter taken up by the swelling of one gram (1 g) of the flour under specific conditions. SC is a function of the size of particles, types of variety (like the presence of starch) and types of processing methods or unit operations involved in the flour production. The results show a significant increase ($p<0.05$) in SC from ComF1 to ComF5. This could be due to increase in the flour's ability to absorb water and swell as it reflects the extent of associative forces in the starch granules Godswill et al., (2019). The effect of their swelling index was reflected on the texture of food prepared from such flours.

3.2.2 Pasting properties of complementary food

The results of the pasting properties such as peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity, peak time and pasting temperature are presented in table 3. There was a significant decrease ($p<0.05$) in the pasting properties as the substitution with soybean flour increased.

The decrease in peak viscosity is in agreement with the reports by Laryea et al., (2017) and Wordu& Vito, (2021) who found similar trends in their composite blends. Lower peak viscosity could be attributed to difference in protein content (Adebowale et al., ~~(~~2005). Peak viscosity is the maximum viscosity developed during or soon after the heating aspect of the test (Ojo., et al 2017). It is an index of the ability of starch-based foods to swell freely before their physical breakdown. Peak viscosity indicates the water-holding capacity of the starch or mixture. It is often correlated with final product quality, and also provides an indication of the viscous load likely to be encountered by a mixing cooker (Iwe et al., ~~(~~2016). The same decreasing trend was observed in trough velocity with ComF1 registering the highest value 94.04 RVU and ComF5 registering the lowest value 55.47RVU.

The lowest value for breakdown viscosity was registered in ComF5, 88.20RVU and the highest value was registered in ComF1, 202.63 RVU. A similar trend was registered for final viscosity with ComF5 having the lowest value 758.33 RVU and ComF1 having the highest value 2736.33RVU. Setback viscosity also reduced from 262.29 RVU in ComF1 to 702.87 RVU in ComF5. The trough viscosity decreased steadily. Trough viscosity depends on the temperature and degree of mixing, or shear stress, applied to the mixture, and the nature of the material itself. The ability of a sample to withstand this heating and shear stress is an important factor for many processes. The breakdown viscosity is an index of the stability of starch and a measure of the ease with which the swollen granules can be disintegrated. The breakdown viscosity of the flour blends reduced with increasing substitution of soybean flour. This is in agreement with ~~reports by~~ Wordu& Vito, (2021) who reported that the higher the breakdown viscosity, the lower the ability of the flour to withstand heating and stress during cooking thus ComF1(internal control) had the lowest ability to withstand heating and stress during cooking and ComF5 has the highest ability. Break down viscosity is also defined as the difference between peak and trough viscosity. The final viscosity of the flour blends gives a measure of the resistance of the paste to shear force during stirring Zambrano et al., (2019). It showed a decreasing trend from the control sample, thus the control sample resists stirring most. Final viscosities are the most used parameter to define a particular sample's quality, as it indicates the ability of the material to form a viscous paste or gel after cooking and cooling. The re-association between starch molecules during cooling is commonly referred to as the setback viscosity. ComF4 (70:25:5) OFSP: Soybean flour:

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tropical almond had the highest setback viscosity. It involves retro gradation, or re-ordering, of the starch molecules, and has been correlated with texture of various products.

3.2.3 Proximate Composition of Complementary Food

The proximate composition of the complementary food samples is presented in Table 4. The increase in moisture content in the complementary food samples as the substitution with soybean increased could be attributed to increase in the hydrophilic property of fiber in the SBF and TASF as the level of incorporation increased. Moisture content indicates the shelf-stability of a product; such that, the lower the moisture content, the better the shelf stability of such products (Dong et al., 2016). The results of this study are similar to those reported by Adesanmi et al., (2020) (3.32–6.7%) who produced complementary diet from defatted almond seed, yellow maize and quality protein maize flours. The trend in results also agree with other studies (Akindele et al., 2017).

The protein content agrees with that reported by Adegunwa et al., (2014) who produced breakfast food from blends of OFSP and African yam. Bukuni et al., (2022) reported protein content of 1.56 to 23.81%, while Tenagashaw., (2016) reported protein content of 12.94 to 13.30%. This shows that the gruels herein produced are very rich in protein. The protein content in this study was also higher than those reported by Laryea et al., (2018) for sweet potatoes based complementary food of 14.78-16.96%.

There was a significant increase in the fat content of the samples as substitution with SBF increased. Samples with 25% SBF (ComF4) had the highest fat content while the control sample (ComF1) recorded the least. This increase in the fat content differed significantly among all the samples. The increase in the fat content could be due to the substitution effect as a result of some residual fat content in the SBF. This result confirms a study by Ojinnaka et al., (2013) for substitution with soybean flour in a peanut flour-based complementary food. The results in this study are lower than those reported by other authors Adesanmi et al., (2020) and Bukuni et al., (2022). Ojinnaka et al., (2013) reported lower fat content values (1.22-1.93%) for complementary food gruels from soybean, ginger and modified cocoyam starch. The high fat content of the flour blend samples was expected as was shown by the significant increase in the OAC of the flours with increase in the level of incorporation with SBF. This high fat content could also be attributed to absorption of oil by the samples during frying as well as the difference in the recipes.

An increase in the ash content of the samples was seen as substitution with SBF increased. The increase in ash content could be attributed to the high ash content of SBF of 5.03% as reported by Tenagashaw et al., (2016). Ojinnaka et al., (2013) also reported an increase in the ash content of complementary food gruels produced from soybean, ginger and modified cocoyam starch. The ash content in this study was higher than those reported by (Ojinnaka et al., 2013) on the production of complementary food. However, the trend in results is comparable to those reported by Abioye et al., (2020) in wheat-germinated finger millet-based complementary food. The ash content of a product indicates a rough estimate of its mineral content. (Adelekan et al., 2019). This study therefore indicates that the flour blend samples would contribute enormous mineral elements to the body.

The significant increase in the fibre content of the samples could be attributed to the high fibre content (3.02%) in SBF. Crude fibre content of this study was lower than those obtained in OFSP, soybean and mushroom based complementary food by Akinbode et al., (2023). While the fibre content in this study are comparatively higher than those reported by Ukom et al., (2019) who produced yellow maize ogi porridge enriched with orange fleshed sweet potato and African yam bean seed flour.

The increase in the proportion of SBF brought about a decrease in the carbohydrate content of the flour blend samples. This result is in agreement with the findings from Bukuni et al., (2022) and Shiriki et al., (2015) who reported a decrease in carbohydrate content (53.91-50.25%) and (68.00-21.30%) who produced complementary food from Bambara groundnuts and soybean flour respectively. The carbohydrate content in this study are higher than those in the study by Ugwuanyi et al., (2020) but lower than those of (Akindele et al., 2017; Dong et al., 2016).

The energy content results in this study are higher than those reported Siyame et al., (2021) who reported values ranging from 344.68Cal to 273.33kCal for complementary food with soybean flour.

3.2.4 Mineral composition of the complementary food

Calcium is known to play a major role in muscle contraction, building strong bones and teeth, blood clotting, nerve impulse, transmission, regulating heart beat and fluid balance within cells (Grace et al., 2015). It has also been identified to play major role in managing blood pressure, and preventing breast cancer.

The increase in the potassium content could be due to the fact that legumes are rich in potassium (Oluwamukomi et al., 2021). These values are lower than those reported by Barber et al., (2017) but are higher than those reported by Vito &Wordu, (2021) who reported 1.87-2.03mg/100g for OFSP and soybean complementary food

The higher values of Mg obtained for the flour blend samples compared with the reference sample (ComF5) showed that combining OFSP, soybean n and tropical almond flour enhanced the magnesium content of the gruels. Value obtained in this study was lower than the range of 32-51.47mg/100g reported for food formulated from pea and anchote flours due to the high Mg content of pea. Magnesium is essential to good health because it helps to maintain normal muscle and nerve function, keeps heart rhythm steady, supports a healthy immune system and keeps bones strong.

The increase in sodium content is due to the higher content of sodium in soybean and tropical almond compared to OFSP. This result shows that sodium is greater in soybean and almond than OFSP (Akpakpan& Akpabio, 2012).Monitoring sodium intake is crucial for individuals who need to manage their sodium levels due to health conditions such as high blood pressure, heart disease, or kidney problems. Excessive sodium intake can lead to fluid retention and increased blood pressure, which can have negative health implications.

The Iron content of complementary food significantly increased in the samples. The results reported by this study are higher than those reported by (Mbah et al., 2013), who reported 0.7mg/100g-1.3mg/100g in roasted almond nuts. This could be due to the high iron content of legumes as reported by USDA, (2015). The values reported here follow the same trend as reported by (Vito &Wordu (2021) but are comparatively lower. Bukuni et al., (2022) reported higher values of iron in Bambara groundnut-based complementary food.

The zinc content of the samples in this result compared favorably with those reported by Gemede, (2020) who reported a Zn content of 2.73-3.2 in foods formulated from maize, pea and anchote flours. Zinc helps with hormone production, growth and repair; improves immunity and facilitates digestion. Zinc also has a big impact on hormonal balance, so for this reason, zinc deficiency can result to an increased risk for infertility or diabetes. Legumes are rich in zinc and this increase is justified (Arya et al., 2016). Zinc has been recommended for the treatment of diarrhea by the World Health Organization (WHO) and United Nations Children 's Fund (UNICEF). Zinc is an effective therapy for diarrhea and will decrease diarrhea morbidity and mortality (Fischer Walker & Black, 2010). It is also known to be an important co-factor for more than 70 enzymes and plays a central role in cell division, protein synthesis and growth. Hence its deficiency will result to growth failure, anemia, enlarged liver and spleen, impaired skeletal development (Guyih et al., 2020).

Comment [D7]: Unit missing

3.2.5 Vitamin composition of the complementary food

The complementary food samples were analyzed for Vitamin C, B1, E, and Beta carotene and the results are presented on table 4.

The observed trend in the vitamin C content of the samples could be due to the high content of vitamin C in OFSP. The control sample was observed to have the least vitamin C content which was significantly different ($p<0.05$) from the other samples. Vitamin C has been reported to contribute to the antioxidant activities of plant food and it is a good reducing agent and exhibits its antioxidant activities by electron donation (Fanta., et al 2019).

There was a significant increase ($p<0.05$) in the vitamin E content as the level of substitution of the samples with OFSP increases. The highest value of vitamin E was recorded in the reference sample (4.29 mg/100g), indicating that soybean is a rich source of vitamin E

Okoronkwo et al., (2023) reported a vitamin B1 content of 1.05 mg/100g in complementary food which did not vary much with the one reported in this research. The slight variation might be due to the blends of the sample. As observed, the vitamin B1 content increases significantly as the level of substitution of the soybean flour increases (Sharma, 2020). The observed trend is due to the fact that soybean is a better source of vitamin B1 compared to OFSP so an increment in the soybean flour saw a significant increase in the vitamin B1 content (Sharma, 2020).

Pro-vitamin A (beta carotene) values reduced significantly from 27.61ug/100g in ComF1 and the highest value was registered in ComF5, 6.65 ug/100g. The orange nature of OFSP will significantly add to the composition of carotene in the soybean, tropical almond flour blend. This makes the product a good source of beta carotene, as it is a vitamin A precursor. Fanta, 2019 and Mohammad et al., (2016) also support this claim.

CONCLUSION

The present study showed that OFSP, soybean and tropical almond flour have great potentials in the production of highly nutritious complementary food.The substitution of OFSP flour with soybean and tropical almond flour for the production of complementary food significantly improved the nutritional composition in terms of protein, ash, fat, and crude fibre contents while carbohydrate content was observed to decrease. Energy content of the flour blends decreased as substitution of soybean flour increased. The functional and pasting properties provided insights into the texture, stability, and processing characteristics of the formulations and also provided an understanding of how the formulations behaved under heating and mechanical agitation. These insights are pivotal in optimizing processing methods and ensuring the desired sensory attributes and nutritional benefits of the foods are retained. ComF3 was most acceptable because it contained all essential nutrients in their correct proportions, had a minimum antinutrients content and compared favorably with the reference sample.

The mineral analysis highlighted appreciable amount of mineral such as calcium, magnesium, potassium, and iron, which are crucial for healthy growth, development, and overall well-being. Vitamin analysis showed that OFSP is rich in provitamin A carotenoids, which is a noteworthy approach to combat vitamin A deficiency especially in children. Antinutrient analysis showed that the procession methods greatly reduced the anti-nutrients in the raw material since their concentrations were significantly low. This is important for enhancing the bioavailability of essential nutrients in the complementary foods and maximizing their positive impact on health.

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