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Proximate Composition and Sensory Properties of Complementary Food from Sprouted (Sorghum & Soybean) and Carrot Flour

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ABSTRACT

Objectives: Complementary food consisting of sprouted sorghum, sprouted soybean and carrots was formulated at blend ratio of Sample A (70%:20%:10%), sample B (60%:30%:10%), Sample C (55%:30%:15%), Sample D (100%) & Sample E (Cerelac). **Methods:** Proximate composition and sensory evaluation were determined. **Results:** Sensory analysis showed that there was significant difference (P<0.05) among samples in colour, texture, taste, consistency, flavor and overall acceptability result shows that Sample B was more acceptable to the panelists. Proximate analysis revealed that moisture content ranged from 1.00 – 3.0%, protein content ranged from 10.48-15.50%, fat content ranged from 3.45-10%, and ash content ranged from 1-3%, fiber content ranged from 2.00-7.09%, carbohydrate content ranged from 55.16 – 66.82% and energy content ranged from 344.28 – 410.02kcals. **Conclusion:** This formulated complementary food has an increased nutrient absorption, protein availability found in grains which are attributed to the sprouting process. Thus, study reveal that the formulated complementary food could serve of another food source for infant and children, adult breakfast cereal, also use to fight malnutrition and reduce risk of vitamin A deficiency disorder.

Keywords: complementary food, sprouted sorghum, sprouted soybean, carrot, proximate composition, sensory analysis.

1. Introduction

Complementary foods play a crucial role in meeting the nutritional needs of infants when mother's milk is no longer sufficient after the exclusive breastfeeding period (Obinna-Echem et al., 2018). These foods are primarily derived from various sources such as cereals like wheat, maize, and rice, as well as roots, tubers, and legumes including soybeans and cowpeas. Formulating complementary foods often involves utilizing single or combined plant products, such as pairing cereals with legumes (Adepeju et al., 2024; Obinna-Echem et al., 2018).

Sorghum, belonging to the grass family Poaceae, encompasses a genus of flowering plants. Out of the twenty-five species, seventeen are indigenous to Australia, while others extend their range to regions such as Africa, Asia, Mesoamerica, and certain islands in the Indian and Pacific Oceans (Arukwe et al., 2022). Sorghum stands out for its abundant supply of vital nutrients, boasting high levels of protein, fiber, and essential B vitamins like niacin, thiamin, and vitamin B6. Additionally, it contains several dietary minerals, including iron and manganese (Adepeju et al., 2024; Arukwe et al., 2022).

Soybean (Glycine max), a legume species native to East Asia, is extensively cultivated for its versatile edible bean (Adepeju et al., 2024). Soybeans are notable for their relatively low carbohydrate content and relatively high protein content, along with a variety of health-promoting compounds. Collectively, soybean oil and protein constitute approximately 60% of the dry beans by weight, with protein accounting for 40% and oil for 20%. The remaining composition includes 35% carbohydrate and about 5% ash. Soybeans typically consist of approximately 8% seed coat or hull, 90% cotyledons, and 2% hypocotyls axis or germ (Ijabadeniyi et al., 2023).

Carrot (Daucus carota) stands out as the most significant crop within the Apiaceae family,

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widely distributed as a root vegetable across the globe. Initially utilized for medicinal purposes, carrots gradually transitioned into a dietary staple (Aduke et al., 2024). Historical documentation from Europe suggests their cultivation dating back to before the tenth century. Carrot flesh displays a spectrum of colors including white, yellow, orange, red, purple, and very dark purple (Pc et al., 2022). Renowned for their abundance in antioxidant compounds, carrots hold the title of being the richest vegetable source of pro-vitamin A carotene. These antioxidants play a vital role in shielding against cardiovascular disease and cancer while bolstering vision health, particularly in low-light conditions (Obinna-Echem et al., 2018).

Studies have shown that germination is used to improve nutritional efficiency and digestibility (Lemmens et al., 2019). Germinated grains contain high levels of amino acids essential for protein production in the human body. Evidence has shown that sprouting decreases anti-nutritional factors and increases the minerals and vitamin content of food materials (Benincasa et al., 2019).

Cereals lack important essential amino acids such as lysine and tryptophan, while legumes are rich in lysine and tryptophan (Ademulegun et al., 2021). Enhancing the nutritional quality of locally-produced complementary foods using soybeans and carrots is cheap and effective. The presence of small quantities of soybean and carrot can increase the protein, vitamins, and mineral content of the locally-produced complementary food (Ademulegun et al., 2021). This study aims to produce and evaluate the proximate composition and sensory properties of complementary foods from sprouted sorghum, sprouted soybean, and carrot flour.

2. Materials and Method

Preparation of sprouted sorghum, sprouted soybean and carrot flour

The sorghum, soybean, and carrot were bought from Kasuwa-bacci and Bakin-dogo market, Kaduna, Kaduna State.

One kilogram of sorghum was sorted, washed, and soaked in water for 24 hours. After 24 hours, the water was drained and the seeds were washed again. The seeds were spread on jute bags and water was sprinkled every 3 hours for 3 days (72 hours) allowed to sprout at room temperature. The sprouted sorghum was washed and oven-dried at 105^{o}C. After drying, the sprout was removed and milled with a hammer mill. The flour was sieved and packaged in a well-labeled plastic container and, stored for nutrient analysis.

One kilogram of soybean was sorted, washed, and soaked in water for 24 hours. After 24 hours, the water was drained and the seeds were washed again. The seeds were spread on jute bags and water was sprinkled every 3 hours for 3 days (72 hours) allowed to sprout at room temperature. The sprouted soybean was washed and oven-dried at 105^{o}C. After drying, the sprout was removed and milled with a hammer mill. The flour was sieved and packaged in a well-labeled plastic container and, stored for nutrient analysis.

Fresh carrots were washed and the outer layers were scraped. About 2kg of the carrots were grated, dried at 50^{o}C for 8 hours, and blended with hammer mill to obtain carrot flour. The prepared flour was packaged in well labeled plastic container and stored for nutrient analysis.

2.1. Recipe formulation for the sprouted sorghum, sprouted soybean and carrot complementary food

The recipe comprises of sprouted sorghum, sprouted soybean and carrot flour as shown in Table 1. Sprouted sorghum without any substitution and Cerelac (commercial product) served as negative and positive controls respectively.

2.2. Proximate Composition

Proximate analyses were carried out on the samples using AOAC standard methods (Adepeju et al., 2024). Moisture content was calculated after drying at 105oC to constant weight in an air oven (Thermo Scientific-UT 6200, Germany). Lipids were estimated by exhaustive extraction of the known weight of samples with petroleum ether using a rapid Soxhlet extraction apparatus (Gerhardt Soxtherm SE-416, Germany). The determination of protein was by the Kjeldahl method. The efficiency of the nitrogen values was corrected with acetanilide values and multiplied by the factor of 6.25 to obtain the protein value. Ash was determined gravimetrically after incineration in a muffle furnace (Carbolite AAF-11/18, UK) for 24 h at 550oC. The crude fiber was obtained by the difference after the incineration of the ash-less filter paper containing the insoluble materials from the hydrolysis and washing of moisture -

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-free defatted sample (0.5 g). Carbohydrate content was determined by the difference: 100 %-(% MC+% Ash+% Crude protein+% Fat+% Crude fiber). Energy (Kcal/g) was calculated using the Atwater factor of 4.0 Kcal/g for protein and carbohydrate and 9 Kcal/g for fat.

2.3. Sensory Evaluation

Each of the various blends as shown in Table 1 was mixed with 200 mL of cold water to make slurry. Then equal part of boiling water was added to the slurry with continuous stirring to obtain the sprouted sorghum-sprouted soybean-carrot pap. Sensory evaluation of the complementary food samples was carried out for consumer acceptance and preference using 20 untrained panelists consisting of students of Kaduna Polytechnic, Kaduna State who were randomly selected, a 9point hedonic scale according to Adepeju *et al*. (2024) where 1 represents dislike extremely and 9 represent like extremely was used. The panelists were provided with 5 coded samples of the weaning food labeled A-E and were asked to assess the quality attributes in terms of color, texture, taste, flavor, consistency, and overall acceptability using appropriate scores and ratings for each sample.

Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA) using statistical package for social science (SPSS) version 22 to test significant difference among means ($P \leq 0.05$).

3. Results and Discussion

The proximate composition of the formulated complementary food shown on Table 2.

Generally, protein has been shown to increase as a result of germination and the net syntheses of enzyme protein during germination accounted for the protein increase (Benincasa et al., 2019). The slight decrease in the protein content of 100% sorghum flour processed by germination may be attributed to the low protein present in sorghum. Evidence showed that a large amount of nitrogen was transferred to the roots and shoots of sorghum during malting. The protein content of the complementary foods was within the range of 16-20% recommended for infants (Adepeju et al., 2024; Aduke et al., 2024; Obinna-Echem et al., 2018).

The protein contents of the complementary foods were in agreement with 15, 16, 15, and 10.8% reported for Cerelac, Nutrend, Rebena, and Cowbell which are popular complementary foods in Nigeria (Agu & Kloyah, 2004). The protein quality of the blends may have been improved due germination. Evidence have shown that sprouting increased the available lysine content of soybean flour (Ademulegun et al., 2021; Aduke et al., 2024; Obinna-Echem et al., 2018). However, this needs to be studied. Increase in lysine and tryptophan contents during germination of maize was also reported (Pc et al., 2022). Several studies have shown that germinated grains are digestible i.e., increased accessibility of the amino acids to digestive enzymes (Benincasa et al., 2019). Proteins are popular source of essential amino acids and source of energy during energy deprivation, although fat and carbohydrate and utilized preferentially by the body (Benincasa et al., 2019). Protein deficiency is almost always accompanied by inadequate energy intake and the two together leads to protein calorie malnutrition (PCM), one of the commonest forms of malnutrition worldwide (Benincasa et al., 2019).

The decrease in ash content of germinated blends was probably due to leeching of the minerals during soaking and the redistribution of minerals from the sorghum soybean seeds to the roots and shoots during germination (Lemmens et al., 2019). The roots and shoots of the germinated sorghum and soybean seeds were discarded in this study. The germination decreased fat content and improves crude fiber content of millet (Aanchal et al., 2024).

In this study, the fat was oxidized (probably) for the energy needs of the germinating sorghum and soybean seedlings. However, in this study, the fat contents of the complementary food blends were lower than the 9% recommended for weaning foods in Nigeria (Aduke et al., 2024; Obinna-Echem et al., 2018). Studies reported that the decreased fat content of germinated beans was attributed to increased lipoxygenase activity during germination, rapid use of lipids for energy, and synthesis of certain structural constituents in the young seeding (Nemzer &

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Table 1. The recipe comprises of sprouted sorghum, sprouted soybean and carrot flour as shown in Table

Sample	Sprouted sorghum	Sprouted soybean	Carrot
A	70%	20%	10%
B	60%	30%	10%
C	50%	35%	15%
D	100%		
E	Cerelac		

Table 2: Proximate composition (%) of complementary food formulated from sprouted sorghum, sprouted soybean and carrot flour blend.

Sam-	Moisture	Protein	Fat	Ash	Fiber	Carbohydrate	Energy
A	14.01±0.01	13.54±0.01	8.51±0.01	1.00±0.01	6.80±0.0	56.16±0.01	355.35±0.06
B	15.50±0.01	15.50±0.01	8.11±0.01	1.50±0.01	7.09±0.0	56.31±0.02	344.28±0.12
C	13.50±0.01	15.00±0.00	7.94±0.01	1.50±0.00	6.90±0.0	55.16±0.00	352.19±0.13
D	11.01±0.01	10.48±0.04	3.45±0.00	1.50±0.01	6.75±0.0	66.82±0.05	340.20±0.36
E	5.01±0.01	15.01±0.01	10.00±0.0	3.00±0.01	2.00±0.0 1	65.00±0.01	410.02±0.2

Values with different superscript in the same column differ significantly (P≤0.5).

Al-Taher, 2023; Zinia et al., 2022).

The decreased fat content of sprouted (Sorghum & soybean) and carrot complementary foods would reduce the development of rancidity in the foods. Fats are essential nutrients in human and animal diets. Fats make foods more palatable, giving a sense of fullness following a meal. Linoleic acid is highly concentrated in the brain and is important for cognitive and behavioral health along with normal growth and development (Lemmens et al., 2019; Nemzer & Al-Taher, 2023). Palmitic acid facilitates the long-term storage of energy in human cells. According to the Protein Advisory Group Guidelines for weaning foods, protein content should be 20%, fat levels up to 10%, and total ash not more than 5% (Aduke et al., 2024; Pc et al., 2022).

The increase in crude fiber content of sorghum and soybean on germination may be attributed to synthesis of cell wall materials to support the shots and roots. The crude fiber content of the complementary food varied from 6.7 to 7.09% values, being higher than report of Akubor (2016) germinated cowpea and sweet potato flour blends. The therapeutic effects of fibre in prevention of heart disease, colon cancer and diabetes and its role in the treatment of digestive disorder (diverticulitis and constipation) in adults are well documented (British Nutrition Foundation, 2018; Sureda et al., 2020). However, increase intake of fiber increase stool bulk, may cause flatulence, and decreases appetite. Furthermore, fiber load can also affect the efficiency of essential nutrient absorption from a diet with marginal nutrient contents, and recommend that complementary foods fiber should be reduced to a level not exceeding 5g per 100g on a dry weight basis (Ademulegun et al., 2021).

In this study, three samples of sorghum-soybean-carrot flour blend had

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adequate amounts of carbohydrates (55.16 - 66.80 gram), which are comparable to 62, 63, 66 and 53% reported for Cerelac, Nutrend, Rebena, and Cowbell complementary foods, respectively (Pc et al., 2022). The high contents of carbohydrates gave the blends adequate amounts of calories that were comparable to those recommended for infants (Esan et al., 2022).

The moisture content, a crucial parameter widely employed in food processing and quality testing, was observed to range from 11% to 15.50%. Specifically, sample A exhibited 14%, sample B 15.50%, sample C 13.5%, and sample D 11%. These values surpass the moisture content reported for Cerelac (5%) and cowpea and sweet potato flour blend (9.8%), as documented by Akubor (2016). Elevated moisture content has the potential to adversely impact the storability and overall quality of the product.

Sensory properties of foods are influenced by the method of preparation, formulation, processing, and storage conditions (Fellows, 2016; Martínez & Carballo, 2024). The germinated samples were bitter which affected the taste of the blends due to the presence of germinated sorghum and soybean. Germination modified the structure of sorghum and soybean via starch hydrolysis which gave improved texture to the blend containing germinated sorghum and soybean (Ademulegun et al., 2021). There were probably increased lipolytic enzyme activities which hydrolyzed fats to free short-chain fatty acids that imparted flavor and aroma to the complementary foods containing the germinated flour (Ijabadeniyi et al., 2023). Even though the Cerelac (reference) received higher scores for the sensory quality attributes assessed, the germinated and carrot flour complementary food was generally accepted and the acceptance would improve with continued use. Many types of processed complementary foods have been developed and tested in Nigeria and many other developing countries (Adepeju et al., 2024; Aduke et al., 2024; Pc et al., 2022). The choice of complementary food is affected by family dietary patterns, culture, customs, beliefs, previous experience with feeding patterns, nutritional knowledge, and climate (Ademulegun et al., 2021). However, the development of complementary foods should be guided by higher nutritional value to supplement breastfeeding, acceptability, low cost, and use of local food items (Pc et al., 2022).

4. Conclusion

This study has shown that the complementary foods that can prepared at household levels contain appreciable amounts of carbohydrates, protein, fat, fiber, and ash. Soybean which is a utilized legume, locally available in Nigeria presents a great potential for use at the household level in enriching cereals-based complementary foods to prevent malnutrition in infants, especially in poor resource settings. Supplementing complementary food with vitamin A-rich food as carrots will also reduce and prevent vitamin A deficiency disorder among infants and children.

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