ID: 274

Complementary Food Produced from "*Atilla-Gan-Atilla*" Wheat, Sorghum and Groundnut Fortified with Baobab Fruit Pulp

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Abstract

The aim of this research work is to improve the nutritional quality of complementary food products by supplementing some percentage of the composite mixture with baobab fruit pulp powder. The baobab fruit (BF) pulp was added in different proportions (17%, 12%, 9%, 5% and 2%). Five different complementary formulations of wheat (*Atilla-gan-Atilla*), sorghum, ground nuts and baobab fruit pulp were prepared in different ratios, the following samples were obtained: ASG1, ASG2, ASG3, ASG4 and ASG5. The samples were analyzed for proximate composition, functional analysis and sensory evaluation. The results obtained show that ASG1 has a significantly higher value at $P<0.05$ of moisture content compared to the remaining samples, while sample ASG5 has significantly high amount of ash (1.22%), fat content (9.31%), fiber (3.40%) and protein (39.92%). The carbohydrates (74.68%) was found to be significantly higher in the control sample. As for the functional properties of the complementary food, the swelling index was significantly high in the control sample (100.35%), followed by sample AGS2 (94.72%). The lowest swelling index was observed for sample AGS3 (88.48%), while sample AGS4 had the highest significant level (97.30) which was close to the control sample. Sample AGS2 was found to have the highest water absorption capacity compared to all the remaining samples (76.7%). Bulk density of the sample AGS1, AGS2 and AGS3 were not significantly different ($P<0.05$). The scores obtained for the organoleptic test for the sample shows that, sample AGS2, AGS3 and AGS4 had no significant difference at $P<0.05$ for flavour, colour, taste and texture. Samples ASG3 and ASG4 had a 7.15 acceptance score in sensory analysis on a 9-point hedonic scale scorecard, which made them more acceptable than the other samples. The results showed that the addition of baobab pulp powder significantly increase the nutritional composition of the complementary food product and will as well help in decreasing the malnutrition in children.

Key Words: *Complementary food, Baobab fruit pulp, Wheat (atilla-gan-atilla)*

Introduction

The greatest meal for infants is breast milk, which provides them with all the nutrients they need for healthy mental and physical development. It offers all necessary minerals in an easily absorbed form, along with proteins, immunological and bioactive components, and polyunsaturated fatty acids (Ballard and Morrow, 2013). However, beyond 6 months of age, human milk is no longer enough to supply the growing newborns' nutritional needs (Hampson et al., 2019). A lot of mothers, particularly in developing nations, breastfeed for 12 months, while others continue up to 24 months. Weaning, also known as supplementary feeding, starts at 6 months and lasts until the child is 24 months old or older and is therefore necessary to meet their developing nutritional needs in addition to mother's milk (World Health Organization, 2019). It is the period between the children's regular family meals and their exclusive breastfeeding. Weaning, which involves giving newborns mashed or semi-solid adult meals, must be balanced and properly adapted nutritionally for the infants (Cichero, 2016; Koletzko et al., 2019).

Foods during weaning should be calorie-dense and high in quality protein, vitamins, and minerals. In order for newborns to readily swallow and digest these foods, they should be precooked or properly processed with low amounts of indigestible fiber (Abeshu et al., 2016). The key time around weaning is when many children first experience malnutrition, which greatly contributes to the high prevalence of malnutrition in children under the age of five. In low-income nations, 40% of children are malnourished, according to WHO (World Health Organization, 2018). According to the UNICEF study, global trends in child undernutrition, including stunting and wasting, shortages of crucial micronutrients, and childhood overweight and obesity, continue to be extremely concerning despite progress in some places (WHO, 2022). Estimates show that 45 million children under the age of five are underweight, 39 million children under the age of five are overweight, and 149 million children under the age of five have stunted growth and development as a result of a chronic lack of nutrient-rich foods in their diets (UNICEF, 2023).

Native to sub-Saharan Africa's semi-arid and sub-humid regions, the baobab (Adansonia digitata L.) is a multipurpose tree. More than 300 traditional uses are listed, with a long lifespan (a few hundred to thousands of years) (Dossa et al., 2023). Due to its high mineral and vitamins content, the pulp of the baobab fruit enhances the nutritional value of diets. Traditional uses of baobab products, such as their bark, fruits, seeds, and leaves, support the local populaces' ability to survive in Africa by providing them with a source of food, fiber, and medicine

(Kamatou et al., 2011), as well as serving as a significant source of revenue (Muthai et al., 2017). In addition, , the various plant parts have been utilized to cure a number of illnesses, including toothaches, fever, malaria, diarrhea, and dysentery (Monteiro et al., 2022).

Baobab pulp is typically dissolved in water or milk and used as a beverage, condiment, snack, or a fermenting agent in regional beers (Rahul et al., 2015). Fructose, saccharose, and glucose gives the pulp its sweetness, while organic acids including citric, tartaric, malic, succinic, and ascorbic give it its acidic flavor (Nouruddeen et al., 2014). After the European Union (EU) approved the sale of baobab dried fruit pulp as a novel food component in 2008 (OJEU, 2008), the scientific community's interest in baobab grew. Baobab fruit pulp was subsequently designated as GRAS (Generally Recognized as Safe) by the US Food and Drug Administration (FDA) in 2009 (FDA 2017). Recent research on the nutritional value of various baobab parts (leaves, pulp, and seeds) has found high phenolic compound concentrations (Ismail et al., 2019), high antioxidant capacity (Nouruddeen et al., 2014), and essential fatty acids, vitamins (A, D, E, and F) (Chepngeno et al., 2022), at levels that meet the daily recommended intake requirements. Baobab pulp is further characterized by a low water content, high ascorbic acid, procyanidins, flavonol glycosides, dietary fiber, calcium (Ca), and potassium (K) levels, as well as other properties (Ismail et al., 2019). Some natural product vendors refer baobab as a "superfood" due to its abundant chemical compounds thought to be good for human health, a claim that lacks any scientific backing beyond speculative health benefits. The word "superfood" is clearly more effective for its marketing potential than for giving the best nutrition, even when science supports the health benefits of some foods (such as quinoa, flax seed, and buckwheat), labeling them as "superfoods"(Chadare et al., 2009). Therefore, the rising tendency of baobab consumption may boost these meals in the near future. As a result, the current study's goal was to improve the nutritional composition and functional properties of the complementary foods with fatty acid levels, nutritional content, bioactive substances, mineral composition, vitamins and sensory acceptance.

Materials and Methods

Samples Collection

Atilla-gan-Atilla Wheat, Sorghum, Groundnut and Baobab fruit pulp were bought from Kano State Agricultural & Rural Development Authority (KNARDA). All chemicals and solvents used in this research were of analytical grade.

Preparation of the Sample

Figure 1 presents the flow chart of the sample preparation method for converting the grains into flour.

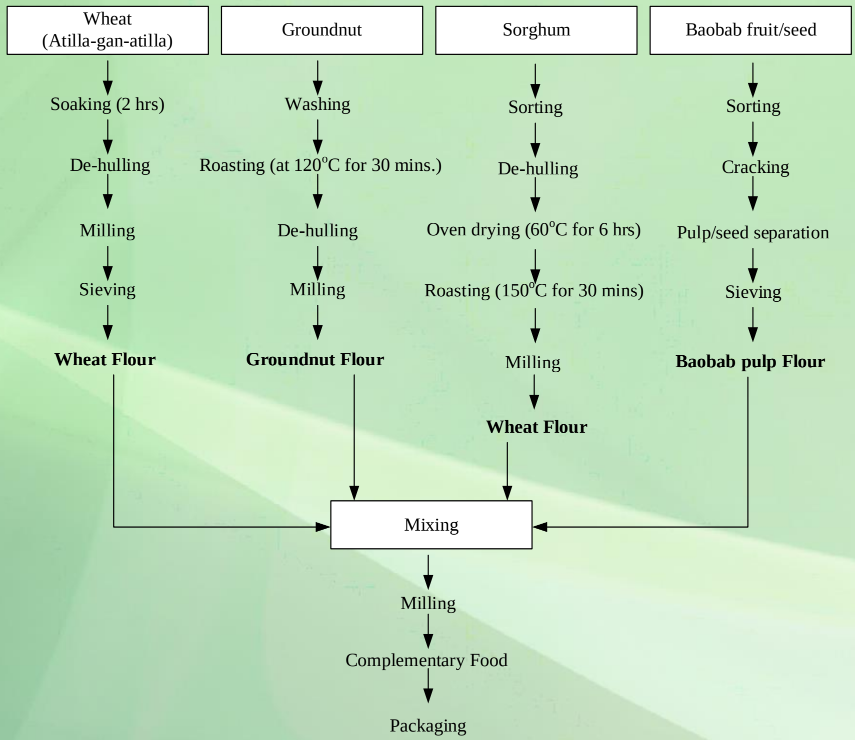

Figure 1: Flow Chart of the Flour Sample Preparation

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Experimental Design

Table 1 shows the five samples of the complementary food that were produced in this study.

Table 1. Formulation of Complementary Food

s/n	Sample Name	Wheat *(Atilla-Gan-Atilla)* (%)	Sorghum (%)	Groundnut (%)	Baobab Fruit Pulp (%)
1	Control	80	10	10	0
2	ASG 1	63	10	10	17
3	ASG 2	68	10	10	12
4	ASG 3	71	10	10	9
5	ASG 4	75	10	10	5
6	ASG 5	78	10	10	2

Methodology

Proximate of the Complimentary Food

The proximate composition of the complimentary food were analyzed using the AOAC official methods (1984) viz. moisture (method: 948.12), crude protein (method: 955.04), crude fat (method: 920.39C), ash content (B 920.117). Crude fiber content was determined using the methods described by Pearson (1976), while the total carbohydrate content was determined by difference.

Determination of Color and Bulk Density

The color and bulk density were determined according to the method described by Wan *et al*. (2014). For color, the measurement was done by placing the complimentary food sample in a transparent glass cuvette and transferred to a colorimeter (HunterLab, UltraScan Pro 1092, USA), which was equipped with a tri-stimulus software (EasyMatch QC) with coordinates L*, a*, and b*. L* (0 to 100) denotes dark (0-50) to bright (50-100). The a* denotes redness (+) to greenness (-) and b* denotes yellowness (+) to blueness (-). The machine was standardized with black and white tiles before the start of measurement.

For bulk density, a graduated glass tube was weighed (W_1) and was filled with a complimentary food sample which was tapped gently to reach the 10 mL mark until there was no further diminution of the particles. The tube containing the sample was weighed (W_2) and bulk density was calculated as the difference in weight (W_2-W_1).

Water Absorption Capacity

The water absorption capacity was determined using the method described by Rodriguez-Ambriz *et al*. (2005) with a slight modification. Complimentary food sample (1 g) was weighed into a 15 mL pre-weighed centrifuge tube and 10 mL of distilled water was slowly added to the tube under continuous stirring with a glass rod. The mixture was centrifuged at 2000 ×g for 20 mins. The supernatant was gently decanted, and the tube was reweighed. Water absorption capacity was calculated using equation (1):

$$\text{Water absorption capacity (\%)} = \frac{W_2 - W_1}{W_0} \times 100 \qquad (1)$$

where W_0 is the weight of the dry sample (in g), W_1 is the weight of the tube plus the dry sample (in gr), and W_2 is the weight of the tube plus the sediment (in g).

Determination of Swelling Power

Swelling power of complimentary food sample was determined according to the method of (Sosulski. 1962). About 250 mg (W1) of the sample was taken in a centrifuge tube and weighed the centrifuge tube with sample (W2) and 10 ml (VE) of distilled water was added. Then it was allowed for 30 mins in a boiling water bath at 100 °C. The contents were cooled and centrifuged at 5000 rpm for 10 mins. The supernatant was carefully decanted in a test tube. The water adhering to the sides of centrifuge tube was wiped well and weight of the centrifuge tube was taken with swollen material (W3). The swelling power of seed flour per gram was calculated using equation (2):

$$\text{Swelling Power} = \frac{W_3 - W_2}{W_1} \qquad (2)$$

Determination of Dispersibility

10g of each flour sample was weighed into a 150ml measuring cylinder. 100ml distill water was added and then vigorously stir and allowed to settle down for 3hours, (Onwuka, 2005). The volume of the settled particles was recorded and then subtracted from 100 to give a difference that is taken as percentage dispersibility.

Dispersibility (%) = 100 ml – volume of settled particles (ml).

Statistical Analysis

Triplicate sample preparations were used to obtain measurement values which were reported as mean ± standard deviation. One-way ANOVA was used to teste the statistical significance (*P<0.05*) using Turkey test. Minitab statistical software was used for the statistical analyses.

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Results and Discussion

Table 2 displays the proximate compositions of the control and five supplemental food samples (ASG 1, ASG 2, ASG 3, ASG 4, and ASG 5). The results obtained show that ASG1 has a significantly higher value at P<0.05 of moisture content compared to the remaining samples, while sample ASG5 has significantly high amount of ash (1.22 %), fat content (9.31 %), fiber (3.40 %) and protein (39.92 %). The carbohydrates (74.68%) was found to be significantly higher in the control sample. The sample ASG 5 was discovered to have the greatest protein content, fat content (9.3 %) and fiber (3.40 %) among these five supplementary foods (39.92 %). The high protein and fat content may be attributed to the presence of ground nuts (24 %) in the sample compared to the remaining samples, while the highest percentage of fat observed in sample ASG 5, when compared to the commercial weaning meals (control) is of good importance. According to Satish & Shrivastava., (2011), the recommended percentage of fat in weaning food is up to 10%. However, because legumes are an excellent source of unsaturated fatty acids, this formulated sample (ASG 5) contains the most of them compared to other formulated and locally produced weaning foods.
The high fiber content may be due to the bran from the wheat and sorghum (24 %). Furthermore, the first year of life is critical for the development of the gut flora, and low dietary fiber can impede this development. Low fiber diets may also increase the risk of constipation in children. Our best sample had a fiber percentage of 3.4 %, whereas the commercial sample had the fiber level at 1.15 %. The result for the protein content was in line with that of Barde et al., 2022. Additionally, sample ASG 1 had the highest carbohydrate content of the three samples (64.72%), which was mostly due to the large proportion of wheat (Atilla-gan-Atilla). Some previous studies stated that children at complementary feeding age need more energy to cope up with their daily requirements (Abeshu*et al*., 2016).

Table 2. Proximate Composition of Complimentary Food Formulation

Sample	Moisture (%)	Ash (%)	Fat (%)	Fiber (%)	Protein (%)	Carbohydrate (%)
Control	9.7±0.14^{b}	0.81±0.01^{d}	2.10±0.14^{e}	1.15±0.04^{f}	11.71±0.45^{f}	74.68±0.50^{a}
ASG 1	9.96±0.05^{a}	0.81±0.14^{d}	3.50±0.00^{d}	1.87±0.07^{e}	19.13±0.77^{e}	64.72±0.91^{b}
ASG 2	9.22±0.02^{c}	0.80±0.00^{d}	4.22±0.03^{c}	2.05±0.04^{d}	24.51±0.64^{d}	59.18±0.54^{c}
ASG 3	9.30±0.14^{c}	0.90±0.00^{Cd}	5.47±0.03^{c}	2.73±0.07^{c}	29.13±0.55^{c}	52.45±0.51^{d}
ASG 4	8.70±0.14^{d}	1.13±0.02^{ab}	6.70±0.28^{b}	3.27±0.01^{b}	36.09±1.54^{b}	44.11±2.00^{e}
ASG 5	8.60±0.00^{d}	1.22±0.03^{a}	9.31±0.28^{a}	3.40±0.02^{a}	39.92±0.77^{a}	37.55±0.49^{f}

Each value in the table represents the mean of three replicates ± standard deviation. Values in the same column followed by different superscript letters are significantly different at $P<0.05$.

Table 3. Bulk Density and Color of Complimentary Food Formulation

Types of protein	Bulk density (g/cm^3)	Color		
		*L**	*a**	*b**
Control	0.81 ± 0.04^{a}	50.89 ± 0.60^{a}	4.15 ± 0.10^{bc}	15.12 ± 0.14^{c}
ASG1	0.67 ± 0.03^{b}	41.11 ± 0.13^{b}	4.40 ± 0.11^{c}	16.40 ± 0.10^{bc}
ASG2	0.66 ± 0.02^{b}	40.44 ± 0.21^{b}	5.06 ± 0.10^{bc}	17.08 ± 0.10^{b}
ASG3	0.66 ± 0.02^{b}	39.92 ± 0.10^{b}	5.21 ± 0.50^{b}	17.12 ± 0.12^{ab}
ASG4	0.63 ± 0.02^{c}	39.84 ± 0.10^{b}	5.32 ± 0.10^{ab}	17.53 ± 0.09^{a}
ASG5	0.60 ± 0.02^{d}	37.92 ± 0.10^{c}	5.92 ± 0.10^{a}	17.92 ± 0.10^{a}

Each value in the table represents the mean of three replicates ± standard deviation. Values in the same column followed by different superscript letters are significantly different at $P<0.05$.

Table 4. Functional Properties of Complimentary Food Formulation

Sample	Dispersibility (%)	Water Absorption Capacity (%)	Swelling Index (%)
Control	0.81±0.00^{a}	82.5±0.01^{a}	100.35±0.02^{a}
ASG 1	71.50±2.12^{b}	76.89±0.01^{b}	89.63±0.15^{e}
ASG2	72.50±0.70^{b}	76.7±0.02^{b}	94.72±0.40^{c}
ASG3	72.00±1.41^{b}	68.66±0.02^{c}	88.48±0.34^{f}
ASG4	72.50±0.70^{b}	67.78±0.00^{c}	97.30±0.11^{b}
ASG5	73.00±0.00^{b}	67.77±0.02^{c}	90.74±0.23^{d}

Each value in the table represents the mean of three replicates ± standard deviation. Values in the same column followed by different superscript letters are significantly different at $P<0.05$.

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Table 5. Sensory Evaluation of Complimentary Food Sample

Sample Code	Flavour/ Aroma	Color	Taste	Texture	Overall Acceptability
ASG1	6.50±1.46^{b}	5.90±1.29^{d}	6.75±1.55^{c}	6.50±1.31^{b}	6.65±1.38^{b}
ASG2	7.05±0.88^{a}	6.70±1.21^{c}	7.45±1.05^{b}	6.45±1.19^{b}	6.75±0.78^{ab}
ASG3	7.40±1.35^{a}	7.05±1.23^{a}	7.00±1.29^{a}	6.90±1.11^{a}	7.15±0.98^{a}
ASG4	7.45±1.19^{a}	7.70±1.21^{b}	7.05±1.66^{a}	6.40±1.53^{b}	7.15±1.26^{a}
ASG5	6.60±1.46^{b}	7.30±1.38^{ab}	7.10±1.16^{a}	6.65±1.46^{ab}	6.65±1.08^{b}

Each value in the table represents the mean of three replicates ± standard deviation. Values in the same column followed by different superscript letters are significantly different at *P*<0.05.

The functional properties of the complementary food as seen in Tables 3 and 4, the swelling index was significantly high in the control sample (100.35%), followed by sample AGS2 (94.72%). The lowest swelling index was observed for sample AGS3 (88.48%), while sample AGS4 had the highest significant level (97.30) which was close to the control sample. Sample AGS2 was found to have the highest water absorption capacity compared to all the remaining samples (76.7%). Bulk density of the sample AGS1, AGS2 and AGS3 were not significantly different (P<0.05). In the formulation of the product, functional traits such bulk density, water absorption, swelling index, and dispersibility features are crucial (Otegbayo et al., 2009). The complementary food's texture characteristics and functional characteristics will serve as a guidance. The results also showed that the addition of baobab pulp at different proportions decreased the bulk density and *L** as compared to the control samples, while the *a** and *b** increases as the substitution of baobab pulp increase.

Results for water absorption capacity (WAC) as seen in table 4.3 show significant difference (*P<0.05*) between the samples analysed as presented in table 4.3. Compared to the control sample the % WAC and dispersibility of the sample were decreasing as baobab pulp was added. High and low WAC in complimentary food could be attributed to several factors such as size, shape, steric factors, conformational characteristics, hydrophilic-hydrophobic balance of amino acids in the protein molecules as well as lipids, carbohydrates and tannins associated with the proteins (Zayas, 1998; Mao and Hua, 2012). There was an inconsistency in the swelling index result from the control down to the formulated samples. Generally, swelling reduces as the pH increases until it reaches the isoelectric point, because at this pH, minimum swelling takes place because of minimum repulsion among the constituent amino acids. Then, a progressive increase of the solubility occurs with a further increase in pH. The balance in positive and negative charge minimised the electrostatic repulsion (Ogunwolu et al., 2009). The content of vitamin c in the baobab pulp could be the reason for the inconsistency of the swelling index.

Five samples (ASG 1, ASG 2, ASG 3, ASG 4 and ASG 5) with various proportions of the locally produced, readily available crops (wheat, sorghum, groundnut and baobab fruit pulp) in Nigeria with the goal of creating a more affordable and nutrient-dense complementary food. Twenty infants between the ages of 6 and 24 months served as panelists alongside their mothers to interpret whether the product was accepted or rejected based on the infants' actions and attitudes. The five samples' sensory characteristics were evaluated using a 9-point hedonic scale. The scores obtained for the organoleptic test for the sample as seen in Table 5, shows that, sample AGS2, AGS3 and AGS4 had no significant difference at P<0.05 for flavour, colour, taste and texture. Samples ASG3 and ASG4 had a 7.15 acceptance score in sensory analysis on a 9-point hedonic scale scorecard, which made them more acceptable than the other samples. The high protein content in all formulated sample most especially ASG 5, which had a protein level of 39.92% will be of advantage. On the other hand, inadequate dietary fat consumption is bad for immune system and mental development in children, while adequate dietary fat intake is helpful for both.

Conclusion

Commercial supplementary foods are relatively expensive in Nigeria, making them unaffordable for the majority of parents with young children. The majority of kids have inadequate nutrition throughout the weaning stage and are at risk of malnutrition. Because of this, it's crucial to produce nutritionally sound weaning foods using inexpensive basic components that are readily available locally. According to the findings of this study, supplementary foods that are high in antioxidants and match infants' macronutrient needs can be prepared with a small amount of baobab fruit pulp added. According to the results of the sensory evaluation, samples ASG 1 and ASG 2 were disqualified because the product was too sour due to the baobab pulp's percentage addition. The study's findings indicated that adding baobab pulp will boost the food's nutritional value and antioxidant content, which will nourish the baby during the weaning stage.

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