Nutrient, Anti-nutrient, Functional and Sensory Properties of Complementary Diet Made from Brown Rice, Kidney Beans, Orange Fleshed Sweet Potato and Carrot Flours

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Abstract

The study evaluated the nutrient, anti-nutrient, functional and sensory properties of complementary food from brown rice *(oryza sativa)*, kidney beans *(phaseolus vulgaris l.)*, orange fleshed sweet potato *(ipomoea batatas)* and carrot *(daucus carota l)*. The kidney beans *(phaseolus vulgaris l.)* and carrot *(daucus carota l)* was purchased from Relief Market Owerri, Imo State, brown rice was purchased from Abakiliki Market, Ebony State, while orange fleshed sweet potato was purchased from National Root Crop Research Institute (NRCRI) Umudike Abia State. These raw materials were sorted, cleaned and processed into individual flours. The composite flour blends were formulated into four samples in ratio of BK (Brown rice (70%) and kidney beans (30%) flour), BKOC (Brown rice (60g), kidney beans (25g), orange fleshed sweet potatoes (10g), and carrot (5g) flour), $BKOC_1$ (Brown rice (50g), kidney beans (20g), orange fleshed sweet potatoes (15g), and carrot (15g) flour), $BKOC_2$ (Brown rice (40g), kidney beans (20g), orange fleshed sweet potatoes (20g), and carrot (20g) flour). Chemical and functional properties analysis of the samples were determined using standard methods while sensory evaluation was done using a nine-point hedonic scale. Data obtained were analyzed with ANOVA to compare different variables using IBM SPSS Statistics Version 23. Result of mineral composition showed that showed that Sample BKOC2 was significantly higher ($p < 0.05$) in the mean value of Iron (7.44 mg), Zinc (5.61 mg), Potassium (416.33 mg), magnesium (183.67 mg) and sodium (209.50 mg) contents than other samples. Result of the anti-nutrients composition showed that BK had tannin content of 0.683 mg/100 g, $BKOC_1$ had a tannin content of 0.42 mg/100g, Cerelac had a phytate content of 0.084 mg/100g, BKOC recorded phytate content of 0.85 mg/100g, $BKOC_2$ had an oxalate content of 0.4 mg/100 g. The study showed that the complementing of brown rice-based complementary foods with kidney beans, orange fleshed sweet potatoes and carrot flours improved the protein, fat, carbohydrate, mineral and vitamin contents of the products as well as improved the functional properties. Results obtained in this present study also showed that the complementary food blend samples analyzed in this present study presented a low content of anti-nutrients and therefore, does not constitute a major health hazard in this regard, making it suitable for human consumption.

Keywords

Nutrient, Anti-nutrient, Functional, Sensory Properties, Brown Rice, Kidney Beans, Carrot Flours

1. Introduction

In order to supplement breastmilk, children aged 6 to 23 months are given solid, semi-solid, and soft meals (both commercially manufactured and locally cooked). Complementary feeding is the practice of giving a kid solid, semi-solid, and soft foods in addition to breastfeeding. There comes a time when a baby's nutritional demands cannot be met by breast milk alone as they get older and more active. In order to bridge the gap between the child's overall nutritional demands and the amounts supplied by breast milk, supplemental foods are therefore required [1]. Breastfeeding and having access to a wide variety of nutrient-dense foods during the supplemental feeding period, which lasts from 6 to 23 months, give kids the vital vitamins, minerals, and nutrients they need to reach their full physical and mental potential, with advantages that last well into adulthood [2]. Additionally, the supplemental feeding period is a crucial time to prevent micronutrient deficiencies, stunting, wasting, overweight, obesity, and non-communicable disorders linked to diet. Furthermore, childhood is frequently the time when lifetime eating preferences, tastes, and habits are formed [3]. Since both early and delayed introduction of complementary foods are linked to low nutritional status and increased morbidity, timing is crucial. In order to help newborns satisfy their nutritional needs and to prevent developmentally unready infants from being exposed to food-borne infections, the World Health Organisation (WHO) advises introducing meals other than human milk at six months of age [4]. Mothers' feeding habits alter when supplementary foods are introduced, and they may adopt other feeding techniques that don't meet the guidelines for the best infant nutrition. The kinds of food that mothers give their babies, as well as the frequency and sufficiency of feedings, are some frequent practices during the supplemental feeding era. Concerns about food limits resulting from cultural customs, unsanitary bottle-feeding methods, food preparation and handling, and responsive breastfeeding are also present during the child's supplemental feeding stage [5]. One of the most nutrient-dense grains is brown rice. It helps with digestion, is heart-healthy, and may lower the risk of diabetes, high cholesterol, and cancer. Around the world,

brown rice (Oryza sativa) is cultivated as a principal crop and a staple meal. Though their health advantages varies, brown rice comes in a variety of forms, including sticky (or glutinous) brown rice, black rice, white brown rice, and long-grain basmati. The preparation of brown rice contributes to its health advantages by encouraging the benefits of eating a balanced diet. The three components of the grain kernel are present in brown rice since it is a whole grain: the bran, which is the outside, fiber-rich layer; the germ, which is the nutrient-rich centre; and the endosperm, which is the starchy middle layer. [6] People typically eat kidney beans (Phaseolus vulgaris) as part of their diet. It comes from a common bean parent and is typically kidney-shaped and dark red in colour. Other names for this plant include rajma, surkh lobia, navy bean, pinto bean, snap dragon, and common bean. Brazil is one of the top producing nations. The perennial nightshade Solanum tuberosum L. produces the starchy, tuberous potato. The term "potato" can be used to describe either the edible tuber or the plant itself. There are several closely related cultivated potato species in the Andes, where the species is native. About 400 years ago, potatoes were brought outside of the Andes, and they have since grown to be a staple of a large portion of the global food supply. After rice, wheat, and maize, it is the fourth-largest food crop in the world. [7] The nutritional and physiological benefits of carrots are astounding. Since carrots are rich in carotenoids, phenolic compounds, polyacetylenes, and vitamins, they have solid reasons to be a part of a person's diet and may help lower the risk of certain diseases. According to experimental data, these carrot chemicals have immunostimulating, anticarcinogenic, and antioxidant properties. In Nigeria, malnutrition is pervasive in both rural and urban areas. Strict economic regulations and insufficient food production and supply-particularly of foods high in protein and micronutrients-are to blame for this. Our native crops are also being neglected. But recent increases in food costs and the need for foods high in protein have made it necessary to look into the nutritional potential of local foods that may aid in the fight against malnutrition [8]. Malnutrition has a severe negative impact on a country's population's growth, health, productivity, and standard of living. To the detriment of already disadvantaged people, it is a significant barrier to socioeconomic progress and feeds a vicious cycle of underdevelopment. Children who do not receive enough nutrition are unable to reach their full potential, and adults will struggle to sustain theirs.
For older infants and small children, the majority of families rely on locally prepared meals. Porridges and pap, two regionally prepared foods, are high in anti-nutritional elements that lower the bioavailability of some micronutrients and poor in protein. The proper processing techniques, including as soaking, dehulling, germination or sprouting, fertilisation, and heat processing, may make these foods safer even though they are not considered safe. When older infants are fed these meals, poor processing and cooking techniques can significantly contribute to the loss of micronutrients, which can result in micronutrient deficiency illnesses [9]. The majority of these supplemental foods are highly priced, making them less accessible to individuals who cannot afford them. Taking all of these factors into account, this research might be helpful in creating nutrient-dense, reasonably priced complementary diets for everyone utilising locally sourced ingredients such kidney beans, brown rice, potatoes, and carrots

2.Materials and Methods

2.1 Study Design

Experimental study design was employed for this study, the complementary food that was formulated from composite flours of brown rice, kidney beans, orange flesh sweet potato and carrot. The formulated complementary samples would be subjected to food analysis and the prepared gruels from each samples would be evaluated on the sensory attribute in the Department of Nutrition and Dietetics, Imo State University Owerri.

2.2 Procurement of Sample

The Kidney bean (*Phaseolus vulgaris* L.) and carrot (*Daucus carota* L) used for this study was purchased from relief market, Owerri, Imo State, Brown rice (*Oryza sativa)* was purchased from Abakiliki Ebony State while Orange fleshed Sweet potato (*Ipomoea batatas*) was purchased from National Root Crop Research Institute (NRCRI) Umudike, Abia State at 15kg each.

2.3 Processing of Brown Rice Flour

About 5kg of brown rice was cleaned to remove sand, broken grains and other foreign materials. It was washed, dried using food dehydrator at 60^{o}C, dry-milled using Kenwood blender, sieved, packaged in an airtight container and then packaged in airtight container for analysis.

2.4 Processing of Kidney Bean Flour

About 5kg of kidney beans was cleaned to remove sand, broken grains and other foreign materials. It was divided into two portions. One portion will serve as the control. The control portion was washed, dried using food dehydrator at 60^{o}C, dry-milled using Kenwood blender, sieved, packaged in an airtight container and stored in the refrigerator for analysis while the other portion was sprouted by soaking it in water for eight hours after which it was washed, rinsed and drained out completely. The well drained kidney beans were poured into a jute bag and allow to stay for 2-5days to initiate sprouting. During the sprouting days, it was washed 2-3 times daily to avoid fermentation and bacterial growth. After sprouting, it was dried using a food dehydrator at 60^{o}C, dry milled using Kenwood blender, sieved, cooled and packaged in airtight container for analysis.

2.5 Processing of Orange Fleshed Sweet Potatoes Flour

About 5kg orange fleshed sweet potatoes was washed, peeled, sliced, dried using food dehydrator, dry-milled, sieved, and packaged in an airtight container and stored in the refrigerator for analysis. Below is the step by step procedure on how the orange fleshed sweet potato was processed into flour.

2.6 Processing of Carrot Flour

About 5kg carrot was washed, peeled, sliced, dried using food dehydrator, dry-milled with Kenwood blender, sieved, cooled, packaged in an airtight container and stored in the refrigerator for analysis.

2.7 Formulation of Coding of Composite Blends

The brown rice, kidney beans, orange sweet potato and carrot flours were thoroughly mixed together at varying proportions of samples A = 70:20:0:0, B = 60:25:10:15 (24hr sprouted kidney beans), C = 50:20:15:15 (48 hrs sprouted kidney beans flour), D = 40:20:20:20 (72hrs sprouted kidney beans flour) samples.

2.8 Formulation of the Composite Flour

The composite flour samples was formulated according to the recommended daily allowance for infants for all the nutrients and micronutrients (carbohydrate (95g per day), Protein (base on 0.8g per kg body weight) = 13.5g per day, fat (30g per day), zinc (3mg per day), iron (11mg per day), calcium (270 mg per day), vitamin (500μg RAE per day).

Four (4) samples was generated and was used to obtain optimal blends using the proximate, mineral and anti-nutrient composition as responses. Besides moisture content that was minimized, all other responses were maximized while getting the optimization goals. The optimal blends were selected based on high protein, vitamin A and other nutrient contents. The composite blends produced was individually packaged in a moisture proof and air tight plastic containers, labelled and preserved in a refrigerator until needed for further use.

Table 1. Formulation of the Composite Flour

Samples	Brown Rice	Unsprouted Kidney Beans	24hrs Sprouted Kidney Beans	48hrs Sprouted Kidney Beans	72hrs Sprouted Kidney Beans	Orange Fleshed Sweet Potato	Carrot
Cerelac (Control)							
BK	70	30					
BKOC	60		25			10	5
$BKOC_1$	50			20		15	15
$BKOC_2$	40				20	20	20

2.9 Homogeneous Mixture of the Composite Flour

In order to obtain a homogenous composite blends, samples A, B and C was mixed separately in a food mixer (NSF, ARM-02, thunder bird, Canada) with mixing speed set at position two for 10 minutes.

Mineral Content (iron, zinc, magnesium potassium, and sodium contents were determined using standard method. Also, Anti-Nutrient Determination such as Tannin, Phytate and Oxalates content determination were determined using standard method as well as Functional Properties of the Complementary Food Samples

3. Statistical Analysis

The data obtained was statistically analyzed using SPSS (version 16) one-way Analysis of Variance (ANOVA) and Duncan's New Multiple Range Test. Statistical significant accepted at $p < 0.05$. The results were presented as frequency, percent, means and standard deviation in tables.

4. Results

4.1 Mineral Composition the Complementary Food Blends

Mineral composition of the flour samples was conducted on the five samples. Table 2 shows the mineral composition of the five samples.

The result showed that sample BKOC2 was significantly higher ($p < 0.05$) in the mean value of Iron (7.44 mg), Zinc (5.61 mg), Potassium (416.33 mg), Magnesium (183.67 mg) and Sodium (209.50 mg) contents than other samples. (40g, brown rice, 20g kidney beans, 20g carrot) had highest mineral composition amongst other samples while *Cerelac* had the least mineral content in all. Iron content of BKOC 1 is 6.967 mg/100 g, BKOC is 6.433 mg/100 g. Zinc content of BK shows 2.85 mg/100 g, BKOC indicates 3.77 mg/100 g, while BKOC2 had 5.61 mg/100 g. $BKOC_2$ had high values of 416.33 mg/100 g, 183.667 mg/100 g and 209.5 mg/100 g in potassium, magnesium and sodium respectively. BK indicates 162.79 mg/100 g magnesium, while *Cerelac* had 45.29 mg/100 g of sodium. There was significant difference $P<0.05$ in all the mineral contents of the samples.

Table 2. Mineral composition of the complementary food blends samples

Sample	Iron (mg/100 g)	Zinc (mg/100 g)	Potassium (mg/100 g)	Magnesium (mg/100 g)	Sodium (mg/100 g)
Cerelac	$2.61^e \pm 0.01$	$1.467^e \pm 0.015$	$83.82^e \pm 0.02$	$65.27^e \pm 0.03$	$45.29^e \pm 0.01$
BK	$4.33^d \pm 0.01$	$2.85^d \pm 0.01$	$296.4^d \pm 0.10$	$162.79^d \pm 0.01$	$185.543^d \pm 0.06$
BKOC	$6.433^c \pm 0.015$	$3.77^c \pm 0.01$	$320.617^c \pm 0.17$	$175.313^c \pm 0.08$	$192.517^c \pm 0.076$
$BKOC_1$	$6.967^b \pm 0.015$	$5.17^b \pm 0.01$	$385.727^b \pm 0.03$	$180.473^b \pm 0.06$	$206.79^b \pm 0.01$
$BKOC_2$	$7.44^a \pm 0.01$	$5.61^a \pm 0.01$	$416.333^a \pm 0.05$	$183.667^a \pm 0.07$	$209.5^a \pm 0.1$

*Mean ± SD of three replications

*Mean value with the same superscript within the same column are significantly not different ($p > 0.05$).

Key

Cerelac = (control)

BK = Brown rice (70%) and kidney beans (30%) flour

BKOC = Brown rice (60g), kidney beans (25g), orange fleshed sweet potatoes (10g) and carrot (5g) flour

BKOC1 = Brown rice (50g), kidney beans (20g), orange fleshed sweet potatoes (15g), and carrot (15g) flour

$BKOC_2$ = Brown rice (40g), kidney beans (20g), orange fleshed sweet potatoes (20g), and carrot (20g) flour

4.2 Anti-nutrient Composition of the Complementary Food Blends

Anti-nutrient analysis was conducted on the five samples. Table 3 showed the anti-nutrient composition of the five sample. The results showed that BK had tannin content of 0.683 mg/100 g, $BKOC_1$ had a tannin content of 0.42 mg/100g, Cerelac had a phytate content of 0.084 mg/100g, BKOC a phytate content of 0.85 mg/100g, $BKOC_2$ had an oxalate content of 0.4 mg/100 g. There was significant difference $P<0.05$ in the tannin, phytate and oxalate content of all the samples.

Table 3. Anti-nutrient Analyses of the Complementary Food Blends

Sample	Tannin (mg/100 g)	Phytate (mg/100 g)	Oxalate (mg/100 g)
Cerelac	$0.061^e \pm 0.01$	$0.084^e \pm 0.006$	$0.333^e \pm 0.015$
BK	$0.683^a \pm 0.06$	$1.34^a \pm 0.012$	$0.78^a \pm 0.002$
BKOC	$0.46^b \pm 0.00$	$0.85^b \pm 0.010$	$0.62^b \pm 0.002$
$BKOC_1$	$0.42^c \pm 0.00$	$0.65^c \pm 0.001$	$0.527^c \pm 0.012$
$BKOC_2$	$0.393^d \pm 0.06$	$0.46^d \pm 0.001$	$0.40^d \pm 0.002$

*Mean ± SD of three replications

*Mean value with the same superscript within the same column are significantly not different ($p > 0.05$).

Key

Cerelac = (control)

BK = Brown rice (70%) and kidney beans (30%) flour

BKOC = Brown rice (60g), kidney beans (25g), orange fleshed sweet potatoes (10g) and carrot (5g) flour

BKOC1 = Brown rice (50g), kidney beans (20g), orange fleshed sweet potatoes (15g), and carrot (15g) flour

$BKOC_2$ = Brown rice (40g), kidney beans (20g), orange fleshed sweet potatoes (20g), and carrot (20g) flour

4.3 Functional Properties of the Complementary Food Blends

Functional properties were analyzed on the five samples. Table 4 showed the functional properties of the five sample. The result showed that bulk density, water absorption capacity, and the least gelation time of Cerelac are 0.545 g/ml, 1.777 g/g, and 6.5% wt. / vol respectively. Sample BK had 0.645 g/ml bulk density, Sample BKOC had 2.60g/g water absorption capacity, sample BKOC1 had least gelation capacity 12.79%. Significant difference existed between the samples in each functional property.

Table 4. Functional properties of the complementary food blends

Sample	BD (g/ml)	WAC (g/g)	LGC (% wt. / vol)
Cerelac	$0.545^{a} \pm 0.06$	$1.777^{e} \pm 0.05$	$6.50^{e} \pm 0.00$
BK	$0.645^{a} \pm 0.01$	$2.84^{a} \pm 0.03$	$8.00^{d} \pm 0.00$
BKOC	$0.618^{a} \pm 0.02$	$2.60^{b} \pm 0.04$	$10.29^{c} \pm 0.012$
BKOC $_1$	$0.594^{a} \pm 0.02$	$2.52^{c} \pm 0.03$	$12.46^{b} \pm 0.015$
BKOC $_2$	$0.585^{a} \pm 0.06$	$2.35^{d} \pm 0.06$	$12.79^{a} \pm 0.012$

*Mean ± SD of three replications. Mean value with the same superscript within the same column are significantly not different ($p > 0.05$).

Key

Cerelac = (control)

BK = Brown rice (70%) and kidney beans (30%) flour

BKOC = Brown rice (60g), kidney beans (25g), orange fleshed sweet potatoes (10g) and carrot (5g) flour

BKOC1 = Brown rice (50g), kidney beans (20g), orange fleshed sweet potatoes (15g), and carrot (15g) flour

$BKOC_2$ = Brown rice (40g), kidney beans (20g), orange fleshed sweet potatoes (20g), and carrot (20g) flour

BD = Bulk density

WAC = Water absorption capacity

LGC = Least gelation concentration

4.4 Sensory Scores of the Complementary Food Gruel Samples

The result of the organoleptic evaluation of the complementary food gruel samples is presented in Table 5. The appearance of the samples showed mean scores of 7.66, 7.50, 6.80, 6.50 and 5.70 for cerelac and samples BK, BKOC, $BKOC_1$ and $BKOC_2$ respectively. The mean score of mouthfeel attribute of the products range between 5.30 for $BKOC_2$ to 6.80 for cerelac. Aroma ranged between 5.50 to 6.20. Sample BK had the highest score of 6.80 while $BKOC_2$ had the lowest score of 5.50. The taste of sample cerelac was superior to those of the other samples recording the best score of 7.00 while sample $BKOC_2$ was least accepted in terms of taste recording the lowest score of 5.10. In terms of general acceptability mean score showed 7.80, 7.60, 7.40, 6.85 and 6.50 for cerelac and samples BK, BKOC, $BKOC_1$ and $BKOC_2$ respectively.

Table 5. Sensory Scores of the complementary food gruel samples

Sample	Appearance	Mouthfeel	Parameters Aroma	Taste	General Acceptability
Cerelac	$7.66^{a} \pm 0.08$	$6.80^{a} \pm 0.14$	$6.20^{c} \pm 0.17$	$7.00^{a} \pm 0.14$	$7.80^{a} \pm 0.14$
BK	$7.50^{a} \pm 0.11$	$6.02^{b} \pm 0.11$	$6.80^{a} \pm 0.08$	$6.85^{ab} \pm 0.10$	$7.60^{ab} \pm 0.18$
BKOC	$6.80^{b} \pm 0.15$	$5.80^{b} \pm 0.10$	$6.40^{b} \pm 0.11$	$6.60^{b} \pm 0.17$	$7.40^{b} \pm 0.11$
BKOC $_1$	$6.50^{c} \pm 0.08$	$5.40^{c} \pm 0.08$	$5.60^{d} \pm 0.10^{c}$	$6.25^{c} \pm 0.08$	$6.85^{c} \pm 0.08$
BKOC $_2$	$5.70^{d} \pm 0.14$	$5.30^{c} \pm 0.08$	$5.50^{d} \pm 0.15$	$5.10^{d} \pm 0.15$	$6.50^{d} \pm 0.15$

Values are means ± SD. Values on the same column with different superscripts are significantly ($p < 0.05$) different.

Key

Cerelac = (control)

BK = Brown rice (70%) and kidney beans (30%) flour

BKOC = Brown rice (60g), kidney beans (25g), orange fleshed sweet potatoes (10g) and carrot (5g) flour

$BKOC_1$ = Brown rice (50g), kidney beans (20g), orange fleshed sweet potatoes (15g), and carrot (15g) flour

$BKOC_2$ = Brown rice (40g), kidney beans (20g), orange fleshed sweet potatoes (20g), and carrot (20g) flour

5. Discussion

The designed complementary food samples (BK, BKOC, BKOC1 and BKOC2) recorded considerably ($p<0.05$) higher values for the analysed minerals (iron, zinc, potassium, and sodium) than the control sample (cerelac). Additionally, adding sprouted kidney beans, orange-fleshed sweet potatoes, and carrot flour to brown rice flour resulted in a significant ($p<0.05$) increase in minerals. It is well known that minerals have significant physiological and metabolic functions in biological systems. When taken in sufficient amounts, mineral elements are sources of micronutrients necessary for strong bones, minds, and bodies [10]. Potassium was the most prevalent mineral in the food product, according to the mineral composition of supplemental food samples. This finding was consistent with earlier research, such as [11], which found potassium to be the most prevalent mineral in Nigerian agricultural goods. The prepared samples' higher iron content and improved nutritional quality of the complementary meal were made possible by the addition of sprouted kidney bean, orange fleshed sweet potato, and carrot flours. Both oxygen transport and cognitive development depend on iron. Adults should consume no more than 9-17 mg of iron per day, while children should have no more than 1-5 mg [12]. As a result, the iron content of the complimentary flour samples may be regarded as safe for adult intake but low for children. Iron is necessary for the production of haemoglobin, the transportation of oxygen, and the development of greater resistance to infection. The zinc content trend was also noted in the sample. Protein synthesis, cell development and differentiation, immunological function, and intestinal transport of water and electrolytes all depend on zinc, an essential mineral. [13] Zinc deficiency can cause diarrhoea, dermatitis, and stunted growth, among other symptoms. Zinc deficiency can affect people of all ages, although it is especially dangerous for newborns and young children [14]. The results found in this study are greater than the 0.6 mg of zinc that is advised for infants (6-12 months) to consume each day. Additionally, it was noted that as the rate of adding sprouted kidney bean, orange skinned sweet potato, and carrot flours rose, the potassium content of the complementary meal samples consistently increased. This showed that the potassium content of the supplemental meal is improved when sprouted kidney bean, orange fleshed sweet potato, and carrot flours are added during manufacture. This supports the study by [15], which found that kidney beans' high calorie content due to their strong protein, lipid, and mineral contents-particularly calcium and potassium-has led to a recent increase in awareness of their use as a supplement in weaning food formulations. The supplemental food provided in this study had a greater magnesium concentration than the 3.47-4.15 mg/100g reported by [16]. As the amount of sprouted kidney bean, orange fleshed sweet potato, and carrot flours was increased, the magnesium content of the blended flour samples increased significantly ($p<0.05$). This could likely be because kidney bean flour has a high magnesium level. Legumes like kidney beans and soybeans can provide youngsters with enough magnesium and ions to meet their daily needs. Magnesium is thought to be crucial for maintaining glucose homeostasis and is a necessary cofactor for several enzymes involved in glucose metabolism [17]. Magnesium strengthens bones and supports heart, neurone, and enzyme processes. Because iron deficiency is so common, it is crucial to fortify supplemental foods like kidney beans with iron-rich sources. The salt content showed the similar pattern. The anti-nutrient composition analysis's results indicated that the supplemental food samples examined in this investigation had low values. Since the anti-nutritional composition has been decreased and the nutrients, such as protein and minerals, in the food samples won't be hampered, this suggests that the food products could be used efficiently. Studies have shown that by altering the chemical makeup of legumes and cereals and removing anti-nutritious elements, fermentation and other processing techniques like sprouting enhanced their nutritional value [18]. Additionally, it was noted that the complementary food samples' tannin concentration was below the acceptable threshold. By forming a compound with proteins (both substrate and enzyme), tannin reduces the nutritional content of food products by preventing absorption and digestion [19]. Additionally, they bind iron, rendering it inaccessible [20], and additional data indicates that condensed tannins may break DNA when copper ions are present [21]. The FDA recommends a safe limit of less than 15 mg/100g. The supplemental food blend samples' phytic acid concentration fell within the acceptable range. Calcium, iron, and zinc bioavailability has been shown to decrease when 2.5g or more of phytic acid is consumed daily. Moreover, the oxalate concentration was low. It is well known that applying heat to food can lower its oxalate content [22], and the amount found in this study should decrease as the biscuits bake. However, a healthy heartbeat, neuromuscular function, and metabolic processes all depend on a moderate intake of oxalate. [23] Oxalate levels in the complementary food blend samples that were examined ranged from 0.33 mg/100 g to 0.78 mg/100 g, which was less than the 2.5 g hazardous limit that was reported by [24]. The designed food samples' functional characteristics were similar to those of the control food sample. Functional qualities of dietary ingredients are crucial for diet appropriateness, especially for developing children. [25] As the amount of sprouted kidney bean, orange skinned sweet potato, and carrot flour in the mix increases, the bulk density values drop. The values obtained for the formulations do not differ substantially ($p<0.05$) from the control sample (cerelac). This pattern is in line with the findings of [26], who found that adding soybean decreased bulk density in millet-based supplemental foods because of its larger protein proportion and lower starch content. One significant factor affecting the energy density, processing, and packaging of supplemental foods is bulk density (BD). Infant foods should have lower bulk density ratings since they are lighter and have a more porridge-like consistency. Low bulk density is beneficial from a nutritional standpoint since it encourages the intake of larger amounts of the lighter food item, which results in the user consuming more nutrients. Accordingly, food samples that contain sprouted kidney bean flour may be more nutrient-dense than those made with unsprouted kidney bean flour (Sample BK). In food packing, the low bulk density is also cost-effective. A high water absorption capacity is ideal for improving food product mouthfeel and reducing viscosity. The water absorption capacity (WAC) values of the supplementary foods were the same, however they differed considerably ($p<0.05$) [27]. The WAC values of the complementary foods decreased when the flour content of kidney beans and brown rice decreased, whereas the flour content of carrots and sweet potatoes with orange flesh increased. The meal mixes' decreased ability to absorb water could be due to a drop in their carbohydrate content. One important factor influencing supplementary foods' potential to hold onto moisture during reconstitution is their water absorption capacity. It serves as a gauge for how much water a food item could possibly absorb and hold onto [28]. Higher water absorption capacity flour might have more hydrophilic ingredients, including polysaccharides. [29] This is consistent with [22], who reported higher least gelation concentrations in soybean-enriched complementary foods. The control sample (cerelac) had a significantly ($p<0.05$) lower least gelation concentration (6.50%) than the formulations (8.00 - 12.79%) containing sprouted kidney bean, orange fleshed sweet potato, and carrot flours. Because of their protein structure, it was also shown that flours made from legumes had a higher least gelation concentration. The texture of complementary foods is influenced by the least gelation concentration, which quantifies the lowest concentration needed for a sample to gel. The larger protein content in the test formulations, which needs more energy to produce a stable gel network, could be the cause of the increased least gelation concentration [29]. The materials' gelling qualities suggested that they could be employed in supplemental food formulations. There were notable ($p<0.05$) variations in the gruels' appearance, taste, aroma, mouthfeel, and general acceptability between the control (cerelac) and designed complementary meal samples (BK, BKOC, BKOC1, and BKOC2). Although sample BKOC2 (40g of brown rice, 20g of kidney beans, 20g of orange fleshed sweet potatoes, and 20g of carrot flour) had significantly ($p<0.05$) lower scores for every parameter examined, the gruels made from the control sample (cerelac) and those made from the blends of brown rice, kidney bean, orange fleshed sweet potato, and carrot flour were generally acceptable. The way the samples looked demonstrated how much the product's light rays affected the eyes [30]. The product's smoothness and feel are referred to as its mouthfeel. When assessing a food's sensory qualities, taste is a crucial factor. Even if the product is attractive and has a high energy density, it is unlikely to be accepted if it lacks flavour. Because the panellists were more used to cerelac than the recently developed complementary food samples (BK, BKOC, BKOC1, and BKOC2), the control sample (cerelac) recorded higher sensory scores for nearly all of the characteristics examined. In conclusion The more costly proprietary formula product (cerelac) can be replaced with complementary food mixtures to help address the issue of newborn and child malnutrition in Nigeria and other poor nations. According to the study, adding kidney beans, orange-fleshed sweet potatoes, and carrot flour to brown rice-based supplementary foods enhanced their protein, lipid, carbohydrate, mineral, and vitamin contents as well as their functional qualities. Mineral and vitamin deficits are common, and the higher mineral content in the composite supplement samples would help treat these. According to the study's findings, the complementary food mix samples examined in this investigation had a minimal anti-nutrient content and, as a result, posed no significant health risks, making them safe for human consumption. In comparison to the combination of brown rice and unsprouted kidney bean flour, the functional characteristics of the complementary food formulations indicate that the addition of sprouted kidney beans, orange fleshed sweet potatoes, and carrot flours enhanced bulk density, water absorption capacity, and gelation concentration. Additionally, the outcome implies that complementary foods enhanced with legumes are both nutritionally advantageous and organoleptically acceptable. During the complementary feeding time, nursing moms could feed their newborns and young children the complementary foods developed in this study.

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